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Epidemiology of Haemonchosis in Goats Under Different Management Practices in Bangladesh

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University of Rajshahi

Ph.D.
THESIS

Epidemiology of Haemonchosis in Goats Under Different Management Practices in Bangladesh

A Thesis

Submitted to the University of Rajshahi in fulfillment of the requirements for the degree of DOCTOR OF PHILOSOPHY (Ph.D.)

by

LOVELY NAHAR

DVM; MS in Parasitology
Ph.D. Fellow
Roll No. 09810
Registration No. 0300
Session: 2009-2010

Department of Animal Husbandry and Veterinary Science
Faculty of Agriculture
University of Rajshahi, Rajshahi-6205, Bangladesh.

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In the Department of Animal Husbandry and Veterinary Science
Rajshahi University, Rajshahi-6205, Bangladesh.

by

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DEDICATED

TO

MY BELOVED PARENTS

&

MY HUSBAND

DECLARATION

I hereby declare that the thesis titled ***"Epidemiology of Haemonchosis in Goats Under Different Management Practices in Bangladesh"*** *has been prepared by me from an original research work in the Department of Animal Husbandry and Veterinary Science, University of Rajshahi, Bangladesh under the supervision of Prof. Dr. Jalal Uddin Sarder, Dept. of Animal Husbandry and Veterinary Science, RU and Co-supervisors Prof. Dr. Motahar Hussain Mondal, Dept. of Parasitology and Prof. Dr. Md. Omar Faruque, Dept. of Animal Breeding & Genetics, BAU, Mymenshingh, Bangladesh in the fulfillment of the requirement for the degree of Doctor of Philosophy (Ph.D.).*

The thesis or any part of it has not been submitted to any other University or elsewhere for any degree or for other similar purpose. All sources of information are shown in the text and listed in references. The assistance and help received during the course of investigation have duly been acknowledged.

(Lovely Nahar)
Ph.D. Fellow

CERTIFICATE

*We have pleasure in certifying the thesis entitled "**Epidemiology of Haemonchosis in Goats Under Different Management Practices in Bangladesh**" submitted in the Department of Animal Husbandry and Veterinary Science, Faculty of Agriculture, University of Rajshahi, Bangladesh for the Degree of Doctor of Philosophy (Ph.D.).*

*We hereby certify that the candidate **Lovely Nahar** has fulfilled the requirements and the research work embodied in the thesis was carried out by the candidate. To the best of our knowledge, all the data and materials are genuine and original. This research work has not been submitted in part or in full previously for any academic degree in this University or any other University.*

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ABSTRACT

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The present study was designed to evaluate the prevalence of haemonchosis of goats at greater Rajshahi (Rajshahi and Noagon district), and was conducted at the parasitological laboratory in the Department of Animal Husbandry and Veterinary Science, University of Rajshahi, Bangladesh for the epidemiological and morphological studies of *Haemonchus* spp during the period from March, 2011 to December 2013. In this cross-sectional study, a total 720 goats were randomly selected from the villages, farms, pastures, veterinary hospitals, abattoirs and examined for *Haemonchus* infection. The aim of this study was to determine the occurrence of haemonchosis in relation to host factors like age, sex, breed, body condition as well as management factors like husbandry system, de-worming status, housing system, feeding system and herd-size of the goats, environmental factors like month, season and other factors like study area, examination procedure and vulvar morphology of adult female *Haemonchus* spp. A total of 720 goats examined, of which 416 goats were found positive for *Haemonchus* spp infection and the overall prevalence of haemonchosis in goat was 57.8%. The prevalence was compared with age, sex, breed, and body condition of the goats. There was statistically significant ($P<0.001$) difference observed among the risk factors of age, sex and body condition of goat. However, there was no significant difference ($P>0.05$) observed in breed of goats. In the present study, the prevalence of haemonchosis was also compared with husbandry system, floor of housing, de-worming status, feeding system and herd-size of goats. All the management factors were observed statistically significant ($P<0.001$) difference in the epidemiology of haemonchosis in goats of the study area. During this study, the highest prevalence was observed in the month of July (82.1 %) followed by August (79.7 %) and lowest in the January (28.3 %) followed by February (38.7 %). Among the season, the peak level of *Haemonchus* infection was recorded in rainy (76.6%) season followed by summer (56.0%) and lowest in winter (40.5%) season. The prevalence among different month and season when compared statistically (Chi-square test and ANOVA) was revealed significant differences ($P<0.001$). Prevalence of haemonchosis did not vary significantly ($P>0.05$) between the study sites. The prevalence of haemonchosis was higher in necropsy (65.5%) compared to coproscopy (50.1%) findings and statistically ($P<0.01$) influenced by the examination procedure of the present study. It was also noted that light infection (48.4%) were higher followed by moderate (41.2%) compared to (10.4%) heavy infection of the affected goats. In necropsy, moderate infection was higher (54.2%) than light (28.6%) degree infection followed by heavy (17.0%) degree of infection was identified by counting of adult *Haemonchus* spp in the abomasum of slaughtered goats. In both examination procedure, chi-square test result was highly significant ($P<0.001$) difference among the degree of infection of affected goats.

From the collected stomach worms, the percentage of female were 63.0% significantly (P<0.001) higher than adult male (37%) *Haemonchus* spp. The result also revealed that sex ratio of adult *Haemonchus* spp were found 1:0.59. The knobbed type of vulvar flap was the predominant (46.1%) type of *Haemonchus* spp compared to other morphs. In the statistical analysis, significant (P<0.001) fluctuation was observed among three major vulvar flap morph types in both of the study area. Among the linguiform subtypes, linguiform-B (LB) was the higher (96.6%) compared to linguiform-A (LA) but there was no found in LC, LD, LI linguiform subtypes of *Haemonchus* spp in the study area. The present work showed the widespread occurrence of polymorphism in vulvar morphology of female *Haemonchus* spp of goats in the study area of Bangladesh. The present study suggests that young aged group, female, poor body conditioned goats and management practices like husbandry system, floor of housing, de-worming status, feeding system and herd-size of goats were more susceptible to haemonchosis in the study area but cross-bred goats was least susceptible to haemonchosis and requires special attention for its control. Therefore, the epidemiological evidence of the present investigation showed that haemonchosis is considerably prevalent disease of goats in the study area. Hence, strategic control method and good management practices are recommended. Prevalence, epidemiology, morphological, molecular and genetic characterization of *Haemonchus* spp with biology and significance of different vulvar flap types, subtypes and identification of *Haemonchus* in all species in different agro-ecologies, animal species and breeds on management system in other districts of Bangladesh and other countries will need to be pursued.

LIST OF THE ABBREVIATION AND SYMBOLS

Abbreviations	Full meanings
%	Percentage
BER	Bangladesh Economic Review
BBS	Bangladesh Bureau of Statistics
Km	Kilometre
mi	Mile
°Ċ	Degree Celcius
°F	Degree Farenhight
mm	Milimetre
in	Inch
et al	Et alia
FAO	Food and Agricultural Organization
OIE	World Organization of Animal Health
GDP	Gross Domestic Product
L_3	Infective third larva
L_5	Fifth larva
PCV	Packed Cell Volume
P	Probability
GI	Gastro Intestinal
GIN	Gastro Intestinal Nematode
GIT	Gastro Intestinal Tract
GIP	Gastro Intestinal Parasite
GIPs	Gastro Intestinal Parasites
Spp	Species
ml	Mililitre
µl	Microlitre
µm	Micrometre
cm	Centimetre
i.e.	That is
e.g.	For example

L_1	First larva
L_2	Second larva
L_4	Fourth larva
L	Linguiform
LA	Linguiform-A
LB	Linguiform-B
LC	Linguiform-C
LD	Linguiform-D
LI	Linguiform-I
RAPD	Random Amplified Polymorphic DNA
d	Day
N	North
E	East
Sq.Km.	Square Kilometre
<	Is Less Than
>	Is Greater Than
=	Equal
BCS	Body Condition Score
RU	Rajshahi University
AHVS	Animal Husbandry and Veterinary Science
NaCl	Shodium Chloride
rpm	Rotation Per Minute
gm	Gram
MAFF	Ministry of Agriculture, Fisheries and Food
SPSS	Statistical Program for Social Science
ANOVA	Analysis of Variance
DMRT	Duncan Multiple Range Test
n	Number of observation
NS	Non Significant
df	Degree of Freedom
F	Factorial value
etc.	Etcetra

GIT	Gastro-intestinal tract
ELISA	Enzyme linked Immuno Sorbent Assay
Dot-ELISA	Dot Enzyme linked Immuno Sorbent Assay
KDa	Kilo Dalton
ITS	Internal Transcribed Spacer
ITS_2	Second Internal Transcribed Spacer
DNA	Deoxy Nucleic Acid
PCR	Polymerase Chain Reaction
RT-PCR	Real Time Polymerase Chain Reaction
GINs	Gastro Intestinal Nematodes
AR	Anthelmntic Resistance
EPG	Egg Per Gram
FEC	Faecal Egg Count
HCl	Hydrochloric Acid
BZ	Benzimidazole
BZs	Benzimidazoles
ATP	Adenosine Tri-phosphate
NADP	Nicotinamide Adenine Di-nucleotide Phosphate
NADPH	Nicotinamide Adenine Di-nucleotide Hydrogen Phosphate
&	And
Sig.	Significance
BAU	Bangladesh Agricultural University

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CHAPTER ONE
INTRODUCTION

1.1. General Introduction

Bangladesh is one of the poorest and densely populated, subtropical country with subsistence agro-based economy. It is the fourth largest agricultural country in the world (Habib, 2001). Livestock is very important sector which can remove poverty instantly. Bangladesh has 140 million skilled and unskilled people. Out of 140 million, more than 70% are as unskilled but they depend on livestock and agri-based business. In Bangladesh, more than half of the total population is based on agricultural product and livestock (Shamsuddoha, 2009). The economy of Bangladesh largely depends on agriculture. The agriculture of Bangladesh is almost entirely based on livestock. The total livestock population is about 536.60 (lacs) contributing 37.38 (lac ton) milk, 30.21 (lac ton) meat (BER, Bangla, 2014). Among the sub-sectoral contributions of agricultural are dominated by crops (56.07 %) followed by fisheries (22.18 %) and livestock (13.25 %) and the rest by forest and related services (8.50 %) (BBS, 2010).

Bangladesh is a low-lying, riverine country located in South Asia with a largely marshy jungle coastline of 710 km. (441 mi.) on the northern littoral of the Bay of Bengal. Formed by a delta plain at the confluence of the Ganges (Padma), Brahmaputra (Jamuna) and Meghna rivers and their tributaries, Bangladesh's alluvial soil is highly fertile, but vulnerable to flood and drought. Hills rise above the plain only in the Chittagong Hill Tracts in the far southeast and the Sylhet division in the northeast, Rajshahi division in the north-western part of Bangladesh. Bangladesh has a tropical monsoon climate characterized by wide seasonal variations in rainfall, high temperatures, and high humidity. Regional climatic differences in this flat country are minor. Three seasons are generally recognized: a hot, muggy summer from March to June; a hot, humid and rainy monsoon season from June to November; and a warm-hot, dry winter from December to February. In general, maximum summer temperatures range between 38 and 41°C (100.4 and 105.8°F). April is the hottest month in most parts of the country. January is the coolest month, when the average temperature for most of the country is 16-20°C (61- 68°F) during the day and around 10°C (50°F) at night. Heavy rainfall is characteristic of Bangladesh causing it to flood every year. With the exception of the relatively dry western region of Rajshahi, where the annual rainfall is about 1,600 mm (63.0 in.), most parts of the country receive at least 2,300 mm (90.6 in.) of rainfall per year. Bangladesh forms the largest delta in the world and is situated between 88°10́ and 92°41́ East longitudes and between 20°34́ and 26°38́ North longitudes. The Rajshahi division is relatively high and cannot hold waters during monsoon (Wikipedia, 2014).

1.2. Importance of Livestock

Livestock play an important role in the national economy of Bangladesh. Livestock production is a major component of the agricultural economy of developing countries and goes well beyond direct food production. Sales of livestock and their products provide direct cash income to farmers. Livestock are the living bank for many farmers and have a critical role in the agricultural intensification process through provision of draught power and manure for fertilizer and fuel. They are also closely linked to the social and cultural lives of millions of resource-poor farmers for whom animal ownership ensures varying degrees of sustainable farming and economic stability (Jabbar *et al*., 2006) has been duly argued that animal production contributes to food security by providing a source of energy, dietary protein of high nutritional quality and micronutrient. Animal production contributes directly and indirectly to countries GDP and to the income and purchasing power of the various operators in the production, processing and marketing chains, at both the national and international levels (FAO/OIE, 2012). Statistics show that about 1.78% of national GDP (Gross Domestic Product) is covered by the livestock sector, and its annual rate of growth is 5.5% (BER, Bangla, 2014). The numbers of livestock in Bangladesh are estimated to be 23.43 million cattle, 1.45 million buffalo, 25.61 million goats, and 3.15 million sheep up to February, 2014 (BER, Bangla, 2014).

Livestock is important in food security, income generation and improving the small holder’s livelihoods and poverty alleviation strategies offering the poor the way out of the poverty trap (FAO/OIE, 2012). It has been argued that, livestock production is an important source of income for the rural poor in developing countries (Delgado *et al.,* 1999), enabling the poor and landless farmers to earn income using public common-property resources such as open range lands. It follows that livestock underpin the livelihoods of the poor through the developing world (Delgado *et al.,* 1999; Perry *et al.,* 2002), and provide income, quality food, fuel, draught power, building material and fertilizer, thus contributing to household livelihood, food security and nutrition (FAO, 2009). Consequently, livestock contributes directly to food availability and access for small holders often in complex ways (FAO, 2009). Livestock is central to the livelihood of the rural poor in the country and can contribute substantially to poverty alleviation by strengthening the socio-economic conditions of pastoralists (Gadahi *et al.,* 2009). Historically the livestock sector was subsistence-oriented and dominated by smallholders, and even today livestock are considered a secure source of income for small farmers and landless poor, and a source of employment generation at the rural level (Gadahi *et al.,* 2009; Khajuria *et al*., 2013). Livestock production covers up to 40% of the gross value of agricultural production globally.

1.3. Contribution of Goat

Goat is important livestock species all over the globe and especially in tropical and subtropical regions. It has a pivotal role in small scale farming and rural economy of developing societies by generating employment and supplementing house hold income. Goats are primarily raised for milk, meat, hair and leather production (Hasan *et al.,* 2011). Goat requiring little inputs, play vital role in rural economy through provision of meat, milk, blood, cash income, accumulating capital, fulfilling cultural obligations, manure, and contribute to the national economy through the export of live animals, meat and skins (Amenu, 2005). At the national level, sheep and goat account for about 90% of the live animal/meat and 92% of skin and hides export value of the country (Gizaw *et al.,* 2010). Smallholder farming systems are also characteristic of poor access to conventional knowledge and information, and little or no mechanization (Boyazoglu *et al*., 2005). Smallholder goat production systems consist of sedentary resource-poor farmers, each with a small piece of land on which they practice mixed farming (Kosgey *et al*., 2006). Most households keep only a few goats, along with other livestock species such as cattle, sheep, pigs, horses/donkeys and chickens. The integration of goats with other enterprises indicates a way of diversification so as to improve food security. The neglect of the goat enterprise is due to various reasons. Most goat products flow through the informal markets (Lebbie, 2004) where they are not taxed, thus leading to non-recognition of their contribution to the national economy. In addition, goat-keepers are often resource poor, and are economically and politically marginalized (Peacock *et al*., 2005).

1.4. Goat Management System

Good feeding management can reduce the cost of production significantly. Stall-feeding is commonly practcised in the densely populated and intensively cultivated areas. Stall-feeding is mainly identified with small-holder dairy goat keepers and research institutions. Roughages are included in the diet, especially in small ruminants such as goats to reduce the risk of digestive disturbances. Foraging preferences of goats encompass a wider spectrum of plants than for other ruminants. Goats are good browsers and can selectively utilize a wide variety of shrubs, woody plants, weeds and briers. Depending on the management system, you may use pastures, dry forage (hay), and silage or haylage. Silage and haylage in moderation and along with other roughages are very good sources of roughage for goats. Very young goats (up to 5-6 months of age) should not be fed silage (Solaiman, 2011). Tethering is a widespread system of small ruminant management by small-holders. Tethered goats are secured with a rope and tied to a peg to prevent them from destroying crops and to enable farmers to conduct other farm activities. Due to scarcity of land and shortage of labour fewer goats are kept per household. Tethering can also be practised in areas where goats are herded (Mbuh *et al*., 2008). In some cases, however, goats are tethered in the morning hours and then herded in the afternoon when school children are back from school (Wilson and Azeb, 1989). Since tethering restricts a goat to a specific area, the animal will have little choice of feed, resulting in poor body condition, inferior weight gains and higher predisposition of the goat to heavy helminth burdens (Caldeira *et al*., 2007) indicating how a production system can impact on productivity levels of the goats.

Goat kids are the most fragile and perishable component of a goat flock any attempt made to ensure their survival in bound to increase productivity and economic returns (Lebbie and Manzini, 1989). The death of kids before they are weaned is perhaps the single biggest cause of loss experienced by farmers. The predisposing factors may be a lack of colostrums at birth, poor mothering, poor nutrition of the dam leading to low milk production, dirty housing and pen areas which allow build up of infective agents, dirty water and failure to vaccinate dam appropriately (Peacock, 1996). High mortality among kids and slow growth among those that survive are the major constraints to production. Diseases, inadequate nutrition and poor management are the main underlying causes of the high mortality and low growth rates, specially young (Lebbie and Manzini, 1989). Diseases and parasites have a heavy impact on kids because of the poor immunity status of these young animals leading to an increased susceptibility (Sebei *et al*., 2004). Goat production depends on feed supplies, good health practices and appropriate animal husbandry management. Various climatic and casual factors are leading to a high degree of parasitic infestation resulting in decreased longevity, fertility and productivity of infested animals (Khajuria *et al*., 2013).

1.5. Parasites infestation in goat

Bangladesh have large livestock number of small ruminants however the owners of these animals get very few benefits because of parasitic/infectious diseases, inefficient productions systems, lack of balanced nutrition, improper housing and outdated management practices. The climatic conditions of our country are very favourable for the survival and development of the all stages of parasites outside the host on the pastures round the year. Parasitic infestations are the major veterinary problems in most of the developed & under development countries of the world. Among the problems encountered, Parasitism is the major cause hindering the development and productivity of livestock population in the country (Dewan *et al*., 1979; Nooruddin *et al*., 1987; Shahiduzzaman *et al*., 1999). Parasitism is of supreme importance in many agro-ecological zones and still a serious threat to the livestock economy worldwide (Vercruysse and Claerebout, 2001). Gastrointestinal helminth infections are recognized as a major constraint to livestock production throughout the tropics and elsewhere (Githiori *et al*., 2004). Internal parasitism is one of the biggest problems in the small ruminant industry. Among livestock, goats are much susceptible to gastrointestinal nematode infections due to their specific feeding habits, underfed, unplanned farming and poor management practices adapted by farmers (Ibrahim, 2009). Parasitism is claimed to be one of the main obstacles in livestock rearing in

Bangladesh (Jabbar *et al.,* 2003). The agro-ecological and geo-climatic conditions of Bangladesh are highly favourable for growth and multiplication of parasitic diseases in goat (Huq and Sheikh, 1968). Parasites also reduce voluntary feed intake, efficiency of feed utilization and increase the endogenous loss of protein in the gastrointestinal tract (Alexandre and Mandonnet, 2005).

Helminth is a general term that applies to the parasitic worms. Helminths are parasitic because they survive on the nourishment they receive from their hosts as well as the protection they need to survive, all of which happens at the expense of the host (Hale, 2006). Helminths include the monogeneans, which includes the nematodes (roundworms), trematodes (liver flukes) and the cestodes (tapeworms). These parasites often infect animals and/or humans through vector bites, ingestion of contaminated food and water and walking barefoot on infected soil. Helminth infestations often disrupt the ability to efficiently convert food material and absorb nutrients, the result of which is weakening and even death. This poses a serious threat on human health and on the production of animals which in turn impacts negatively on the economy (Gasser *et al*., 2008; Bott *et al*., 2009; Ahmadi and Meshkehkar, 2010; Ahmed, 2010; Sweeny *et al*., 2011), as there is reduced yield and quality of products such as meat, milk and wool (Tsotetsi and Mbati, 2003; Aldemir, 2006; Maphosa *et al*., 2010), not forgetting the condemnation of infected meat at abattoirs (Cucher *et al*., 2006). Helminth infestation lowers the animal’s immunity and renders it susceptible to other pathogenic infections; finally this may result in heavy economic losses (Garedaghi *et al.*, 2011).

Internal parasitism is one of the biggest problems in the small ruminant industry. Internal parasite infestations of herds can cause major health issues, which have a major effect on the animal’s performance and cause great economic loss to the producer. In fact, most of the economic losses caused by internal parasites are actually not due to mortality but production loss (Waller, 2004). Mulcahy *et al*. (2004) reported that parasitic diseases represent a major problem for the health of small ruminants and hamper the poverty alleviation programs in livestock farming system in the developing countries. Goat production depends on feed supplies, good health practices and appropriate animal husbandry management. Various climatic and casual factors are leading to a high degree of parasitic infestation resulting in decreased longevity, fertility and productivity of infested animals (Khajuria *et al.*, 2013). Helminthiasis is, however, of high economic significance in view of its insidious nature and easy transmissible due to underfeeding, availability of a wide variety of hosts and vectors, inadequate/low level of awareness of farmers and high medication costs (Garedaghi *et al*., 2011; Terefe *et al*., 2009). Several authors (Raza *et al*., 2007, 2012; Khan *et al*., 2010; Farooq *et al.*, 2012) have explored various aspects of helminth infestation in different localities of Pakistan and reported prevalence ranges of 25 - 92%. Helminth infestation lowers the animal's immunity and renders it susceptible to other pathogenic infections; finally this may result in heavy economic losses (Garedaghi *et al*., 2011). The problem is however much more severe in developing countries due to very favorable environmental conditions for helminth transmission, poor nutrition of the host animal (Mbuh *et al*., 2008) and poor sanitation in rural areas (Badran *et al.*, 2012). As a result diseases caused by helminths remain a major impediment to small ruminant production in the tropics and elsewhere (Kumsa *et al.*, 2011), and up to 95% of small ruminants are reported to show helminth infestation in these latitudes (Mbuh *et al*., 2008; Terefe *et al*., 2012). However, the majority of animals infested with helminths do not show clinical signs owing to the chronic nature of the disease. Gastrointestinal parasitism is a world-wide problem for both small- and large-scale farmers and is a great threat to livestock industry (Saddiqi *et al*., 2010). In parasitism, gastrointestinal (GI) helminths are recognized as a major constraint to livestock production throughout the tropics and elsewhere (Githiori *et al.*, 2004). Gastrointestinal parasitic infections in small ruminants are of considerable economic importance because small ruminants' rearing has been a major source of income especially to the marginal farmers and labours of the country (Bandyopadhyay, 1999). The loss through reduced productivity is related to reduction of food intake, stunted growth, reduced work capacity, cost of treatment and control of helminthosis (Pedreira *et al.*, 2006; Chaudhary *et al.*, 2007; Odoie, *et al.*, 2007). Adverse effects of different species of helminthes include significant impairment in wool, loss of body weight, and reduced milk production. In addition, helminthes lower resistance of the animals and predispose them to the secondary infections *i.e.* bacterial, viral and etc. which lead to heavy economic losses (Soulsby, 1982; Khan *et* *al*., 1989). Parasitic infestations exert adverse effects on the health and productivity of animals (Rehman *et al*., 2009). These effects are varied and more pronounced in sheep and goats compared to those seen in other species of livestock (Iqbal *et al*., 1993). Gastrointestinal nematodes of small ruminants are one of the major causes of productivity loss (Garedaghi *et al*., 2013).

Among the gastro-intestinal parasites, many species of parasites are seen in sheep and goats and usually include *Haemonchus, Oesophagostomum, Ostertagia, Cchabertia, Nematodirus, Trichuris, Moniezia* and *Fasciola*. The most important of these is *Haemonchus contortus* (Husnain and Usmani, 2006). It is an important blood sucking parasite of the ovines and causes an insidious drain on production (Ijaz *et al*., 2008), weight losses and even mortality in young animals (Husnain and Usmani, 2006). The disease caused by various gastro- intestinal nematodes is prevalent wherever sheep and goats are raised, but it exerts the greatest economic losses in temperate and tropical regions (Ijaz *et al*., 2009; Raza *et al*., 2009). According to several studies carried out other parts of the world, (Sissay *et al*., 2007; Nabavi *et al*., 2011;Taylor *et al*., 2013) gastrointestinal nematodes could be harmful to the health of infected animals and causes economic losses due to mortalities, reduce weight gain and other production losses. *Haemonchus contortus*, *Trichostrongylus circumcincta*, *Ostertagia trifurcata*, *Trichostrongylus axei*, and *Marshalalgia marshali* and *Teladorsagia species* are most common abomasal worms of sheep and goats in most part of the world including tropical areas resulting in significant loss of production (Kumsa and Wossene, 2006; Taylor *et al*., 2007; Abunna *et al*., 2009). The prevalence of anthelmintic resistance is a serious constraint to goat production globally (Kaplan *et al*., 2004; Howell *et al*., 2008). Gastrointestinal nematodosis especially haemonchosis is probably the single most important constraint to small ruminant production on both commercial farms and resource-poor production systems in the summer rainfall regions of South Africa (Krecek, 2000 and Vatta *et al*., 2001). Parasitic diseases pose serious threat to livestock farmers specially sheep and goats keepers. Parasitic diseases of ruminants are linked to the environment; interest in sustainable livestock production provides challenge for those concerned with control and prevention of animal parasitism (Qamar *et al*., 2011).

The main constraints are high prevalence of diseases and parasites, inappropriate housing and lack of records and, use of inappropriate breeds and inbreeding, limited forage availability (Raghuvansi *et al.*, 2007) and poor marketing strategy (Kusina and Kusina, 1999). Among the diseases of goats, the parasitic diseases are of prime importance in Bangladesh. About 25% kids and 43% adult goats die of gastrointestinal parasitism under both rural and farm condition (Rahman *et al*., 1975). Nematodes of the gastrointestinal tract of ruminants are responsible for huge economic losses in many countries of the world (Waller, 1997). Goats are very sensitive to the effects of internal parasitism (such as anemia and low blood protein). Parasitism can cause decreased fertility, abortion, unthriftiness, increased susceptibility to disease, and death (Stehman and Smith, 1995). In terms of constraints that hamper productivity and full development of “goat subsector”, high mortality rate at weaning, development of anthelmintic resistance, and endoparasitism were identified as the top three concerns that should be addressed (Pcarrd, 2004). Caprine parasitic gastrointestinal infection is worldwide in distribution (Baker *et al.*, 1999; Chiejina *et al.*, 2002), especially in the tropical and other sub tropical areas, ostensibly due to poor management practices and inadequate control measures (Akhtar *et al.*, 2000).

1.6. Haemonchosis problems in goat

Helminthes infections in small ruminants are serious problems in the developing world, particularly where nutrition and sanitation are poor (Oddoi *et al*., 2007). Gastro-intestinal nematode infection is one of the major health problems in the world. These nematode infections affect the health of millions of people and and causing huge economic loss in livestock farming (Ahmed, 2010). Haemonchosis is a parasitic (gastro-intestinal) disease caused by nematode of the genus *Haemonchus* commonly called ‘Stomach-worm’ or ’Wireworm’ or ‘Blood worm’ under the order Trichostrongyloidea. Nematodes of the genus *Haemonchus* parasitize the abomasum of wild and domestic ruminants and are widespread throughout terrestrial ecosystems. Currently, thirteen *Haemonchus* species have been recorded in the world fauna. The ruminants from the families Cervidae, Antilocapridae, Giraffidae, Bovidae, as well as Camelidae, have been recorded as definitive hosts (Hoberg *et al*., 2004). These nematodes are widespread and cause serious disease (i.e. anemia, loss of appetite, diarrhea, constipation). Losses caused by these diseases to goat husbandry are significant (Waller and Chandrawathani, 2005). Roberts *et al*. (1954) believed that *Haemonchus contortus* (Rudolphi, 1803) parasitize both small and large ruminants. Lichtenfels *et al.* (1986; 1994) believe that two *Haemonchus* species, *H. contortus* and *H. placei*, parasitize both small and large animals. Infection with *H. contortus* is referred to as haemonchosis (Mehlhorn, 2008). Several scientists reported that haemonchosis, was the highly prevalent and pathogenic gastro-intestinal nematode and most economically deteriorating disease of goats (Maqsood *et al.,* 1996; Mortensen *et al.*, 2003; Shahiduzzaman *et al*., 2003; Qamar, 2009; Nuruzzaman *et al*., 2012; Akkari *et al.,* 2013). *Haemonchus* has become the most serious parasite affecting small ruminants throughout the world (Kaplan and Vidyashankar, 2012). Prevalence of haemonchosis in the small ruminants being very high. They cause adverse effects on the host like haematological and biochemical disturbances (Rasool *et al.,* 1995; Hayat *et al.,* 1996; Iqbal *et al.,* 1998; Hayat *et al.,* 1999), loss of body weight (Khan *et al.,* 1988) and huge economic losses (Iqbal *et al.,* 1989; Iqbal *et al.,* 1993).

1.7. Clinical manifestations and signs of haemonchosis

Haemonchosis has three forms i.e., hyper acute, acute or chronic in nature. In the hyperacute disease, death may occur within one week of heavy infection without significant signs. In hyperacute form there are sudden deaths due to intake of large number of infective larvae by sheep and goats grazing on heavily parasitic contaminated pastures. During the period of wet and warm weather conditions massive numbers of *Haemonchus* eggs rapidly develop into infective stages. Postmortem examination of dead animals reveals that large numbers of worms varying from 20,000 to 50,000 are found in the abomasa. The acute disease is characterized by severe anemia accompanied by generalized edema; anemia is also characteristic of the chronic infection, often of low worm burdens, and is accompanied by progressive weight loss. Diarrhea is not a sign of pure *Haemonchus* infection; the lesions are those associated with anemia. In cases in which diarrhea is present, there may be mixed infection with other worm genera. The abomasum is edematous. In acute form, there is an anaemia and progressive dramatic fall in packed cell volume and hematocrit, which causes increase in appetence, the bone marrow eventually exhausted due to continuous loss of iron and proteins in the gastrointestinal tract and thus resulting into death. At necropsy, abomasal contents become brown due to the presence of blood and lesions are seen on the abomasal mucosa, ranging from 2,000 to 20,000 worms may be found in the abomasa. If grazing continues and treatment is not given to affected animals than the condition of animals become worsen progressively and death is the usual outcome. In chronic form, there is a progressive loss of weight and weakness but anaemia is not very severe. The chronic form is the most commonly observed during natural infections. The lesions are associated to anaemia resulting from blood loss, with the exception of the L_3, all other stages of development feed on blood, *Haemonchus contortus* is known to produce calcium and a clotting factor binding substance known ascalreticulin, enabling the parasite to feed easily on host blood (Getachew *et al*., 2007). Chronic type has financial consequences due to increased feed intake but poor weight gain.

Eggs shed by the host on to pasture via fecal matter will hatch and go through two larval molts, arriving at larval stage 3 (L_3) (Balic *et al*., 2006) within 7 days. After a goat has ingested L_3 larvae, the worm will burrow into the mucosal (internal layer) of the stomach, nourishing on the red blood cells of the goats, which can be life-threatening to the goat. Onset of pathological condition of brings after the fifth stage larvae (L_5) penetrate the mucosa of the abomasum in sufficient number causing profuse bleeding. *Haemonchus* spp usually cut the mucous membrane and underlying tissues, ingest blood and thereby produce constant haemorrhage. They usually change places leaving haemorrhage continue in the pin head spots for several minutes due to the effects of anticoagulants. About 2000 *Haemonchus* spp are sufficient to cause pathological effects. Anaemia is purely haemorrhagic in nature and is characterized by a rapidly progressive oligochythemia which later become microcytic and hypochromic. There is also decrease in the digestibility and absorption of protein, calcium and phosphorus (Rahman *et al.,* 1996).

Haemonchosis thus causes emaciation, anaemia, loss of weight and poor quality of wool and anasarca, anemia, low packed cell volume (PCV), diarrhea, dehydration, peripheral, and internal fluid accumulation are common signs of barber pole worm infestation. Infested goats have lower growth rates, reduced reproductive performance, and are susceptible to diseases that eventually lead to death. *Haemonchus contortus* may consequently account for a great reduction of profits in small ruminant operation. Adult worms feed on blood and can cause severe anaemia, resulting in poor growth rate, weight loss, and decrease in haemoglobin that can lead to death in heavily infected animals (Miller *et al.,* 1998; Githigia *et al.,* 2001; Vatta *et al.,* 2001; Waller *et al*., 2004). These parasites are common blood feeders that cause low productivity, blood loss, and decrease in haemoglobin that can lead to death in heavily infected animals (Githigia *et al.,* 2001; Vatta *et al.,* 2001). It has been estimated that each worm sucks about 0.05ml of bloods by seepage or ingestion from lesions per day (Urquhart *et al*, 2000; Qamar *et al*., 2011). Infestation by *Haemonchus contortus*, which inhabits the fourth stomach in sheep and goat, is very high (85%), mostly in young animals (Rahman, 2006). The larvae and the adults cause small haemorrhages at sites of the abomasal mucosa where they feed. The ingesta may be reddish brown and fluid. Worms may either be attached to the mucosa or free in the lumen (Love and Hutchinson, 2003). Clinical signs are largely due to blood loss. Sudden death may be the only observation in acute infection other common clinical signs include pallor of the mucous membrane due to anemia, oedema, ill thrift, lethargy, diarrhoea and depression. The accumulation of fluid in the submandibular tissue, a phenomenon commonly called "bottle jaw", may be seen (Wikipedia, 2014).

Animals with heavy infections of *Haemonchus* lack stamina, have pale gums and conjunctiva, and may also have bottle-jaw or constipation. Sheep and goats with lighter burdens have a gradual onset of weight loss and loss of colour in the gums and conjunctiva.

1.8. Economic losses due to *Haemonchus* spp

Helminth parasites are a major cause of economic loss in ruminants throughout the world (Gill and Le Jambre, 1996; Stear *et al.,* 1997; Vercruysse and Dorny, 1999). Globally parasitic diseases continue to be a major constraint for poor developing countries. They are rarely associated with high mortality and their effects are usually characterized by lower outputs of animal products, by-products, manure and traction all contributing to assure food security (FAO, 2006). Haemonchosis is a serious health problem caused by *Haemonchus* spp which causes lower production due to high mortality in young animals, high morbidity, and control measures and cost of treatment. This disease is prevalent wherever goats are raised, but it exerts the greatest economic losses in temperate and tropical region (Blood *et al*, 1989; Raza *et al*, 2007;

Ijaz *et al*, 2008; Raza *et al*, 2009). Surveys in countries around the world have shown that amongst domestic animals, Goats suffer more frequently from haemonchosis Maqsood *et al*. (1996); Shahiduzzaman *et al*. (2003); Nwosu *et al*. (2007); Tariq *et al.* (2008) and Asif *et al.* (2008) was found 75%, *Haemonchus* infection of goats in Pakistan. Inspite the large livestock population of Bangladesh the economic benefits remain marginal due to prevailing diseases, poor nutrition, poor animal production systems, reproductive insufficiency, management constraints and general lack of veterinary care. Gastro-intestinal nematodiasis is a major threat and a primary constraint to sheep productivity, it endangers animal welfare worldwide (Tariq *et al*., 2010). The prevalence of GIN in tropical and sub-tropical areas has adversely affected the production potential of sheep and goats, leading to countless deaths and insidious economic losses in livestock sector (Al-Quaisy *et al*., 1987). One of the main culprits in ruminant nematodiasis is *Haemonchus contortus* which causes haemonchosis, anemia and parasitic gastroenteritis in goats, sheep and cattle (Leiper, 1957). They cause significant economic losses worldwide due to their feeding behaviour being haematophagous, *Haemonchus contortus* and *Ostertagia ostertagi* suck 0.05ml of blood/worm/day (Soulsby, 1986; Urquhart *et al.,* 2000). Heavy economic losses due to reduced productivity, mortality and parasite control measures are recorded in nematode parasites (Theodoropoulos, 2002). Economic losses, lowered productivity, reduced animal performance and weight gain, retarded growth, cost of treatment and mortality are caused by parasites affecting the income of Smallholder farming communities. Most of the losses are caused by the gastro-intestinal nematodes (Badran, 2012). Ayaz *et al*. (2013) was reported losses caused by helminthes invariably depend on the prevalence, nature and intensity of infection and management practices.

The incidence of helminthes infection varies with age, sex, season and agro-climatic conditions. The higher incidence of parasitic infections in domestic animals in a grazing system lowers productivity, leading to important economic losses. The parasite infected animals increase their metabolic rate and reduce the amount of metabolic energy used for production, as the parasites use their nutrients, damage some vital organs and cause animals to become more susceptible to other pathogenic agents (Skykes *et al*., 1992).

1.9. Epidemiology of the haemonchosis

Epidemiology is the study of diseases or infections in host populations and the factors that determine their occurrence. In addition, it includes investigation and assessment of other health related events in livestock, such as productivity, and resistances to the drugs used to control these infections (Thrusfield, 1986). Kusiluka and Kambarage (1996) reported the epidemiology of *Haemonchus* spp infections is influenced by climatic factors (particularly rainfall and temperature), management systems used for the animals host factors and parasite factors. The epidemiology of abomasal nematode is governed by parasite-host relationship and reaction with environmental conditions. Epidemiology of haemonchosis depends on weather conditions of the area, epidemiological characteristics of the female *Haemonchus* worms and intensity of worms within the host physiological status of the host (animals). *Haemonchus* spp has the highest biotic potential, a prominent ability to develop resistance to the most widely use anthelmintics and a unique survival strategy, due to its great biological and ecological plasticity (Tod, 1965). Gastrointestinal nematodes of goats are transmitted horizontally and directly. The relationship of parasite with host and environment. Many factors linked to this relationship determine the type and severity of infection. Host-related factors are age, immunity, sex, species and genetic resistance; parasite-related factors include life history, duration of the histotropic phase, survival of larvae in the environment and their location in the host; environmental factors include climate, weather, season, type of vegetation and microclimate. The interactions between host and parasite mainly determine the potential for disease to occur and the pattern/course of infection, whereas the interaction between host-environment and parasite environment influence disease transmission (Levine, 1968).

1.9.1. Host related factors

Nabi *et al*. (2014) studied high infection rate was recorded in young and immature i.e. 48 % while in adults was 26 % ($P<0.05$). It was also suggested that higher shedding of helminth egg around parturition can be a source of environment contamination that ultimately results in transfer of infection to young susceptible animals. Higher prevalence in young animals can be contributed due to contaminated environment, overstocking and lack of immunity (Biu *et al.*, 2009). With increase in age the prevalence of GIT nematodes decreases due to the development of immunity and it is well documented that small ruminants develop partial immunity against GIT nematodes. Age has significant influence on the prevalence of GIT nematodes (Tariq *et al.*, 2008) that agree our findings that young ones are more susceptible to nematode infections. These results are also related to the findings of (Rizvi *et al*., 1999; Magona and Musisi, 2002; Lateef *et al*., 2005), those researchers reported that, prevalence of haemonchosis was higher in young goats due to the fact that with the advancement of age, vigor of the goats become better and they develop resistance against the parasitic diseases. Diseases and parasites have a heavy impact on kids because of the poor immunity status of these young animals leading to an increased susceptibility (Sebei *et al*., 2004). Gradually, as the exposure to parasitic infection increases, the immune system of host animals builds up specially against *Haemonchus* spp and age resistance develops. Most of the researchers have observed higher rate of *Haemonchus* infection in female goats compared with males (Pal and Qayyum, 1992); Maqsood *et al*., 1996; Komoin *et al.*, 1999; Valcarcel and Romero, 1999; Lateef *et al*., 2005; Gauly *et al.*, 2006; Al-Shaibani *et al*., 2008; Khan *et., al*., 2010; Shimelis *et al*., 2011; Tehrani *et al*,. 2012; Demissie *et al.*, 2013; AL-Hasnawy, 2014**)**. Demissie *et al.* (2013) also reported the sex related prevalence in goats was 81.6% in female and 71.9% in male for *Haemonchus* species. Kakar *et al.* (2013) was studied the prevalence of gastrointestinal nematodes was higher in female (56.87%) as compared to male (42.08%). Hassan *et al.* (2011) gave almost similar findings, 57.49 % in female and 42.51% in male goat in the Chittagong, Bangladesh. Maqsood *et al.* (1996) reported that the rate of haemonchosis was higher (74.6%) in females than males (59.1%). Shahiduzzaman *et a*l. (2003) reported that the infection rate of *Haemonchus* was significantly ($P<0.05$) higher in females than the male goats. Raza *et al.* (2007) studied that incidence in female goat was 31.09% and male goat was 29.91%. Saiful *et al.* (2008), Qamar *et al.* (2007) and Zeryehun (2012) was observed higher rates of nematode infection in female hosts compared with the males. Higher prevalence of haemonchosis in females compared with males might be due to lowered resistance of female goats on the part of their reproductive events and unbalanced diet against higher needs and hench the females needs more nutrition for the nourishment of their kids they are voracious eaters by nature, which gives more chance of acquire of infective larvae than the males.

The breed wise investigation of helminths revealed that local (indigenous) breeds, 19.04% of study area were found to be resistant to helminths parasites as witnessed due to low prevalence of infection in sheep (Mir *et al*., 2013) . The reason for high prevalence of helminths in exotic breeds of animals may be that the exotic animals which are grazed here before slaughtering pick up the infection at a higher rate because of less immunity and less exposure to these parasites they are easily infected (Maraqa *et al.,* 2005). Chaudhary *et al*. (2007) stated that genetic variations and natural resistance could be responsible for the differential prevalence of *H. contortus* among different breeds of small ruminants. Muluneh *et al.* (2014) also found that the slightly higher prevalence of nematode infection in poor body condition animals (48.1%) followed by good (43.0%) and medium (37.1%) body conditioned animals in Ethiopia. The highest infection rate recorded in poor body condition may be due to the effect of heavy infection rate of *Haemonchus* parasite and other factors, which lead to significant weight loss. Small ruminant with poor body conditions were the most affected compared to the medium and good body conditions. When animals suffer from shortage or scarcity of nutrition, and infected with gastrointestinal internal parasites their immunity compromised. Hence, possibly this can be accounted for the higher prevalence of the *Haemonchus* spp in poor body condition animals. Well-nourished animals are known to withstand the effects of worm infection much better than those given a lower plane of nutrition. Meanwhile, the resistance of animals to establishment of worm larvae can be enhanced by improved protein nutrition (Sykes and Coop, 2001). Well-fed animals have better resistance to parasites and most pathogens (Kumba *et al.*, 2003). Muluneh *et al.* (2014) also reported that poor body condition might be due to malnutrition or other concurrent disease and parasitic infection which lead to poor immunological response to infective stage of the parasite.

1.9.2. Management factors related to epidemiology

Goat husbandry is considered as an important sector for security of food supply to the rural people. Goat plays an important role .in the lives of rural marginal and landless farmers, where benefits of scientific research are slow to reach. Recurring losses in productivity are due to the widely prevalent parasitic infection, which is a common problem among small ruminants worldwide (Gall, 1981). The traditional system of goat management is mainly characterized by low survivability and high mortality of kids. There are several factors which affect goat health but feeding, health and general management are possibly the most important. In extensive systems for meat production in tropical areas, mortality rate vary between 12% and 60%, such high mortality rates may be reduced by improved management methods e.g, treatment against parasites, feeding of dams, vaccination as well as housing (Mor and Fhr *et al.*, 1948). Payne and Wilson, (1999) mentioned that suitable goat housing may result in improved output and productivity. Poor and unhygiening housing is one of the causes of losses as it is in the dung of animals that parasites survive and affect young animals (Ficarreli, 1995). Management practices are an important option to improve the resilience and resistance of goats in controlling parasites (Nor-Azlina *et al*., 2011). The diverse agro-climatic conditions, animal husbandry practices and pasture management, largely determine the type, incidence and severity of various parasitic diseases (Mohanta *et al.*, 2007; Tariq *et al*., 2010). Management /husbandry practices, climate and host influence are found to be the main factors that affect gastrointestinal nematode infections in sheep and goats (Blackie, 2014). The extensive rearing environment is considered more conducive of parasitic infections than the intensive rearing environment. In both cases, the closer contact between faeces, parasites and hosts may increase the incidence of existing infections, and potentially result in emergence (or re-emergence) of new parasitic diseases (Ng'ang'a *et al*., 2004; Waller, 2004;). Results of this research are consistent with the findings of other researchers (Keyyu *et al*., 2006; Raza *et al.*, 2007) who found a direct influence of grazing characteristics on the prevalence of most of GIP and who reported that under traditional free-range grazing systems (extensive) there is continuous infection and re-infection from heavily contaminated pastures compared to their intensive-grazed counter parts. Evaluation of genera diversity in the two rearing systems revealed that poor diversity is found in the intensive rearing system. High stocking density on pasture increases pasture larval burden. On lowering the stocking density there occurrence was reduced in amount of manure in given area and higher height of residual grazing forage (Morley and Donald, 1980). Assoku (1981) showed that small ruminant kept under rotational or restricted grazing (semi-intensive) system of management had fever worm egg counts ($P<0.01$) than those kept under the free-range grazing or extensive system.

1.9.3. Environmental condition of the area

The prevalence of parasitic infestation depends on ecology, geographical and climatic condition prevailing in Bangladesh (Hossain *et al*., 2004). The geo-climatic conditions of Bangladesh are highly favorable for the growth and multiplication of parasites. The optimal condition for development from egg to L_3 is 28°C with humidity greater than 70% (Rossanigo and Gruner, 1995) and little or no development of eggs to larvae will take place below 9°C (Silverman and Campbell, 1959). On this basis, the environmental conditions in which external larval stages of *H. contortus* can develop and complete their life cycle are limited in cold temperate climates. *H. contortus* is most prevalent in tropical and subtropical, warm, moist regions of the world (Dorny *et al.*, 1996). The prevalence of gastrointestinal helminthes is related to the agro-climatic conditions like quantity and quality of pasture, temperature, humidity and grazing behavior of the host (Pal and Qayyum, 1993). The main factors which affect the development and survive of infective larvae in pasture undoubtedly are temperature and moisture (relative humidity),The optimum temperature is 23-36°C and relative humidity is 70%, for development eggs of *H. contortus* to infective larvae (O`Connor *et al.,* 2006). Prevalence haemonchosis of goats was frequently observed by other researcher in other parts in Bangladesh (Qadir, 1967; Shahiduzzaman *et al*., 2003). The burden of infections is more evident in developing countries as these regions seldom have a clean supply of water and food as well as the luxury to afford shoes and clothing. Again because of the high costs that are associated with the treatment of parasitic infections, the impact is more apparent in developing countries due to the lack of veterinary care and finances (Ahmed, 2010). Temperature, rainfall and humidity all influence the development and growth of eggs and larvae of most nematodes. Generally, parasites prefer and thrive in climates such as those found in the tropics and subtropics (Hale, 2006; Ahmed, 2010).

Regional differences in climate have major effects on the epidemiology environmental conditions, particularly temperature and relative humidity, are of major importance (Beveridge *et al*., 1989 and O'Connor *et al.*, 2006). The diverse agroclimatic conditions, animal husbandry practices and pasture management largely determines the incidence and severity of various parasitic diseases in a region. Epidemiological pattern of the parasitic diseases in the different agroclimatic zones of the country would provide a basis for evolving strategic and tactical control of these diseases (Jithendran, 2000). Understanding the biology and epidemiology of *Haemonchus* parasite is essential to improve the control measures and decrease in production losses (Pal and Qayyum, 1992). As result, a worthy work has been done on the epidemiology and biology of the nematode parasites in different parts of the world (Louie *et al*., 2007).

The eggs can develop to the infective L_3 stage in as little as 5 days but require fairly warm temperatures to do so. Egg development may be delayed up to 2 months if the weather is cool. The L_3 larvae can survive for months on pasture under moist conditions. Severe disease outbreaks usually occur mid-July to August in young stock as well as adults on pasture but the exact time depends on the air temperature (i.e. prefers > 25°C) and moisture. So outbreaks occur earlier if the summer is hot and wet, and later in cool summers. Hot and dry conditions are not favourable to survival of L_3 on pasture. Finally, many of the ingested L_3 larvae become "arrested" in the abomasum, starting in early fall and do not complete development until the following spring around lambing-time (peri-parturient). The survival and the transmission of infective larvae (L_3) from faeces to herbage depend upon many conditions i.e., humidity, temperature, amount and type of herbage around faeces and breaking pellets by mechanical factors (Fernandez *et al*., 2001). In many tropical and temperate regions, the availability and number of free-living stages of gastrointestinal nematode parasites on the pasture follow seasonal fluctuations (Tembely *et al*., 1997; Cheah and Rajamanickam, 1997; Jithendran and Bhat, 1999; Fernandez *et al.*, 2001; Waruiru *et al*., 2001; Ng`ang`a *et al*., 2004). Since weather conditions vary from region to region, studies on the bionomics of the free-living stages of nematode parasites are needed in the planning for locally applicable control strategies (Na`ang`a *et al*., 2004).

In the month of January, the lowest prevalence indicates to the less survival of eggs and pre-infective larvae (L_1, L_2) on pasture due to minimum temperature (11.7°C) less moisture (relative humidity, 79%) and dry condition. In the winter month, due to the adverse environmental conditions arrested or inhibited (L_4) larval development occurs in the *Haemonchus* spp, this condition is known as hypobiosis. In this period, infective larvae was not developed and eggs of *Haemonchus contortus* was not available in the faeces of goats due to low temperature (17.5°C), humidity (79%) and rainfall (5.5 mm). Arrested larval development plays important role in the prevalence of the *Haemonchus contortus* infection. The infection rate started to decline from November to January and then increased gradually from February to May this is similar to the findings of previous report given by (Al-Dulaimi *et al*., 1985). Yadav *et al*. (2006) also reported maximum prevalence of nematodes in rainy season in sheep and goats of Kashmir. Laha *et al.* (2001) from Bengal recorded the highest percentage of infection with *Haemonchus contortus* during the rainy season. Heavy rainfall and high relative humidity predispose to heavy parasitic infections (Hawkins, 1945). The rainy season which started in the spring and earlier in summer made the environmental conditions more favorable for the development and survival of pre-parasitic stages and led to increased availability of infective larvae in the rainy and post rainy season. It is well documented that gastrointestinal parasitism in grazing animals is directly related to the availability of larvae on pasture and seasonal pasture contamination (Smeal *et al*., 1980). Lima (1998) and Githigi (2005) reported the animals are expected to acquire high number infective larvae during rainy season and harbor higher prevalence of gastrointestinal nematodes.

1.9.4. Parasite factor i.e., biology and morphology of the adult female *Haemonchus* spp

Female *H.contortus* worms produce enormous numbers of ova which facilitates the building up of a heavy degree of pasture contamination in a short time. Each female is capable of producing 5000-10000 eggs per 24 hours so that a lightly infected goat harbouring say 300 female worms, may disseminate 1.5-3 million eggs on pasture every 24 hours. For hatching of *H.contortus* eggs it has been suggested that the minimum screen temperature must be greater than 10°C (Swan, 1970) and the maximum must be equal to or greater than 18°C (Dinaburg, 1944). Development requires a maximum of 18°C or more. The adult female worms laying several thousands of eggs per day in the abomasum of the animal host (Coyne *et al.*, 1991). Adults also have high fecundity, with reports of 10,000 eggs per female worm per day or even more. High levels of pasture contamination with infective larvae can result in early summer, and lambs can acquire heavy worm burdens very rapidly on such pastures (Abbott, 2012). The vulvar morphology of female *Haemonchus* spp was useful to understand the ecology and biology of this nematode (Tod, 1965). Kumsa *et al*. (2008) was found knobbed, 18.5%, linguiform (L), 53.8% and smooth, 27.6% vulvar morph types. Further sub-classification of the linguiform female *Haemonchus* spp 27.4 % LA, 17.5% LB, 6.6% LC and 2.3% LI subtypes were identified goats in northern Ethiopia. Akkari *et al*. (2013) was studied, 27.7% linguiform, 65.8% knobbed 6.4% smooth vulvar morph types of *Haemonchus* spp. Further sub-classification of Linguiform vulvar flap female *Haemonchus* worm 48% LA type, 13.8% LB type, 21.6%, LC type, 4.4% LD type and 12.3% LI subtypes were detected in goats of Tunishia. Gharamah *et al.,* (2012) was found the knobbed morph was predominant in goats (50% and 70%) in Perak and Kelantan, Malaysia respectively. Previous investigators reported that the vulvar process of *Haemonchus* spp. *w*orms varies both in shape and size (Roberts *et al*, 1954; Rose, 1966; Le Jambre and Whitlock, 1968). The variation of vulvar morphology indicates manifestation of genetic factors during worm establishment and development in hosts (Gharamah *et al.*, 2011).

1.10. Importance of epidemiology in relation to haemonchosis

Preventive strategies need a sound knowledge of the epidemiology of the target parasite species so that dosing schedules can be strategically timed and integrated with other management practices to prevent disease, limit parasite proliferation and optimize production. This approach has been used successfully in developing epidemiologically based regimes (Dash *et al.,* 1985) to conserve the efficacy of ivermectin in areas of Australia where *H. contortus* is the predominant parasite. Effective and efficient parasite control is only possible after survey has provided enough information for understanding the existing epidemiological factors which influence disease transmission. Knowledge of the weather conditions, worm population trends and number of infective larvae of *Haemonchus* is very important and crucial for developing control programs that are appropriate for parasitologists and small farmers. Rainfall is considered the main climatic factor determining the availability of infective strongylid larvae and the transmission of infection in grazing animals. However, management systems, and host factors such as age, sex, breed and body condition of the host also influence the incidence rate and severity of infection (Blackie, 2014). The small ruminant livestock industry is plagued in part by the parasite *Haemonchus contortus* because of its resistance to anthelmintic drugs (Prichard, 1994; Rahman, 1994; Borgsteede *et al*, 1996; Hale, 2006; Howell *et al.,* 2008; Scheuerle, 2009). The mechanisms involved in drug resistance may result from decreased drug uptake, increased metabolism of the drug or changes at the drug-receptor site (Prichard, 1990; Roush, 1990). To date, there is little evidence to indicate that changes in drug transport or drug metabolism in nematodes play any significant role in resistance to antinematodal drugs (Prichard, 1990). Anthelmintics are drugs used to treat gastrointestinal nematodes, but are often misused through frequency of use and lack of definitive diagnosis. As a result *Haemonchus contortus* becomes resistant to these and therefore infection is becoming difficult to control, and is costly to the industry. The misuse and or widespread intensive use of sometimes poor quality synthetic or semi-synthetic anthelmintics has lead to development of high level multiple anthelmintic resistance against the three main families of anthelmintic drugs, namely, Benzimidazoles, Macrocyclic lactones and Imidazothiazoles (Hertzberg *et al.*, 2000; Lioyd *et al.*, 2000; Chandrawathani *et al.*, 2003; Melo *et al.*, 2003; Waller, 2003) that leads to failure of controlling the worm parasites in farm animals. These constraints indicate that entire reliance on pharmaceutically derived anthelmintic may present difficulties in management of gastro-intestinal parasitic infections in livestock. In addition, the high cost, residual concern in food animals and environmental pollution have awakened interest on searching for an alternative sources for helminthes control (Pessoa *et al*., 2002; Githiori, 2004). Several control measures are available like vaccination, breeding of resistant breed races, improvement of food quality and better grazing management in breeding and dairy farming.

Tembely *et al*., (1997) and Vlassoff *et al.*, (2001) demonstrated that the effect of helminthes infection on production of particular livestock species depend mostly up on the age of the animals, the breed, the parasite species involved and the intensity of the worm populations within the host. The prevalence and distribution of parasitic nematodes are largely governed by a combination of their ecological requirements for development and survival outside the host and farm management practice. The goat population in Bangladesh faces a lot of obstacles in the development due to their parasitic infestation specially haemonchosis causes a serious problems (Nooruddin *et al.*, 1987). The effect of parasitism is determined by the interactions between the type of parasites present in your geographic area, parasite life cycles, the environment including weather patterns and type of farm management, and the host factors (Stehman and Smith, 1995).

Vulvar morphology is the reflection of true bionomic differences and manifests some genetic factors necessary to establish and develop inside hosts (Tod, 1965). While some authors considered vulvar morphology as markers of ecological adaptation to an area (Rose, 1966; Le Jambre and Whitlock; 1968, Jacquiet *et al.*, 1995; Rahman and Hamid, 2007). Understanding the biology and epidemiology of *Haemonchus* parasite is essential to improve the control measures and decrease in production losses.

Due to the economic importance of haemonchosis, the population of goats in the study sites, and since there is no previous work about the epidemiology of haemonchosis in goats and vulvar morphology of female *Haemonchus* spp of goats in Bangladesh. The author thinks to know about the vulvar morphology of female worm is necessary for the epidemiology of this disease as well as identification of *Haemonchus* spp and its treatment and control measures. Different studies should be done at different parts of the country to get national representative figures and most of the previous studies in Bangladesh were based on coprological examination which is less sensitive for identification of nematode species. For the above reasons, the present study was taken to acquire knowledge about the weather conditions, worm population trends, vulvar flap morphology of female *Haemonchus* spp in the goats of the study area are very important and crucial for developing control programs that are appropriate for parasitologists and small farmers and to provide base line data for planning future research and control strategies. Keeping in view the importance of this disease the study was designed to record the prevalence of disease and morphology of female *Haemonchus* spp under different managerial and environmental conditions of Rajshahi, Bangladesh.

1.11. Objectives of Study

This study was designed to determine the prevalence of *Haemonchus* spp infections and effect of various epidemiological risk factors on that prevalence in goats of Rajshahi and Noagon district.

The specific objectives of the study were:

- To study the overall prevalence of haemonchosis of goat in the study area
- To investigate the effect of host related factors like age, sex, breed and body condition of goats on prevalence of haemonchosis.
- To evaluate the effect of management practices of goats such as husbandry system, floor of housing, de-worming status, feeding system as well as herd size of goats on the prevalence of haemonchosis
- To know the effects of temperature, humidity and rainfall on the prevalence of haemonchosis in goat.
- To determine the prevalence of haemonchosis in relation to month and season
- To compare the prevalence of haemonchosis in two districts of the study area.
- To compare the prevalence of haemonchosis among the methods of examination.
- To identify the major vulvar flap morph types found in the vulvar region of female *Haemonchus* spp.
- To compare prevalence of the major vulvar flap morph types present in two district in the greater Rajshahi of Bangladesh.
- To study the linguiform subtypes of vulvar morph of *Haemonchus* spp in the study area.

CHAPTER TWO

REVIEW OF LITERATURE

The purpose of this chapter is to provide a selective review of recent and past works are revealed to the present study. Many research works have been done in different countries of the world which factors affecting the haemonchosis of goats. But in Bangladesh, very limited research works have been done carried out in this regards. Some of the related findings of research carried out in this country or elsewhere are reviewed in this section. To make it easy and clear the review has been divided into several heading and sub-heading:

2.1. Origin and Domestication of Goats

Goat a member of the genus *Capra* and the species *Capra hircus* of the mammalian order Ungulata. There are about 300 breeds and varieties of goats domesticated in this subcontinent. The majority of goat varieties are found in the tropics and sub-tropics (Banglapedia, 2014). Goat is very important species in Bangladesh. Goats are regarded as an intimate and integral part of rural farming system in Bangladesh (Amin *et.al.*, 2000) Bangladesh possesses 7.05% of the total goat of Asia (FAOSTAT, 2009). The world goat population is estimated at 746 million (FAOSTAT, 2003) with 96% of these being kept in developing countries. Goats are highly prolific, have short generation interval and the products are easily marketable. The importance of goat is strongly emphasized for their versatile production profile and valuable contribution like meat, milk, industrial raw product such as skin, fiber and manure. Black Bengal goats are known to be famous for its adaptability, fertility, pro-lificacy, meat and skin quality. Jamunapari goats are multi-purpose animals, producing meat, milk, skin and hair (Amin *et al.,* 2001). In addition, goats provide hair, leather and manure (FAO, 2010). Goat rearing is an integral part of many farming systems in Bangladesh. The goat is probably the only animal which in Bangladesh is managed for multiple end uses: meat, hides, milk and manure. It provides one of the main sources of income for the farmers of Bangladesh. It is a major contributor of protein and fat and often the goat enterprise can help farmers to overcome an unforeseen crisis, which demands immediate finance (Banglapedia, 2014).

The landless and small farm holdings own the highest percentage of goats (Alam and Aktaruzzaman, 2010). Bangladesh has the fourth highest population of goat in Asia. The old saying of "the goat is the poor man's cow" is still hold true for developing country such as Bangladesh. Many of the rural land-less and marginal farmers own 1-5 goats. These are distributed throughout country and are economically viable households in mixed farming systems. They keep other livestock and produce crops (Chowdhury *et al.,* 2002). Goat was neglected in the past. In the recent years, farmers and government are showing interest to utilize this species to increase supply of meat and to alleviate poverty through creation of employment (Afroz *et al.,* 2010). Goats are reared by farmers mostly as a subsidiary occupation or by poor people in Bangladesh (Sarker and Islam, 2011). Goats rank second in position in terms of meat and skin production representing 38% and 28% respectively, of the total meat and skin produced from livestock in Bangladesh (FAO, 1997).Chevron (goat meat) is famous for tenderness, flavour, and leanness. Their skin is of superior quality for leather goods and is of great demand both in domestic and foreign markets. Black Bengal Goats are much more adaptive to our harsh environmental conditions and fluctuating supply of nutrients. Grazing on shallow lands, crop field dividers, roadsides and embankment are the only means of feeding the animals. They are best users of grasses, shrubs and various tree leaves, which have little alternative use. They can be reared easily without or with a little amount of supplement feed. In Bangladesh most goats are kept by women and children; consequently the production cost is minimum. Economically and culturally, goat has been playing important role in the traditional Bangladesh society. Goat's skins were exported to world market on a large scale in the 18th and 19th centuries. Goat skins are used to make mats, footwear, water/grain containers, tents and drums (Peacock *et al.,* 2005).

However the origin of the domestic goat remains uncertain and controversial despite the archaeological evidence. Goats rear as a popular ruminant species for household income due to its prolificacy character and higher market value for meat and skin. Chevon (Goat meat) is most popular meat of ruminant species and is accepted by all communities in Bangladesh. Bangladesh has only one goat breed of its own, known as the Black Bengal goat. Despite the name, the coat colour of Black Bengal goats is not black in all cases. At least seven recognizable coat colour patterns can be found:, solid black, solid white, black with "Toggenburg pattern" of spotting, brown with "Toggenburg pattern" of spotting, black with "Dutch belt" spotting, silver bezoar, and brown bezoar wild-type pattern. Coat colour is controlled by epistatic genes. The frequency of each colour pattern varies depending upon the location. Different populations also differ in size, with adult animals ranging from 42 to 56 cm at the withers. The exotic breeds exhibit their breed-specific characteristics (Faruque, 2003-2014). It is estimated that more than 90% of goat population in Bangladesh comprised the Black Bengal goats, the remainder being Jamnapari and their crosses (Husain, 1993). There are wide variations in color, body size and weights of goats found in different locations. Black Bengal goats have different coat color variation i.e. black, brown, and white and any combination of those colors at any proportion (Nozawa and Katsumata, 1984). According to FAO (2006), the country possesses 35 million goats and produced 182,000 tons of chevon in 2005. Chevon is obtained from goats of different genotypes like Black Bengal, exotic breeds (mainly Sirohi and Beetal) and crossbred goats (cross between Black Bengal and exotic breeds) in Bangladesh (Devendra and Owen, 1983; Das *et al.,* 2001; Moniruzzaman e*t al.,* 2002). Goat has been recently recognized as a tool of poverty alleviation. But their production is not sufficient and that is why a few private farmers are initiated cross breeding between the exotic buck (Beetal, Sirohi and Jamunapari) and doe of Black Bengal (Sarder, 2012). Bucks of exotic breeds are being imported privately from India and used for crossbreeding, especially in the western part of the country. The real number of crossbred goat population is not known; but mostly found in Rajshahi, Pabna, Kustia, Chuadanga, Jinaidah and Jessore district (Faruque and Khandoker, 2007). The crossbred goat is becoming more and more popular to the western part of the country due to their larger body size, more carcass yield and more market prices as compared to Black Bengal goat. The carcass of crossbred goats contained more fat (ether extract) ($P<0.05$) compared to the Black Bengal goat. The higher carcass yield and dressing percentage observed in crossbred goats reflected to yield more meat compared to the Black Bengal goat (Asaduzzaman *et al*., 2009).

Black Bengal, the only recognized breed of Bangladesh, is known for its excellence in reproductive capabilities and production of quality meat. Most of the goats (90%) in the country are Black Bengal (Amin *et al*., 2001). Recently, Jamunpari has been introduced for cross-breeding with indigenous goats (Amin *et al.*, 2000). Black Bengal goat is a very useful small livestock in Bangladesh. It is also a great source of income for the poor people of this country. Goat farming has a very important role in reducing unemployment and poverty, increasing meat or milk production and earning currency from foreign country. The milk and meat of this goat is very tasty and nutritious than any other goat breed. And its meat and milk has a great demand throughout the world. Improvement in goat production and commercialization of goats can create employment for people as individuals are hired to process and sell goats and goat products. In addition to provision of tangible products, goats contribute towards the livelihoods of the poor through risk mitigation and accumulation of wealth (Peacock *et al.,* 2005). Therefore, goats are an ideal vehicle for generating cash returns to meet food security needs and improve welfare among communal families. Goats play a pivotal role in cultural and ceremonial purposes (Kosgey, 2004; Simela and Merkel, 2008). They are also useful in controlling bush encroachment in natural rangelands of Southern Africa (Saico and Abul, 2007). Manure and urine from goats are invaluable sources of organic fertilizer for maintaining or improving agricultural production and they become quite important when resource-poor farmers cannot afford the expensive inorganic fertilizers for use in their fields. It should also be appreciated that manure is becoming important as there is a global move towards organic agricultural products (Hansson and Fredriksson, 2004).

Bangladesh is the home of the Black Bengal goat, the country's most popular goat breed. It is very popular in Bangladesh because of its very low demand of food and very high baby production rate. Raising Black Bengal goat can be considered as an additional source of income for the landless farmer (Roysfarm, 2012).This breed can adapt to any environment easily and its disease preventive ability is very high. This breed plays a very important role in reducing unemployment and poverty from Bangladesh. The goat belongs to a group of animals called ruminants that have four compartments stomach and a unique ability to digest roughages containing relatively large amounts of cellulose. Cellulose is the chief part of the cell walls of plants and a potential source of energy for ruminant animals. Most goats are herded during the day and penned at night. In cases where there is limited grazing land, all the goats from the entire village may be considered as a single interbreeding flock with no attempts of controlling mating. Flocks from different households of the same village, however, may graze separately where there are vast tracts of grazing land. Following crop harvesting, goats feed on crop residues until the beginning of the rainy season, when the goats have to be herded (Manyema *et al*., 2008). Goats in Bangladesh are typically reared as scavengers. They are used like a cash crop and farmers usually sell them at the time of particular financial need or during festivals of Muslim and Hindu people. With the growing human population and demand for cereal food, the fallow lands used for natural grazing of goats are reducing day by day. Therefore, the traditional goat rearing system in Bangladesh is under threat. Farmers are now trying to adapt and rear goats under intensive management systems (Faruque, 2003-2014).

2.2. *Haemonchus*

It is an important parasite of the abomasum of various ruminants. Three species in the genera *Haemonchus* have been identified to have infected camels in different parts of the world. *Haemonchus contortus* occurs in abomasum of camel, sheep, goats and cattle. It is commonly known as the (stomach- worm) or (wire worm) of ruminants. *Haemonchus longistipes* occurs in camel and Arabian camels in North Africa and India. *Haemonchus placei* occurs in the abomasums of cattle and camels (Falah, 2004). *Haemonchus similis* this species has been reported from cattle and deer in America and also occurs in cattle in Europe (Soulsby, 1982).

2.2.1. Caprine haemonchosis

Etiology: *Haemonchus contortus* - Rudolphi, 1803

2.2.2. Classification

Kingdom: *Animalia*

Phylum: *Nematode* or *Nemathelminthes* .

Class: *Secernentea or Nematoda* - Rudolphi, 1803.

Order: *Strongylida*

Family: *Trichostrongylidae*

Genus: *Haemonchus* - Cobb, 1898.

Species: *contortus* -Rudolphi, 1803.

(Solusby, 1982; Durette-Desset *et al*., 1999; Urquhart *et al*., 2001; Kassai *et al*., 2002 and Myers *et al*., 2013).

The genus *Haemonchus* apparently originated in Africa, with an initial diversification in antelopes and subsequent colonization and development in other wild ruminants. There were independent colonizations in domestic ruminants. Later, human migrations enabled the spread of *Haemonchus* to wild and domestic ruminants on other continents (Lichtenfels *et al*., 1994; Aichi *et al*., 2003 and Hober *et al*., 2004). One of these endoparasites that is, of concern to goat raisers due to its pathologic effects is an important genus of Family Strongylidae that localizes in the abomasum of goats. It is a bloodsucker parasitic nematode (Soulsby, 1982). *Haemonchus* is the most important parasite of domestic ruminants, compared to other gastrointestinal nematodes (Krecek, 2006; Kumsa *et al*., 2008; and Hoberg *et al.,* 2010). There are two species of that are of economic importance among goats and sheep in the locality. These are *Haemonchus contortus* and *Haemonchus placei* (Rosillo, 1995). Both species are important economically in terms of stunted growth, infertility, droped in milk production and/or death of goats (Georgi and Theodorides, 1980). *Haemonchus contortus* is a blood sucking parasite that infects the gastrointestinal tract of small ruminants. *Haemonchus contortus* is a predominant, economically important and highly pathogenic gastro-intestinal nematode of sheep and goats (Uhlinger *et al.,* 1992; Maqsood *et al.,* 1996; Singh *et al*., 1997; Mortensen *et al*., 2003). According to Waller and Chandrawathani (2005) gastro-intestinal nematode (GIN) infection ranks highest on a global index, with *H. contortus* being of overwhelming importance.

Abomasum is one of the most important sites for living bursate nematodes. It is the site location for three pathogen species of GI nematodes e.g., *Haemonchus* spp (barber's pole worm), *Ostertagia* spp. *Teladorsagia* spp. and *Trichostrongylus* spp (black scour worm). Worms of lesser or occasional importance include *Nematodirus* spp, *Oesophagostomum* spp and *Chabertia ovina* (Kamalzadeh *et al*., 2008). In several studies big differences have been shown in the prevalence and intensity of small ruminant's GI Nematodes, according to different climatic condition (El-Azazy, 1995; Uriarte *et al.,* 2003; Tariq *et al.,* 2008). Infestation by *Haemonchus contortus,* which inhabits the fourth stomach in sheep and goat, is very high (85%), mostly in young animals (Rahman, 2006).

2.3. Morphology of *Haemonchus* spp

Heamonchus contortus commonly known as the twisted stomach worm is a blood sucking nematode parasite, primarily occurring in abomasum of small ruminants, notably sheep and goats. *H. contortus* is cylindrical and has a striking reddish appearance, due to its blood-feeding habit. *Haemonchus contortus* has a tooth or lancet in its poorly developed oral cavity to perforate the gastric mucosa and suck blood. Adult *Haemonchus* worms are 1 to 3 cm long and have a reddish color. The female is longer (18 to 30 mm) than the male (10 to 20 mm). Their red and white appearance is due to their white ovaries winding around the blood-filled intestines and is at the origin of its common name "barber-pole" worm (Soulsby, 1982). As in other roundworms, the body of *Haemonchus* worms is covered with a cuticle, which is flexible but rather tough. The cuticle of *Haemonchus* worms is rather transparent and shows longitudinal striations. The worms have a tubular digestive system with two openings, the mouth and the anus. The mouth of *Haemonchus* worms has a dorsal lancet for cutting the host's tissues. They also have a nervous system but no excretory organs and no circulatory system, i.e. neither a heart nor blood vessels. The female ovaries are large and the uteri end in an opening called the vulva, which has a characteristic flap in *Haemonchus* worms. Males have a copulatory bursa with two barbed spicules for attaching to the female during copulation. The eggs are ovoid, The eggs are yellow, and approximately 70-85 µm long by 44 µm wide, have a thin shell and contain 16 to 32 cells (blastomeres) (Junquera, 2007-2014). They have two cervical lateral papillae in the anterior end, and male helminths show a well-developed copulatory bursa characterized by the asymmetrical dorsal lobe; there are spines near the distal end of both spicules (Lichtenfels *et al*., 1994; Jacquiet *et al.,* 1997 and Hober *et al.,* 2004). Females generally have vulvar pouches. Male helminths measure on average 1310 µm and females 1850 µm (Lichtenfels *et al*., 1994). Females are extremely prolific 5000 eggs/day/female (Jambre *et al.,* 1995) and the eggs (70-45 µm), of strongyle type, are excreted into the environment in the morula phase (8-16 cells) in the feces of the infected host.

2.4. Biology of *Haemonchus contortus*

Haemonchus spp have a direct life cycle, i.e. there are no intermediate hosts involved. Adult females lay eggs in the stomach of the host that are shed with the faeces. The life cycle of *H. contortus* starts by the adult female worms laying several thousands of eggs per day in the abomasum of the animal host (Coyne *et al.*, 1991). The developmental cycle consists of eggs, larvae (L_1, L_2, L_3 and L_4) and adult (Olsen, 1974). Infection with *H. contortus* has three distinguishable stages: pre-patent period, patent period and hypobiosis (Bowman, 2003). Eggs shed by the host onto pasture via fecal matter will hatch and go through two larval molts, arriving at larval stage three (L_3) (Balic *et al*., 2006) within 7 days. The L_3 larvae are the infective stage and are consumed by the grazing host. These larvae enter the pit of gastric glands and feed voraciously on blood flowing out of the lesions they cause to the stomach's lining with their mouthparts. Larvae have specific environmental requirements critical to survival. A warm and humid environment with temperatures not exceeding 50°C (Zajac, 2006) will aid larval survival. L_3 larvae are sensitive to desiccation and, in order to ensure survival during varying relative humidity, are protected by a sheath that aids in maintaining osmotic pressure.

The pre-patent period occurs within the animal, lasts from 2 to 3 weeks and is the period when larvae are developing prior to becoming adults. Once consumed, L_3 larvae move with the digesta through the first three compartments of the ruminant stomach, reaching their final tissue destination in the abomasum and beginning to feed on blood within 7 days or less (Colditz and Le Jambre, 2008). The L_3 larvae molt to the L_4 stage in the abomasum, and shortly after become adults capable of reproduction. The appearance of the adult worms marks the end of the pre-patent period and the start of the patent period. The patent period is denoted as when adults begin to reproduce (Whittier *et al.,* 2003).The prepatent period (time between infection and first eggs shed) is 19 to 21 days (without dormancy) but can be shorter in animals with a weak immune system. This is a rather short time that allows several generations during one season.

On contact with the soil, and in favorable conditions, eggs hatch and L_3 larvae then attach to the blades of grass in the pasture. Ingestion of these larvae by the animal begins the infection process and the cycle again (Silverman and Campbell, 1959 and Kelly *et al.,* 1978). It has been ranked as the most important parasite of small ruminants in all regions across the tropics and sub tropics and and causes an insidious drain on production, weight losses and even mortality in young animals as reported, by Paddock (2010), Miller (2004) and Bhat *et al*., (2011). The disease caused by this parasite (*Haemonchus contortus*) is prevalent wherever sheep and goats are raised, but it exerts the greatest economic losses in temperate and tropical regions (Chaudary *et al*., 2010). The disease has also found in the colder climates and recently been found as far north as the Arctic Circle (Durrani *et al*., 2007) Helminthic infection particularly of *Haemonchus contortus* is one of the major causes of wasting and decreased productivity through loss of blood and plasma proteins in gastrointestinal tract (Kumar *et al*., 2005).

During the patent period, effects of parasitism are visible in the host. In the case of *H. contortus* infection, signs include anemia, weight loss, hypoproteinemia, and death (Zajac, 2006). The adult parasites feed on blood by using a lancet, found at the end of the mouth. This lancet is used to pierce the abomasal mucosa and cause bleeding from the host. All of the blood lost from the host is not consumed by the parasite; residual blood mixes with the contents of the abomasum, resulting in a bloody stool. During this period, male and female *H. contortus* mate. The female is capable of producing up to 10,000 eggs per day (Bowman, 2003). Eggs from the adult worms must pass though the digestive tract, develop on pastures and be ingested by another or the same host animal, before they can become pathogenic. *Haemonchus contortus* is one of the most problematic worms worldwide from both pathologic and economic standpoints (Miller *et al*., 1998). Although illness caused by internal parasitism usually results from infestations of multiple parasites, the most pathogenic in small ruminants is *Haemonchus contortus*, or the barber pole worm. *H. contortus* is extensively dispersed, and it tends to thrive especially well in the warm, moist conditions of tropical and subtropical environments like Florida. *H. contortus* is haematophagous, which means that it feeds on the blood of its host. It lives in the abomasum, where it attaches with its mouth to feed, mature, and reproduce. *H. contortus* is a very fertile species. The female lays about 5000 eggs per day, which are expelled through the feces. After the eggs hatch, the larvae inhabit the water that develops on blades of grass from dew or rain. Then the host, such as a goat, ingests the larvae while grazing on the contaminated pastures continuing the cycle. It takes about 3 weeks to complete the life cycle of the worm, but if the worm enters the survival stage of arrested development, it could survive for months. Arrested development involves the larvae remaining in the abomasums of the animal without maturing until months afterwards. This allows the worm to survive the winter months when the egg and larvae do not thrive well on the ground. The survivability of the free-living stage of *H. contortus* is short; in fact, most infective larvae vanish from the pasture within 4-6 weeks in a wet tropical environment (Waller, 2004). Barber pole larvae can also undergo a process called arrested development where they sit quietly in the abomasum (the true stomach of ruminants) following infection and don't become adults until several months later. This is an important adaptation for keeping the worm around through cold winters when eggs and larvae don't survive well on pasture (Nix, 2006).

2.5. Hypobiosis phenomenon

An important phenomenon observed in the life cycle that has epidemiological implications is “arrested larval development” or “hypobiosis”. Hypobiosis is the “temporary cessation of development of a nematode at a particular point in its parasitic development” It is usually due to an unfavourable environmental stimulus, such as cold weather or dry conditions, received by the free-living L_3 prior to ingestion and usually coincides with onset of winter or very dry conditions. Others factors and host factors are involved such as blood group, breed of sheep may play role (Soulsby, 1982).

Arrested development can occur in the gut of small ruminant or on pasture and ensures survival of the nematode under adverse climatic conditions, subsequent maturation of the larvae due to resumption of development known as the ‘spring rise’, when favorable conditions return in the spring, leads to a rapid rise in infection levels or fecal egg counts in the small ruminants (Vanimisetti, 2003).

Haemonchus, Trichostrongylus and *Teladorsagia* have developed an incredible adaptive mechanism, referred to as hypobiosis, to survive during harsh environmental conditions (Bowman, 2003). Hypobiosis is a developmental stage when the parasite becomes dormant, does not cause disease, and is not metabolically active. At the L_4 stage, larvae may be cued to initiate hypobiosis and remain in the abomasum. The larvae will reside at this location until environmental conditions are appropriate for emergence and reproduction. The cues that initiate and terminate hypobiosis are largely unknown, due to the inability to simulate hypobiosis *in vitro*. Relaxation of immunity in late gestation or suppression of immunity by reproductive endocrine activity is theorized to play a role in emergence from hypobiosis (Courtney *et al.,* 1985). Hypobiosis is a driving element in the condition known as spring rise. Sheep reproduction is seasonal, ewes typically breed in fall and lamb in spring. During winter months, most L_3 larvae on pasture will die and adult worms inside of the host will senesce, leaving the only surviving parasites as hypobiotic L_4 larvae. Typically peri-parturient ewes will begin to produce eggs in feces, even if they were not shedding prior to this time. About 30 d after introduction to pasture, the ewes, and more importantly lambs will begin to have high fecal egg output as a result of hypobiotic larvae emerging from the ewes and acting as a source of infection for the lambs (Sargison *et al.,* 2007). Hypobiotic larvae may be treated using macrolide anthelmintics, but this is the only class anthelmintics i,e. effective against this type of larvae (Bowman, 2003). The emergence of anthelmintic resistance in worm populations reduces the level of control of hypobiotic larvae that was once available.

Another important adaptation of the barber pole worm is a phenomenon called periparturient rise. Very simply, the female worms, triggered by hormonal changes in does about to give birth, produce massive numbers of eggs that will be shed about the same time as the doe kids. This adaptation ensures that the next generation will become infected and thus continue the parasite cycle (Nix, 2006). The disease is primarily a disease of tropical and sub tropical regions. However, high humidity at least in microclimate of the faeces and the herbage is also essential for larval development and their survival. The frequency and severity of the disease largely depends on the rainfall in any particular area. Young *Haemonchus* are deeply embedded into the mucosa of the abomasa causing mechanical damage of the epithelial cells and may cause loss of appetite, diarrhoea (dehydration), anemia (loss of protein), reduced growth and even mortality especially in young susceptible animals (Khan *et al.*, 2008). However, the larvae can survive on pasture for some time, particularly during cool conditions, and can affect sheep outside the favorable periods for development. (Besier, 2011). However they are not very resistant to cold. Infective larvae are able to climb upwards in moist leaves and stems of pasture plants, where they are more likely to be ingested by grazing hosts. Barbers pole worm larvae need warm conditions and moisture on the ground to develop. The risk of haemonchosis outbreaks is increased in tropical weathers. Barbers pole worm can survive where pasture remains green over summer. Typical situations include perennial pastures and areas of moisture along creeks and around troughs and seepage points. Irrigated pastures pose an especially high risk. Sheep and goats with a low or impaired immunity to worms have a greater risk of haemonchosis. This includes lambs and kids for two to three months after lambing (Besier, 2011). The intensity and prevalence rate of haemonchosis started to rise steadily from May to October due to continuous pasture contamination during rainy season. Our finding showed that the infection was higher during the rainy season. Several epidemiological studies on the GIN infection were carried out to depict the seasonal pattern of haemonchosis in different agroecological areas of the world (Hoste *et al*., 2001; Agyei, 2003; Ng'ang'a *et al*., 2004). The seasonal trend in the haemonchosis is influenced by a number of abiotic and biotic factors that dictate the development and survival of pre-parasitic stages of *H. contortus* onto the herbage (Gupta *et al.*, 1988).

2.6. Pathogenesis of *Haemonchus* spp

Haemonchus are the most damaging gastrointestinal worms for livestock in tropical and subtropical regions, particularly for sheep and goats. Both the larvae and the adults feed on blood and cause a considerable damage to the stomach tissues. While feeding they release anticoagulants to hinder blood clotting. All this causes numerous lesions in the stomach wall, which becomes inrritated (gastritis). Blood loss results in anemia. Other effects of chronic infections are edema, i.e. accumulation of liquid in the abdomen, thorax, and also in the sub-mandibular tissue, which is known as "bottle jaw" and is characteristic of infections with *Haemonchus* and other gastrointestinal worms. Severe infections can also cause liver damage, weight loss, unthriftiness, diarrhea (mostly dark) and dehydration. Fatalities are not infrequent. Massive infection of young lambs can be fatal in a few days, without previous symptoms and without previous shedding of eggs in the feces. The reason is that the immature stages are already voracious blood feeders. Most *Haemonchus* infections are mixed with other gastrointestinal roundworms (e.g. *Cooperia* spp, *Nematodirus* spp, *Ostertagia* spp, *Trichostrongylus* spp, etc.) which worsen the damage caused to affected livestock (Junquera, 2007-2014).

Several factors are involved in the pathogenesis of the Haemonchosis. In terms of the development of disease, the most important factors are parasites virulence and host response. The main pathogenic mechanism of *Haemonchus contortus* are a direct lesion on the gastric mucosa and hematophagy. The effects of pathogenic mechanisms during intra-host parasite development and the subsequent response of infected ruminants provoke morpho-functional changes, particulary in the abomasums; also variation appears in some blood parameters, resulting in the appearance of both anemic and impaired digestion-absorption syndrome. *Haemonchus contortus* adult parasites can ingest 0.05 ml of blood per helminth per day, causing notable blood loss with a reduction of packet cell volume (PCV). This parameter has, in fact been used a marker of parasite virulence and indirect estimation of parasite burden in Haemonchosis (Francisco, 2007). A reduction of plasma protein concentration has been found inHaemonchosis due to blood loss and haemorrhagic gastritis, in addition leakage of proteins to gastric lumen occur as a result of disruption of intercellular unions and increased permeability, epithelial cell loss, tissue reparation, increase in mucus production and increased requirements for protein synthesis by the immune system (Francisco, 2007). Moreover, many factors prevent such protein losses from being replaced through feeding. Infected animals have lower food intake due to anemia. Gastric reduces food passage through gastrointestinal tract, bad digestion syndrome caused by the increase of abomasal P^H value, which prevent pepsin synthesis, reduces aminoacids and small peptides absorption (Francisco, 2007).

2.6.1. Pathological effects

Macroscopic and microscopic findings

Macroscopic finding showed petechial hemorrhage detected in the abomasal mucosa, with extensive mucosal hemorrhage, inflammation and mucous secretions around lesions, paleness of internal organs were also seen. The larvae and the adults cause small haemorrhages at sites of the abomasal mucosa where they feed. The ingesta may be reddish brown and fluid. Worms may either be attached to the mucosa or free in the lumen (Love and Hutchinson, 2003). The abomasal contents were fluid and partially covered with free blood; the carcasses were paled and have generalized edema and fluid throughout of the body cavities secondary due to hypoproteinemia (Tehrani *et al*., 2012). Microscopic finding showed: mononuclear cells infiltration (lymphocytes, monocytes and plasma cells), prominent eosinophilic infiltration in mucous glands (Fayza *et al*., 2003; Tehrani *et al*., 2012).

In goats; the mixed infection with *Haemonchus contortus* and *Eimeria species* showed; the abomasae of infected animals were congested and the intestine were thick. The spleen, liver, intestines and kidneys were ischemic. Moreover, petechial hemorrhage and purulent exudates was seen in the bronchioles and lobules of the lungs, gelatinous exudates was seen in the interlobular septate (Siham *et al*., 1997)

2.7. Immunology

2.7.1. Immune response to *Haemonchus* spp

Both humoral and cellular arms of the mammalian adaptive immune system are actively involved in response to Haemonchosis, generally, T-lymphocytes, soluble cytokines, B-lymphocytes, plasma cells, various immunoglobulin isotypes, mast cells, eosinophils and globule leukocytes are known to actively take part in immunological reactions, although variability in their production and magnitude of action in different species of parasite and host has been observed. The ultimate result of parasitic invasion of a host animal is either establishment of infection or expulsion of the invading parasite. The latter being the consequence of protective immune response of the host (Krishna, 2007).

2.7.2. Self-cure phenomenon

The most frequent described protective immune response against the abomasal nematode *Haemonchus contortus* in goat is the self-cure reaction. The self-cure reaction was considered as first evidence of immune expulsion of gastrointestinal nematodes. Goat infected with *Haemonchus contortus* when allowed to graze in contatminated pasture showed suppression of egg production within a few days. However, this suppression of eggs often accompanied by elimination of adult worms and by a strong epidemiological re-infections. Self cure reaction was the most protective immune response against abomasal nematodes. (Fayza *et al*., 2003). This reaction is dependent on antigens associated with the living larvae and which act locally. Both host and parasite genetic factors may influence the occurance of the self cure reaction. Self-cure is accompanied by a transient rise in blood histamine, an increase in the complement- fixing antibody titer and intense mucosal oedema in the abomasums (Soulsby, 1982). After being ingested, L_3 start the process of growth and development which includes exsheathing, molting from one stage to another, and shedding excretory and secretory products, during this process antigens are shed in the gastrointestinal tract and are presented by epithelial cells to underlying gut associated lymphoid tissue. Presentation of parasitic antigens are transported by M cells to the antigen specific T and or B cells in the Peyer's patches which is followed by a cascade of cellular and subcellular activities such as activation of antigen specific T and or B cells, production of a variety of cytokines that bring about activation of various cells like eosinophils, mast cells, macrophages and globule leukocytes. In addition, production of different immunoglobulin isotypes brings about immune responses leading to expulsion of worms and protection against re-infection (Krishna, 2007).

2.8. General diagnostic methods of haemonchosis

Clinical diagnosis of gastro-intestinal strongylosis is difficult, since the signs are not pathognomonic. However, diagnosis of gastrointestinal nematode infections plays a major role in investigating parasite epidemiology (Roeber *et al.,* 2013). The ante mortem diagnosis of livestock has been based on the detection of nematode eggs or larvae in the faeces by microscopic examination using the methods of flotation and/or larval culture. Although a direct faecal smear can be examined, the mere presence of parasite eggs is not helpful in determining the parasite load of an animal or animals. Quantifying of the egg per gram of faeces is the best way of estimating parasite loads (Pugh, 2002). Faecal worm egg counts and differential larval counts are a guide to the parasite burden. The number of helminth ova passed per gram of faeces depends on such factors as number of adult parasites established in the gastro-intestinal tract, faecal consistency and bulk, age of the host, species of parasites, host resistance, stage of infection, stage of pregnancy, effects of lactation and whether the worm burden consists of sexually mature parasites. Diarrhoea depresses the faecal egg count. Low and medium egg counts will be more significant where the stocking rate is high, when weather conditions are conducive to epidemics (warmth, rain, humidity) and where the biotic potential is high, e.g. *Haemonchus contortus*.

Diagnosis is based on the clinical signs and confirmed after detection of characteristic eggs in the feces. However, as already mentioned, lambs can become seriously sick before larvae have completed development to adults, i.e. before the onset of egg production (Junquera, 2007-2014). Eggs are found in faeces when the damage has already been done. So, ELISA enables detection of sub clinical infection (Almazan, *et al.*, 2001). Serodiagnostic studies in sheep and goats got benefit from ELISA, as early detection of infection is possible which is less time-consuming and more reliable in contrast to fecal examinations. Diagnosis is by confirmed after detection of characteristic eggs in the faeces. A faecal egg count to assess for presence of *Haemonchus* eggs should be performed. If infection is present, this sample will probably be very high. Post-mortem examination may reveal an extremely high proportion of adult worms (>2000 adult worms in some cases). There will also be numerous haemorrhagic lesions on gastric mucosa and there may be brown fluid in the abomasum.

Blood test may reveal anaemia (low blood haemoglobin, Packed Cell Volume and red blood cell count), elevated blood pepsinogen and hypoalbuminaemia, which would lead to a presumptive diagnosis of haemonchosis in goats. Blood is an important and reliable medium for assessing the health status of individual animals (Oduye, 1976). Serum biochemistry and hematological analysis have been found to be important and reliable means for assessing an animal's health status and might give an indication of the degree of damage to host tissue as well as severity of infection (Otesile *et al.*, 1991).

2.9. Advanced Diagnosis

1. Serological diagnosis

Diagnosis of haemonchosis was based on clinical symptoms as well as laboratory tests. The most reliable method was the identification of eggs in the faeces of infected animals. This method cannot be used until the parasite attains sexual maturity. Therefore, it is necessary that these parasites should be controlled before they can cause damage to the stomach. Hence serological diagnosis should be preferred because *anti-Haemonchus* antibodies could be detected easily one week post infection and thus can help us in the early treatment of infected animals (Qamar *et al.,* 2009). ELISA is a reliable serological assay, which enables the detection of early and subclinical infection if and when needed (Almazan *et al.,* 2001). Furthermore, sero-epidemiological studies in large groups of animals must be examined in contrast to fecal examinations as ELISA test is usually more reliable and less time-consuming. Xiaojun *et al.* (2007) evaluated the diagnostic potential of ELISA, all the *Haemonchus contortus* infected serum samples showed positive values. The diagnostic efficiency of the ELISA was 100%. Detection of infection during prepotency, is of greater importance from the clinical point of view, therefore a simplified, field oriented Dot-ELISA has been developed for the detection of *Haemonchus contortus* soluble antigen in goat /sheep sera. Dot-ELISA performed with immune affinity purified somatic antigen could detect infection as early as one week post infection during pre-patency (Durrani *et al*., 2007; Lone *et al*., 2012).

ELISA analysis clearly discriminated the positive sera from negative ones, so they established ELISA to detect the serum samples, using the purified recombinant as antigen. Rathore *et al.* (2006) reported that 66 kDa adult anti-protein antibody caused loss of *Haemonchus contortus* motility in vitro resulting in the death of the parasite. The fact that *in vitro* killing of adult parasites by antibodies and the protein is recognized by the host makes this protein a promising candidate for vaccination trials. Antibody level in *Haemonchus contortus* infected animals was measured by ELISA. There was a positive correlation between antibody levels and worm burdens. Animals with higher antibody titres had higher worm burdens (Qamar *et al.,* 2009).

2. Molecular diagnosis

The utilization of molecular tools such as PCR and DNA sequencing has enabled the accurate identification of parasite species (Gasser *et al.,* 1993). These advanced techniques are highly sensitive, providing highly accurate identification of strongylids up to species level. Starting from 1990, the Internal Transcribed Spacer (ITS) of nuclear ribosomal DNA (i.e., Second Internal Transcribed Spacer or ITS_2) has been developed as a reliable genetic marker in strongylid species identification (Gasser *et* *al.,* 1993; Gasser *et al*., 1999; Dalas *et al*., 2000; Bott *et al.,* 2009; Gharamah *et al.,* 2012) due to its high interspecific sequence divergence and intraspecific sequence homogeneity (Hoste *et al.,* 1995; Heise *et al.,* 1999). Among these studies, Bott *et al*. (2009) developed a real time-PCR coupled with melting curve analysis based on the ITS2 of ribosomal DNA for the improvement in veterinary parasitology diagnosis on seven common strongylid parasites, namely *H. contortus*, *Trichostrongylus* spp, *Teladorsagia circumcincta*, *Cooperia oncophora*, *Chabertia ovina*, *Oesophagostomum columbianum* and *Oesophagostomum venolosum* in small ruminants.

3. Immunlogical diagnosis

Dipstick assay for *Haemonchus contortus* infection

Commercial test-strips for detection of blood were found to provide a sensitive method for detecting the presence of *Haemonchus contortus* infections, in the faeces even before worms have matured into adults and commenced laying eggs. A provisional patent has been lodged and an extensive field trial. The test is performed on-farm using small faecal samples from a representative number of sheep. One limitation of the test is that it will not alert graziers to the presence of worms other than *Haemonchus contortus*. Consequently, it will still be necessary to conduct conventional worm egg counts and larval differentiation tests until on-farm tests are developed for other worm species (Colditz *et al*., 2006).

2.10. Prevention and control measures against haemonchosis

The aim of control is to ensure that parasite populations do not exceed levels compatible with economic production. This objective could be achieved by three main approaches: grazing management, use of anthelmintics and utilization of natural or artificially induced immunity, but systematic drenching remains the basic feature. It is generally accepted that immune response plays a vital role in the demonstration of inheriting resistance Costa *et al*. (2000); Vanimisetti *et al*. (2004); Good *et al*. (2006). The resistant hosts have the capability to mount a more effective response to parasite than a susceptible host does Barger (1989). However, genetic and immunological display of these with relation to *Haemonchus* needs to be explored further, ultimately the benefit of exploiting the genetic variations in resistance to *Haemonchus* is an excellent approach towards accomplishing sustainable *Haemonchus* in future control management.

2.10.1. Non-chemical prevention

Preventative measures that reduce the contamination of pastures with infective larvae (e.g. pasture rotation) and reduce the risk the animals become infected are essential to control *Haemonchus* infections. This is particularly urgent for this parasite because resistance to almost all available anthelmintics is now widespread in many regions. Such measures must be applied for both young and adult livestock, because *Haemonchus* infections can be fatal for animals of any age. Systematic and thorough removal of all manure, keeping the facilities dry and additional hygienic measures of animal facilities will reduces the risk of infection of housed livestock.

Livestock exposed to these worms often develop natural resistance progressively and may recover spontaneously, but only well fed healthy animals, not already weakened animals. Such resistant animals do not become sick if re-infected, but continue shedding eggs that contaminate their environment. Some indigenous livestock breeds may show a high natural resistance to these worms. Unfortunately such breeds are often not the most productive ones and thus not appreciated by most farmers for economic reasons. Recent studies suggest that Chinese bushclover (*Sericea lespedeza* = *Lespedeza cuneata*) in the form of hay, ground plants or pellets fed to livestock can significantly reduce *Haemonchus* infestations in sheep and goats (Junquera, 2007-2014).

2.10.2. Chemical control

Numerous broad spectrum anthelmintics are effective against adult worms and larvae, e.g. several benzimidazoles (albendazole, febantel, fenbendazole, oxfendazole, etc.), levamisole, as well as several macrocyclic lactones (e.g. abamectin, doramectin, eprinomectin, ivermectin, moxidectin). But not all of them are effective against arrested larvae of *Haemonchus*. Read the product label carefully to find it out.

A few other narrow-spectrum anthelmintics such as closantel, nitroxynil and tetrahydropyrimidines (e.g. morantel, pyrantel) are effective against adult worms but may not control larvae and other roundworm species that often infect livestock simultaneously with *Haemonchus* worms. A few organophosphates (e.g. trichlorfon) is also available in some countries for the control of these worms, but must be used with utmost care because it has a very low safety margin.

Numerous commercial products contain mixtures of two or even more active ingredients of different chemical classes. This is done to increase the chance that at least one active ingredient is effective against gastrointestinal worms that have become resistant, or to delay resistance development by those worms that are still susceptible.

Depending on the country most of these anthelmintics are available for oral administration as drenches, feed additives and/or tablets. Levamisole and most macrocyclic lactones are usually also available as injectables. A few active ingredients are also available for livestock as pour-ons and slow-release boluses. Excepting slow-release boluses, most wormers containing benzimidazoles (e.g. albendazole, febantel, fenbendazole, oxfendazole, etc.), levamisole, tetrahydro-pyrimidines (e.g. morantel, pyrantel) and other classic anthelmintics kill the worms shortly after treatment and are quickly metabolized and/or excreted within a few hours or days. This means that they have a short residual effect**,** or no residual effect at all. As a consequence treated animals are cured from worms but do not remain protected against new infections. To ensure that they remain worm-free the animals have to be dewormed periodically, depending on the local epidemiological, ecological and climatic conditions. An exception to this are macrocyclic lactones (e.g. abamectin, doramectin, eprinomectin, ivermectin, moxidectin), that offer several weeks protection against re-infestation, depending on the delivery form and the specific parasite (Junquera, 2007-2014) .

The principle of a parasite control strategy is to keep the challenge to young livestock by the pathogenic trichostrongyle parasites at a minimum rate. This is achieved in the following ways.

(a) Controlling the density of livestock (stocking rate). Overstocking forces the animals to graze closer to faecal material and closer to the ground, and may result in the consumption of a higher number of infective larvae.

(b) Periodic de-worming.

(c) Strategic de-worming when conditions are most favourable for larval development on the pasture.

(d) Separating age groups in the more intensive production systems.

(e) Reducing the effects of gastro-intestinal parasites by assuring an adequate plane of nutrition. Control programmers should reduce the effect of parasites to sub-economic levels.

(f) Using grazing management to minimize the uptake of infective larvae and to create safe pastures.

The development of such programmes requires a thorough knowledge of the types of parasites present (including their biology and epidemiology), herd structure and grazing management, parasite seasonal availability and survival and the weather conditions in particular areas. Strategic control programmes are based on the seasonality of development and survival of (L_3) on the pasture. Anthelmintic treatment is the most common way of controlling nematode infections in small ruminant particularly in institutional and commercial farms in Bangladesh. Almeida, *et al*., (2010) was reported anthelmintics have been used routinely in the prophylaxis of parasitic gastro-enteritis, however, the frequent use of such drugs has resulted in the selection of parsites with multiple anthelmintic resistance, which jeopardizes the treatment and control of gastro-intestinal nematode infections.There are only three anthelmintic drug classes available to treat GINs, the imidazothiazoles, benzimidazoles and macrolides (Bowman, 2003). However, several countries have reported anthelmintic resistance (AR), representing a limitation for sustainable small ruminant production. The knowledge regarding worm control management represents a baseline to develop a guideline for preventing AR. (Domke *et al.,* 2011). It studied that under-dosing in over 90% of the sheep and goat flocks taken together with a high treatment frequency in lambs, a lack of anthelmintic class rotation and the common use of a dose-and-move strategy, a real danger for development of anthelmintic resistance (AR) seems to exist in Norwegian sheep and goat flocks. The profitability and sustainability of the goat industry are also seriously threatened by rapid development of anthelmintic resistance (Waller, 1997). The use of drug treatment to control parasitic helminths requires rapid and accurate diagnostic methods for successful treatment of the parasitic infestations. There is therefore urgency in development of rapid and accurate diagnostic tools for successful implementation of effective strategic management plans and monitoring anthelminthic drug efficacy (Gasser *et al*., 2008; Sweeny *et al*., 2011).

A moderate to high level of infection indicates the need to treat the animal. A McMaster slide can also be used to determine EPG while regular slides are used to determine the general level of infection like low, medium, and high. It should be noted that the results from a fecal analysis are no more than estimations of the level of infestation of the animal or the herd (Eysker and Ploeger, 2000; Schoenian, 2003). Anthelmintics (anti-helminthes) are chemical dewormers used to treat infections of parasitic worms (helminths). There are a few types of anthelmintics that are commonly used for goats although there are only three (Ivomec©, Valbazen©, and Tramisol©) that are approved for use in goats. For anthelmintics that require "extra-label' use, a veterinarian should be consulted. The different classes or families of anthelmintics use different modes to kill the parasites. Albendazole was highly efficacious in the removal of mono-specific and mixed infection of *H. contortus* and other gastrointestinal nematodes in sheep and goats (Theodorides *et al*., 1976). Furthermore, Craig and Shepherd (1980) reported that, albendazole produced an effect more than 98% against *H. contortus* infestation. Additionally, Theera *et al.* (2005) reported that, albendazole was proven to have a satisfactory efficacy in the treatment and control of *H. contortus* infestation in ruminant, particularly in a herd with no history of albendazole uses.

In order to maintain drug efficacy and reduce the impact of parasitism on production, producers have implemented management strategies that incorporate selective deworming, pasture management, and selection of resistant individuals (Eady *et al*. 2003). Tactical and strategic prophylactic treatments of flocks with anthelmintic preparations are measures recommended by parasitologists for the control of gastrointestinal parasites (Radostits *et al.* 1994; Vassilev, 1995; Garcia-Perez *et al*. 2002). Frequent tactical and strategic treatment is blamed for the emergence, in recent years, of rapid development of anthelmintic resistance to nearly all available drugs, posing serious threats to the small ruminant industry (Boersema and Pandey 1997; Van Wyk *et al.,* 1998; Van Wyk *et al.,* 1999; Van Wyk, 2001). Pasture management is another important tool to decrease parasite exposure. Rotating goats to a clean pasture is a good technique to use. In tropical and sub-tropical regions, pastures that have not been used for four weeks are considered to be clean. Additionally, pastures that have been grazed by another species of animals such as cattle or horses are considered clean because another breed of animal is able to clean the contaminated pasture by "picking up" the parasites without being affected by them. Parasites are usually not able to affect multiple breeds. However, the use of sheep in a co-grazing system is not suggested since some parasites can affect both sheep and goats. Pastures that have been tilled or used to produce hay or row crops that were removed are also considered clean (Schoenian, 2003). The proper management of internal parasites is extremely important to the success of the goat producer. The ability to detect the clinical signs of a major infection, to properly treat the herd, and to effectively reduce the herds exposure to parasites are all very important aspects of internal parasite management. Resistance to many of these anthelmintics is a serious problem in many regions, particularly in sheep and goats, and the problem is increasing and spreading worldwide. *Haemonchus* resistance to anthelmintics is number one resistance problem with gastrointestinal worms worldwide. Resistance has been reported against almost all anthelmintics available for its control including benzimidazoles, macrocyclic lactones, levamisole, salicylanilides, tetrahydropyrimidines and organophosphates. Multiple resistant, i.e. simultaneous resistance to several chemical classes has also been reported in some countries (e.g. Australia, Brazil, etc.), the problem is particularly acute in sheep and goats**,** but problems in cattle are increasing and spreading. This means that if an anthelmintic fails to achieve the expected efficacy against *Haemonchus* worms, there is a high risk that it is due to anthelmintic resistance (Junquera, 2007-2014). As the goat producer faces issues like the rise of anthelmintic resistance among parasites, the knowledge of how to properly manage internal parasites becomes necessary for the survival and the economic viability of his or her herd. *Haemonchus contortus* have become more difficult to manage because of developed resistance to nearly all available dewormers. A severe infection of barber pole worm causes anemia, reduced animal production, bottle jaw, and if not treated, death of infected sheep and goats (Hale *et al.,* 2007).

Thus, if goats, infected with *Haemonchus* spp, are treated with appropriate anthelmintics, one of the links that is "cutoff" is the adult worm. In the absence of adult parasites, dissemination of viable eggs into the environment is stopped; hence development of the parasite cannot perpetuate (Fernandez, 1991). To address this parasitic infection due to is the use of anthelmintic. There are two kinds of anthelmintic, the synthetic and herbal anthelmintics. The study revealed the comparative efficacy of modern anthelmintics like albendazole, Ivermectin and Fenbendazole against gastrointestinal nematodiasis in goats (Akanda *et al*., 2012**).** Another investigtion showed the efficacy of Ivermectin, Fenbendazole and Albendazole against gastrointestinal nematodes in naturally infected goats of government goat development farm (Aktaruzzaman *et al.,* 2012**)**. Black Bengal goats were treated with Cevamec®-1% (Ivermectin, Endex®-1500 (Triclabendazole along with Levamisole), and a placebo. Both of the drugs were equally significant against endoparasitic infections of goats ($P<0.05$; t-test) (Hassan *et al.,* 2012**)**. These anthelmintics have their advantages and disadvantages. The main advantages of synthetic drug are their high efficacy and proven safety if used according to the manufacturer's recommendation. The frequent use of anthelmintics has led to the appearance of resistant parasite populations, which have been jeopardizing the livestock industry worldwide. However, long term usage of synthetic anthelmintic would result to development of drug resistance by parasites thereby decreasing its efficacy (Waller, 1994; Hepworth *et al.,* 2006; Jabbar *et al*., 2006 and Almeida *et al*., 2010). However, dependence on anthelmintics has lead to the rapid and pervasive development of anthelmintic-resistant parasites. The majority of small stock farmers especially those on commercial enterprises rely heavily on the use of anthelmintics to control gastrointestinal nematodes and this has resulted in selection of worm populations that are resistant to anthelmintics (Van Wyk *et al.,* 1999 and Vatta *et al.,* 2001). There are only three anthelmintic drug classes available to treat GINs, the imidazothiazoles, benzimidazoles and macrolides (Bowman, 2003). Resistance has developed in parasite populations to each of these three drug classes (Howell *et al*., 2008). Although, research and dosage trials are currently being conducted on a new class of dewormer (Kaminsky *et al*., 2009). The mechanisms involved in drug resistance may result from decreased drug uptake, increased metabolism of the drug or changes at the drug-receptor site (Prichard, 1990; Roush, 1990).

Preventive strategies need a sound knowledge of the epidemiology of the target parasite species so that dosing schedules can be strategically timed and integrated with other management practices to prevent disease, limit parasite proliferation and optimize production. This approach has been used successfully in developing epidemiologically based regimes (Dash, 1985) to conserve the efficacy of ivermectin in areas of Australia where *H. contortus* is the predominant parasite. Since these regimes involve the use of salicylanilides, such as closantel, and are tailored to suit haematophagous parasites they are not universally applicable. Another strategy is to use only a single class of anthelmintic annually or within a parasite generation, so that multiple resistance is not generated, and to rotate anthelmintic classes on a yearly basis to limit the passage of resistant genes early in the selection process while parasites are heterozygous for the trait allowing for reversion to susceptibility (Conder and Campbell, 1995). Use of any anthelmintic should be discontinued if resistance to it is detected and subsequent treatments should use a drug with a different mode of action. Preventing the introduction of resistant parasite strains with new animals by quarantining, monitoring and treating all replacement stock is a critical management practice and this should critically be observed in sheep and goats especially in the tropics where they graze together. The use of sustainable, integrated parasite control systems, using scientifically proven non-chemical methods and limited use of drugs is being considered to ensure animal health and food safety (Waller, 2006). The traditional approach to control *H. contortus* relies chiefly on broad-spectrum antinematicidal synthetic drugs such as benzimidazoles/pro-benzimidazoles, imidazothiazoles (levamisole HCL and tetramisole), and macrocyclic lactone derivatives (avermectins/milbemycins) in different countries (Ghisi *et al*., 2007 and Taylor *et al*., 2007).

2.10.3. Vaccination

The parasite gut provides a potential source of protective antigens. In fact, substantial protection can be induced against *Haemonchus contortus* by immunizing goat kids with protein fractions isolated from the gut of this parasite. Such proteins are often known as hidden antigens because they are not recognized serologically by sheep which have acquired immunity following infection. Vaccination with the hidden antigen H11, a membrane glycoprotein with microsomal aminopeptidase-like activity isolated from the intestinal brush border of adult *Haemonchus contortus* is known to protect adult sheep and young lambs against Haemonchosis. Substantial protection has also been achieved by immunizing sheep with a glycoprotein fraction isolated from the intestinal membranes of the parasite (Nayebzadeh *et al*., 2008).

2.10.4. Ratio of stock classes

Young or susceptible animals are generally responsible for the vast majority of pasture contamination on a farm. Therefore contamination rates and parasitic disease may be reduced simply by reducing the proportion of young or susceptible stock on a farm This can be assisted by selling or removing young stock earlier, saving fewer replacements or changing the principle product of the operation, e.g. from lamb to beef. Obviously these sorts of decisions will be dictated largely by economic considerations. In a sheep finishing situation, the main aim is to minimize the larval challenge to the most vulnerable and economically sensitive class of stock, the naïve lamb pre- and post weaning. Any reduction in lamb growth rate due to internal parasites reduces carcass weight and/or extends the time period from weaning to slaughter which in turn decreases lamb value; increases competition between finishing lambs and ewes (pre-joining) for late-summer pasture; and increases the total pasture consumption of lambs to a given carcass weight. In the case of goat farms, because all classes of animals tend to remain relatively susceptible to infection, reducing the proportion of susceptible stock will normally mean replacing a proportion of goat stock units with cattle (or less preferably adult sheep). Long term intensive farming of goats by themselves is unlikely to be viable due to difficulties in achieving adequate parasite control (Rattary, 2003).

2.10.5. Level of feeding

Optimal levels of nutrition are essential in combating parasitism and achieving good levels of production in its presence for all classes of stock. Level of nutrition, especially protein nutrition, allows the animals to tolerate internal parasite infections and develop a good immune response. “Drenching is not a substitute for good feeding” and “There is no better anthelmintic than good quality green grass” To optimize feeding levels, a knowledge of feed requirements and optimum pasture covers for susceptible classes of stock is essential. Grazing management decisions should aim at providing these, or if unachievable, high quality supplements should be fed. Good levels of feeding of pregnant and early lactating ewes, in particular multiple bearing ewes and poor conditioned ewes will help to prevent the temporary breakdown in their immunity and the perparturient rise in faecal egg counts. This will result in lower levels of pasture contamination than otherwise would have been the case (Rattary, 2003).

2.10.6. Provision of “Safer” pasture

The main methods of potentially achieving this are:-

- Grazing hay or silage regrowth.
- Cultivation and establishment of new pasture or forage crops for grazing with susceptible stock.
- Using areas previously grazed by a different ruminant species or a non-infective / immune stock class of the same ruminant species.

Hay or silage aftermath: paddocks are usually closed for 40-60 days before hay or silage is cut and removed, and then it is several more weeks before the re-growth is grazed. This time interval combined with the harvesting removes a large proportion of the larvae; if the cutting height is above 5 cm; fewer larvae are likely to be removed than if the pasture is cut lower. Most of the larvae that remain on hay stubble should be killed by ultraviolet radiation and desiccation. Some contamination can remain, especially if the areas were previously grazed by contaminating stock or if the spell is not long enough. Generally the area of such prepared pasture on most farms is too small to provide sufficient safe grazing for susceptible animals, and sooner or later they will have to graze contaminated pasture (Rattary, 2003).

New pasture and summer forage crops: These are generally considered to be free of internal parasite larvae newly established pasture areas have not had any contamination for a long period of time and cultivation should have ensured that very few, if any, larvae survive, generally the area of new pasture is limited. With specialist crops there is generally a long interval between the last grazing of pasture and the establishment and grazing of the crop. This interval and the cultivation should ensure few larvae are present. The physical structure of many fodder crops may preclude the migration of any larvae present into the grazing zone, although grass margins may remain a potential source of larvae. In many situations, such crops may be impractical (hill country) or not economic. In some situations where serious drench resistance has arisen, such as on goat units, taking non-forage crops such as potatoes for two to three years has cleaned the area up (Rattary, 2003). Areas grazed by non-infective animals: pastures from which all infective sheep or goats have been excluded for at least 2-3 months but which have been grazed by cattle during that time can provide safe pasture for sheep or goats and vice versa. This is because they share very few of the same species of worm parasites and cross contamination of pasture by the alternate ruminant species is likely to have minimal infectivity for the principal species. This does not imply that absolutely no cross transmission can take place, but that a high proportion of ingested larvae do not establish in the heterologous host. Those that do, often have a limited, if any, period of patency (egg production) as adults. One ruminant species can essentially clean up pasture contaminated by the other. Cattle are an appropriate alternate species to sheep. In the case of cattle, preparing pasture for lambs, once lambs have grazed and contaminated a paddock with worm eggs, subsequent grazing by cattle will help remove a proportion of any larvae that develop in the following ways: cattle act as vacuum cleaners As they graze, they ingest larvae and those of sheep origin do not establish in cattle and hence die. (Likewise, sheep will help to remove some of the larvae that originate from cattle).Cattle grazing opens up the sward, exposing the larvae to desiccation and ultraviolet radiation. In addition, cattle grazing can increase the white clover content of swards. This can reduce the production losses due to parasitism as well as boosting lamb performance. Because of the extended interval before sheep return to the paddock, in some seasons there will also be considerable reduction in larval contamination through natural larval mortality (Rattary, 2003).

2.11. Treatment of haemonchosis

2.11.1. Broad-spectrum anthelmintics

The broad-spectrum anthelmintics can be divided into three groups on the basis of chemical structure and mode of action. These groups are:

Group 1: Benzimidazole (BZ) (‘white’ drenches).

BZ is effective against all nematodes and is ovicidal although individual generic products may vary in efficacy against some nematode species. After administration, the BZ passes into the rumen, which acts as are servoir, allowing gradual release into the bloodstream. BZs act by inhibiting tubulin activity in intestinal cells of nematodes or tegumental cells of cestodes, preventing uptake of glucose. The longer the time it stays in the animal the more it is effective. There is one BZ anthelmintic (triclabendazole), which is narrow spectrum (liver fluke only) and differs from all the other BZs in many respects but is classed with them because of its chemical structure (Abbott *et al*., 2009).

Group 2: Levamisole (LM) (‘yellow’ drenches)

Include theimidazothiazoles (levamisole) and tetrahydropyrimidines (morantel no longeron the market). These drugs are rapidly absorbed and excreted and most of the dose is lost from the system within 24 hours. Therefore, it is not essential to maintain high concentrations in the sheep for protracted periods. LMs act on the nerve ganglion of the parasite, causing paralysis. They are not ovicidal. The therapeutic safety index, compared to other anthelminticsis low. Animals given levamisole may be hyperactive for a few minutes. Toxic signs, due to a stimulant effect on nerve ganglia, may manifest as salivation, bradycardia, and muscular tremors and in extreme cases death from respiratory failure. Injectable levamisolemay cause inflammation at the site of injection (Abbott *et al*., 2009).

Group 3: Macrocyclic lactones (‘clear’ drenches)

Includes the avermectins (ivermectin/ doramectin) and the milbemycins (moxidectin). These compounds are highly lipophilic and following administration are stored in fat tissue fromwhere they are slowly released. They act on glutamate gated Cl-channels and γ-aminobutyricacid (GABA) neurotransmission sites in nematodes, blocking interneuronal stimulation of inhibitory motor neurones, leading to a flaccid paralysis (Abbott *et al*., 2009).

2.11.2. Narrow spectrum anthelmintics

The substituted phenols (nitroxynil) and the salicylanilides (closantel, oxyclozanide) are narrow spectrum anthelmintics. They are effective only against trematodes (and (*Fasciola*) and blood sucking nematodes (*Haemonchus*). They act by uncoupling oxidative phosphorylation at the mitochondrial level, reducing the availability of ATP, NADH, and NADPH. In the host they bind to plasma protein, which increases the duration of activity against blood sucking parasites. Praziquantel is a quinoline-pyrazine and is active against the tapeworm, *Moniezia expansa*. The drug acts on cell membrane permeability leading to damage to the parasite integument. Praziquantel is only available in combination with levamisole (Peregrine *et al*., 2010).

2.12. Overall prevalence of haemonchosis in goat

AL-Hasnawy (2014) was conducted to investigate the infection rate in goats with haemonchosis in the Hilla city, Iraq, during the period from November 2012 to March 2013. The results showed that the *Haemonchus contortus* infection rate was 29.67% (27 of 91) in goats. As for the examination of tissue samples of infected fourth stomach of goats, the results indicated presence of clear histological changes characterized the presence of necrosis in mucous layer and thickening layer of muscle and hyperplasia of the parietal cells with odema, in addition infiltration by polymorph inflammatory cells and fully fibrosis for some glandular cells of goat.

Muluneh *et al.* (2014) reported a cross sectional study was conducted with the objectives of determining the prevalence and risk factors associated with small ruminant major gastrointestinal nematodes in Dembia district, northwest Ethiopia from November 2013 to April 2014. A total of 69 goats were randomly selected examined using standard parasitological procedure. The overall infection rate was 49.2%.

Nabi *et al.* (2014) was conducted to delineate the epidemiology of gastrointestinal nematodes of goats in District Swat, Khyber Pakhtunkhwa. A total of 150 faecal samples were randomly collected from various age groups and of either sex of caprines. Overall prevalence of gastrointestinal nematodes in goats was 40.67%. Five species of nematodes were identified and included *Nematodirus spathiger*, *Haemonchus contortus*, *Trichostrongylus colubriformis*, *Strongyloides papillosus* and *Trichuris ovis*. Most prevalent species was *Nematodirus spathiger* (28.66%).

Raza *et al*. (2014) was evaluated the prevalence of gastrointestinal helminths in goats of the Cholistan desert, Pakistan, where livestock is the backbone of the regional economy. Fresh faeces (10-15 g) were collected from 500 goats across five different localities. Standard parasitological techniques served to identify parasite eggs, and copro-culture enabled larval determination of specific nematodes. Overall helminth prevalence was 78.1% across the 1000 animals; pure nematode infestations were most prevalent (37.5%), followed by pure trematode (7.9%), pure cestode (2.6%) and pure protozoa infestations (0.8). Given the high infestation rates, particular attention should be paid to management of suckling animals. A general means of reducing infestation rates might be the systematic testing of traditional plant-based remedies against helminths for cheap and regular deworming of the herds.

Demissie *et al. (*2013) was conducted from November, 2011 to April, 2012. One hundred and seventy four (174) goats abomasum were examined according to the standard procedures. The overall prevalence of abomasal nematode was 76.4% for goats. The parasitic species specific prevalence was 75.2, 9.8 and 14.2% for *Haemonchus* species, *Trichostrongylus axei* and *Teladorsagia circumcincta*, respectively in goats.

Teshale and Aragaw (2014) was conducted during during November, 2013 to March, 2014 to identify the species and to determine the burden of abomasal nematodes of small ruminants slaughtered in Bahir Dar town. A total of 115 goats were collected and examined according to the standard procedures. The prevalence of *Haemonchus* spp was 43.5% in goats. Mean worm counts of *Haemonchus* spp was 316.5 in goats.

Garedaghi and Bahavarnia (2013) was carried out to determine the prevalence of abomasal nematodes of goats slaughtered in Tabriz town from January 2012 through June 2012 with special emphasis given to *Haemonchus* species. During the study period 200 abomasa of goats were examined according to standard procedures. Three genera of nematodes were identified in goats abomasa with overall prevalence of 79.5 % (n = 200), respectively. The specific prevalence rates observed were 73.1 % for *Haemonchus* spp., 36.2 % for *T. axei* and 17.3% for *Teladorsagia* spp. in goats. Generally a high infection rate with abomasal nematodes was observed in goats of the study area.

Garedaghi *et al*. (2013) was observed livestock production covers up to 40% of the gross value of agricultural production globally. Gastrointestinal nematodes of small ruminants are one of the major causes of productivity loss. This study was carried out to determine the correlation between the prevalence, seasonal incidence and geographical distribution of abomasal worm infection of native goats in Baneh Town of Iran, suitable for animal husbandry. From February 2011 to February 2012 the contents of abomasums of 400 goats were washed separately in a 100 mesh sieve. The worms present in each abomasum were collected separately, counted and preserved in 70% alcohol containing 5% glycerin for identification to the species. The overall percentage of infection was 25.36% and *Haemonchus contortus*, *Teladorsagia circumcincta*, *Marshallagia marshalli*, *Ostertagia occidentalis*, *Ostertagia trifurcata* and *Parabronema skrjabini* were 6 species identified in studied areas. The overall prevalence rate and intensity of worm's burden as representative of Iran, were low, although *Teladorsagia circumcincta* was the most prevalent and frequent worm species found. Using Chi-Square and ANOVA, no significant relationship was found between prevalence, season, age and sex.

Gupta *et al.* (2013) was carried out from November 2011 to March 2012 with the objective of determining the prevalence, species and worm burden of abomasal nematodes of goats slaughtered at Helmex export abattoir in Debre Zeit, central Ethiopia. A total of 185 goats' abomasums were subsequently collected and examined for adult parasites. Of these, 333 (86.7%) were positive for one or more abomasal nematodes. The overall prevalence was 86.5% in goats, respectively. The recovered species were identified as *Haemonchus contortus*, *Trichostrongylus axei* and

Teladorsagia species in both animals. The nematode parasites identified for goats were *Haemonchus contortus* (77.83%), *Trichostrongylus axei* (75.13%) and *Ostertagia/Teladorsagia* (24.32%). The current study epitomized that the prevalence of nematodiasis were high and consequently; sustainable control programs should warrant.

Hakimzadegan and Khosroshahi (2013) were reported parasitic infections are generally regarded as the most prevalent and important health problems of grazing ruminants in Iran. Gastro-Intestinal nematode parasite infections are a major constraint to the small ruminants (sheep and goat) industry and cause to reduce weight gains, growth rate, nutrient utilization and less meat, wool and milk production, also increased costs of management, treatment and even mortality in several cases. A study was carried out to estimate the prevalence abomasal nematodes of slaughtered goats at the Industrial Urmia slaughterhouse from March 2012 to March 2013. During the study period, 130 abomasums of goats were examined according to standard procedures. Four genera of nematodes were identified in the goat abomasum with an overall prevalence of 46.14%. The specific prevalence observed was *Ostertagia ostertagi* (12.30%), *Ostertagia circumcincta*, (7.69%), *Haemonchus contortus* (16.92%) and *Marshallagia marshalli,* (9.23%). Among the species found *Haemonchus contortus* was the most prevalent and frequent species.

Khajuria *et al.* (2013) was studied a total of 960 faecal samples of goats of stationary flocks of the middle agro-climatic zone of Jammu province were examined, out of which 67.24 % animals were positive for helminthic infections. Significantly ($p < 0.05$) higher infection was observed in monsoon as compared to winter. Strongyles were predominant during all the seasons, but significantly ($P<0.05$) higher infection was observed in monsoon as compared to winter. Coproculture studies revealed that *Haemonchus contortus* (61.18 %) predominated during all the seasons. The effect of prevailing agro-climatic conditions on the prevalence of gastrointestinal helminths has been discussed.

Nizam (2013) was revealed that the overall percentage of helminth infection was found to be 58.23%. Out of 340 goats, 192 (56.47%) were found infected with nematodes and *Haemonchus* spp was (47.94%).

Singh *et al*. (2013) was reported the prevalence of gastrointestinal parasites in goats of Mathura region. A total of 240 faecal samples collected from three different farms were examined by direct smear, Willi's floatation and sedimentation techniques. Quantitative examination was done by McMaster's technique. Out of 240 samples processed 165 samples were found positive for gastrointestinal parasites. The overall prevalence was 68.75%. The most common gastrointestinal parasites were *Haemonchus, Moniezia and coccidian*. The results of the present study suggest that *Haemonchus* is the main gastrointestinal parasite of goats in Mathura region. Necessary steps should be taken in timely manner to improve the productivity from these animals.

Tsegabirhan *et al*. (2013) An epidemiological study was conducted in Woreda Alameta, Southern Tigrary to estimate the prevalence of Haemonchosis in small ruminants in four different hotels of Alameta twon from November 2011 to March 2012. During the study period, 613 abomasum of small ruminants, 355 sheep and 258 goats, were examined. The overall prevalence in this study was 38.6%, with a prevalence of 15.8% were recorded for goats. Therefore, the epidemiological evidence of the present investigation showed that Haemonchosis is considerably prevalent disease of small ruminants in the study area. Hence, strategic control methods and good management practice are recommended.

Akanda *et al. (*2012) was surveyed on the prevalence of gastro-intestinal tract (GIT) parasites in 20 black Bengal goats (*Capra hircus*) of 18 months of age was conducted in Sylhet Govt. Goat Development Farm, Bangladesh during the period of February to May of 2011. Irrespective to sex, using Mc Master method for egg per gram of faeces (EPG) disclose that the percentage of *Haemonchus contortus* 30. Study surveys suggest, appropriate parasitic control approach be explored and tried in order to alleviate the problem of worm saddle.

Farooq *et al*. (2012) carried out to assess the prevalence of gastrointestinal helminths infections among wild and domestic ruminants in Cholistan desert of Pakistan. For this purpose, 1010 faecal samples of different species of ruminants including cattle (n=300), sheep (n=250), goat (n=100), camel (n=200), chinkara (n=150) and blackbuck (n=10) were examined using standard parasitological procedures. The highest prevalence was recorded in cattle (44.7%) followed by sheep (43.6%), goats (39%), camels (37%), chinkara (26.7%) and black bucks (20%). Maximum number of the helminth species were recorded in sheep (n=14) followed by camels (n=13), cattle (n=09), goats (n=08), chinkara (n=07) and black bucks (n=02). Nematodes were the predominantly occurring (n=18) helminths followed by trematodes (n=6) and cestodes (n=3). *Haemonchus* and *Trichostrongylus* were the most frequently recorded genera. It was concluded that wild and domesticated ruminants of the Cholistan desert of Pakistan suffer with heavy infections of a variety of helminths including those of high economic significance.

Fentahun and Luke (2012) was performed with an attempt to determine the prevalence and associated risk factors of haemonchosis in randomly selected slaughtered goats in restaurants and hotels in Gondar town, Amhara region, northwest Ethiopia from November 2011 to April 2012. A total of 49 goats were examined. Overall prevalence was 80.21%. The specific prevalence of *Haemonchus contortus* infection was 73.5% in goats.

Negasi *et al*. (2012) was studied was conducted from November 2011 to March 2012 to determine the prevalence of gastrointestinal (GI) helminth infections and associated risk factors in sheep and goats in and around Mekelle town, Northern Ethiopia. A total of 390 small ruminant's faecal samples (240 sheep and150 goats) were collected and examined using standard parasitological procedures. The study revealed that the overall prevalence of helminthiasis was 35.33% in goats.

Nuruzzaman *et al*. (2012) was studied the prevalence, species composition and worm burden of abomasal nematodes of goats slaughtered at different abattoir of Thakurgaon district, Bangladessh, from November 2009 to April 2010. During the study period, 250 abomasum of goat were examined according to standard procedures. Two species of nematodes were identified in goats abomasum with an overall prevalence of 74.00% (*n* = 250). The specific prevalence rate for *Haemonchus contortus* (58.00%) was higher than *Trichostrongylus axie* (16.00%).

Nabavi *et al*. (2011) observed that Gastro-intestinal nematodes of small ruminants are one of the major causes of productivity loss. This study was carried out to determine the correlation between the prevalence, seasonal incidence and geographical distribution of abomasal worm infection of native goat in 3 different climatic zones of Iran, suitable for animal husbandry. The overall percentage of infection was 30.98%.

Abunna *et al.* (2009) was carried out to estimate the prevalence, species composition and worm burden of abomasal nematodes of small ruminants slaughtered at restaurants of Bishooftu town from October 2008 to March 2009. During the study period, 64 abomasums of goat were examined according to standard procedures. Three genera of nematodes were identified in both sheep and goats abomasum with an overall prevalence of 77.6%. The specific prevalence observed was *Haemonchus* species (76.6%) in goats. In general, a high infection rate with abomasal nematodes was observed in goats during the study period.

Gadahi *et al.* (2009) analysed the 310 faecal samples goats of Rawalpindi and Islamabad to confirm the presence of gastrointestinal parasitic infection. Among the samples from 206 (66.45%) from goats were detected positive for gastrointestinal parasites. The incidence of *Haemonchus* spp was 64.19% in goats.

Tefera *et al*. (2009) was study on GIT parasites of small ruminants was conducted from November 2007 to May 2008 in and around Bedelle with the objectives to determine the major GIT parasites and their prevalence in goats. In this study, a total of 165 fecal samples from goats were collected for qualitative and quantitative fecal examinations and 20 post mortem examinations in butcher house in goats were performed. The study found that 153 (93.29%) goats were found to harbor eggs of GIT helminthes. Amongst the post mortem examinations performed, 19 (95%) goats were found to be infected with two or more of GIT helminth parasites. Eight genera of nematodes with prevalence of 67.5% *Haemonchus* species, 46.1% *Trichuris* species, 48.8% *Trichostrongylus* species, 48.8% *Oesophagostomum* species, 30.3% *Bunostomum* species, 25.6% *Ostertagia* species, and 20.9% *Chabertia* species and 16.3% *Strongyloid* in goats. Similarly two types of Cestodes were recovered with prevalence of 24.8 % Monezia species and 39.5% Avetellina species. There was no significant difference (P>0.05) in the prevalence of GIT helminthosis between sexes, ages and species of animals. Out of 153 goats examined 10.95% were massively affected, 48.52% moderately affected and 40.53% were lightly affected. The study showed that GIT parasites are major problems of goats in the study area. Therefore; comprehensive study on GIT parasites, cost effective strategic treatment and awareness creation to the farmers should be instituted in the study area.

Asif *et al*. (2008) was determined the prevalence of various parasites in and around twin cities of Rawalpindi and Islamabad. From August 2004 to December 2005, a total of 252 fecal samples were collected from goats for this study. Of the total samples examined, 65.7% were found positive for parasites. The prevalence of gastrointestinal parasites tended to be higher in goats 160 (63.7%). The parasites identified in goats *Haemonchus* (75%), were recovered from the fecal samples of goat.

Chavhan *et al*. (2008) studied the prevalence of nematode parasites of ruminants in two villages, viz. Chicholi and Bodala of Nagpur district. Out of 615 animals examined 242 were positive (39.34%) for nematode infection. The infection rate in goat was 51.94%. Higher infection was recorded during monsoon (63.07%) followed by winter (32.22%) and summer (21.33%). The percentage of animals infected with *Haemonchus* spp, *Toxocara* spp, *Trichuris* spp, *Strongyloides* spp and mixed infection was found to be 38.01%, 27.68%, 14.87%, 11.98% and 7.43% respectively.

Pathak and Pal (2008) was studied on the prevalence of gastrointestinal parasites in goats revealed that the percentage of overall prevalence of infection was 85.22%. The prevalence of *Haemonchus* spp was 26.13%.

Rajapakse *et al.* (2008) collected and examined the gastrointestinal tracts of 218 crossbred goats representing the dry zone of Sri Lanka during a year study period. 217 (more than 99%) of the animals examined were infected with one or more species of nematodes. Five species of nematodes were found in the abomasums and intestines. The prevalence of *Haemonchus contortus* was 81%.

Menkir (2007) carried out a two year epidemiology study of helminthes of small ruminants. The study involved the collection of viscera from 632 goats from 4 abattoirs in eastern Ethiopia. A further more detailed epidemiology study of gastro-intestinal nematode infections used the Haramaya University (HU) flock of 60 Black Head Ogaden sheep. The parasitological data included numbers of nematode eggs per gram of faeces (EPG), faecal culture L_3 larvae, packed red cell volume (PCV), adult worm and early L_4 counts, and FAMACHA eye-colour score estimates, along with animal performance (bodyweight change). There were 13 species of nematodes and 4 species of flukes present in the goat, with *Haemonchus contortus* being the most prevalent (65–80%), followed by *Trichostrongylus* spp. The nematode infection levels of both sheep and goats followed the bi-modal annual rainfall pattern, with the highest worm burdens occurring during the two rain seasons (May and September).

Thomas *et al*. (2007) was studied to determine the prevalence of abomasal nematodes of goats slaughtered in Awassa town from January 2006 through June 2006 with special emphasis given to *Haemonchus* spp. During the study period 132 abomasa of goats were examined. Three genera of nematodes were identified in goat abomasa with overall prevalence of 87.1 % respectively. The specific prevalence rates observed were 76.5 % for *Haemonchus spp.,* 39.4 % for *T. axei* and 20.5 % for *Teladorsagia* spp. in goats.

Kumsa and Wossene (2006) was carried out to determine the prevalence, species composition and worm burden of abomasal nematodes of small ruminants of Ogaden region slaughtered at Elfora export abattoir. A total of 82 abomasums of goats were examined according to standard procedures. An overall prevalence rate of 82.9% *Haemonchus* species was recorded in goats. Statistically significant ($p<0.05$) difference in prevalence and average worm burden was noted between months of study for abomasal nematodes. Majority of goats harboring adult abomasal nematodes were with light to moderate degree of infection whereas only small proportions were with heavy degree of infection. Adult male *Haemonchus* recovered from goats were identified as 96.5% *H. contortus*, 3.0% *H. placei* and 0.5% *H. longistipes*. The study revealed the coexistence and sypmatry ofcommunities of two or three *Haemonchus species* in a single small ruminant host, suggesting occurrence of *Haemonchus species* circulation among heterologous hosts sharing the same pastures that should be considered in the control strategy of the parasite.

Lima *et al*. (2006) studied the faecal samples collected from 20 goats in Paulista, Pernambuco, Brazil, from August 1998 to July 1999. They were subjected to eggs per gram faeces (EPG) determination and nematode larvae culture. It was shown that 82% of the samples were positive for helminths. *Strongyloides, Moniezia* and *Trichuris* spp. ova were obtained in 72.8%, 8.4% and 2.0% of the samples, respectively, while third stage larvae of *Haemonchus, Trichostrongylus* and *Oesophagostomum* spp. were obtained from 75.13%, 24.32% and 0.54% of the samples, respectively. The medium number of *Haemonchus* and *Trichostrongylus* spp. larvae per gram faeces was higher in the rainy months. There was a significant correlation between EPG and temperature, EPG and rainfall and EPG and the number of *Haemonchus* spp. larvae per gram faeces. *Haemonchus* spp. was present throughout the study period.

Waruiru *et al*. (2005) conducted a study on gastro-intestinal parasitic infection of sheep and goats in semi-arid area of Machakos district, Kenya. The overall prevalence were *Strongyloides* (51.6%), *Fasciola* spp. (31.5%), *Coccidia* (28%), *Moniezia* (2.5%). *Haemonchus* (58%) was the most prevalent nematode followed by *Trichostrongylus* (29%) and *Oesophagostomum* (13%).

Yadav *et al*. (2005) reported the highest incidence of gastro-intestinal nematodiasis in goats followed by buffalo and cattle in India. *Haemonchus*, *Trichostrongylus*, *Bunostomum*, *Oesophagostomum* and *Strongyloides* species were the main parasites recovered from the intestine of sheep, goats and buffaloes.

Mbae *et al*. (2004) studied 1106 sheep and goats in Kenya for nematode infections. Young animals were found more infected than older ones. The faecal egg counts were significantly higher in wet seasons in both sheep and goats. *Haemonchus contortus* was the most predominant nematode parasite encountered in the study.

Eseta (2004) was conducted from August 2003 to March 2004 with an attempt to determine the prevalence, morphological characteristics and susceptibility of Ogaden isolate of *H. contortus* to Albendazole and Tetramisole. During the study period a total of 196 animals (114 sheep and 82 goats) of Ogaden origin were examined. The overall prevalence of *Haemonchus* as 37.72% and 40.24% prevalence of *Trichostrongylus axei* was recorded in sheep and goats respectively. Statistically significant difference ($P<0.05$) was observed between different months of the study period for both abomasal parasites.

Qamar (2002) was studied the epidemiology of haemonchosis in goats and found the overall prevalence of haemonchosis was 35.25% in goats. The prevalence in slaughtered animals, veterinary hospitals and at livestock farms was 36.07%, 40.01% & 38.45% respectively. The highest district wise prevalence was noted at Gujranjawala (40.67%), followed by Sheikhupara (39.5%) then Kasur (37.97%) and the lowest at Lahore (28.94%).

Ali *et al*. (2000) was investigated the prevalence of gastro-intestinal parasites in sheep and goats in Islamabad, Pakistan. Among the seven species of nematodes, *Haemonchus contortus* (sheep, 87% & goats, 92%) followed by (sheep, 77.41% & goats, 92% had the highest prevalence.

Mondal *et al.* (2000) was investigated two tracer animals (two cow calves and two goats) were released for a month in grassland used for communal grazing of livestock near school premise in Kanthal, Trishal, Mymensingh to determine the association of grassland with parasitic diseases of livestock. After slaughtering, the determined species were *Haemonchus contortus*, *Trichostrongylus axei*, *Mecistocirrus digitatus*, *Oesophagostomum* spp, *Trichuris* spp, *Bunostomum* spp and *Moniezia* spp. The numbers of parasites in each cow calf were from 42 to 154 for *Haemonchus contortus*, from 18 to 33 for *Trichostrongylus axei*, from 15 to 34 for *Mecistocirrus digitatus*, from 22 to 47 for *Oesophagostomum* spp, from 23 to 32 for *Trichuris* spp, from 13-32 in *Bunostomum* spp and from 3 to 16 for *Moniezia* spp. The numbers of parasites in each goat were from 22 to 45 for *H. contortus*, from 10 to 27 for *T. axei*, from 24 to 160 for *Oesophagostomum* spp, from 16 to 35 for*Trichuris* spp, from 2 to 8 for *Bunostom*um spp and from 12 to 21 for *Moniezia* spp.

Gatongi *et al*. (1998) investigated the epidemiology of *Haemonchus contortus* infection of goats (Small East African Goat) in a semi-arid area of Kenya. Prevalence of *Haemonchus contortus* was over 90% in both sheep and goats and this species contributed to about 80% of the total worm burden. Only about 10% of the hypobiotic larvae were recovered from the mucosal digest whereas about 90% were recovered from the abomasal contents.

Maqbool *et al.* (1997) conducted an epidemiological study on haemonchosis in slaughtered and live goats under local climatic conditions. The overall infection rate was 18.18% and 17.54% in live and slaughtered goats.

Maqsood *et al.* (1996) reported the 47.1% prevalence of haemonchosis in goats. The prevalence of haemonchosis was higher in goats less than two years of age (47.8%) than above two years (33.3%).

Frutschi *et al.* (1993) on autopsy of 52 goats, the following gastrointestinal nematodes were identified and counted in order of predominance, *Trichostrongylus* spp (96%), *Oesophagostomum columbianum* (82%), *Haemonchus contortus* (67%), *Strongyloides papillosus* (55%), *Cooperia* spp (47%) and *Trichuris ovis* (12%).

Iqbal *et al.* (1993) was studied the prevalence of haemonchosis was 10.9% in slaughtered goats. However, there was no difference in the prevalence between male and female goats.

Kamal *et al*. (1993) was examined eight hundred and seventy goats from naikhongchari, Bandarban district, Bangladesh for gastro-intestinal nematodes. The parasites encountered in the region were *Haemonchus* sp, *Bunostomum* sp, *Oesophagostomum* sp *and Strongyloides* sp. The overall infection rate was 78.41%. Among various found, *Haemonchus* sp emerged as the most prevalent, although *Bunostomum Oesophagostomum* were also found n this studies. The seasonal fluctuation was assessed by monitoring the faecal egg count. The maximum values for the prevalence and overall mean EPG were observed after the heavy rainfall season and remained at a relatively with level from June to November.

Yadav and Tandon (1989) were studied twelve hundred and twenty-eight goats (*Capra hircus* L.) from a sub-tropical and humid zone of India was examined for gastrointestinal nematodes. The species encountered in the region were: *Haemonchus contortus, Bunostomum trigonocephalum, Oesophagostomum columbianum, Trichuris globulosa, O. aspersum,* and *T. ovis.* The overall infection rate was 86.8%.

Among various species found, *H. contortus* emerged as the most prevalent, although *B. trigonocephalum* and *O. columbianum* were also significantly in evidence. The seasonal fluctuation in infection was assessed by monitoring the faecal egg count of 1638 goats slaughtered during the 1-year period. The maximum values for the prevalence and overall mean eggs per gram of faeces (EPG) were observed after the heavy rainfall season and remained at a relatively high level from July to December. *H. contortus* and O. *columbianum* appear to be of major importance as parasites in the goats of this climatic zone.

Hsiang *et al.* (1990) studied 4534 faecal samples, collected in Taiwan over a three year period from randomly selected dairy goats for parasites. The most frequent parasites found were *Oesophagostomum* spp. (19%), *Haemonchus contortus* (17.3%), *Strongyloides papillosus* (8.5%), *Ostertagia ostertagi* (7.1%) and *Trichostrongylus colubriformis* (6.8%). Overall prevalence was observed greater in autumn and winter, and goats with access to pasture were more commonly infected than goats which fed indoors (penned goats).

2.12.1. Host related factor affects the epidemiology of haemonchosis

2.12.i. Effects of age on the epidemiology of goats

AL-Hasnawy (2014) was conducted to investigate the infection rate in goats with haemonchosis in the Hilla city, Iraq, during the period from November 2012 to March 2013. The results showed that the *Haemonchus contortus* infection rate was 29.67% (27 of 91) in goats. According to age of examined animals, the results appeared no significant variation ($P>0.05$) between ages of infected goat where referred to the rates of infection were inversely proportional to the age of the animal, and the highest infection rate in the ages of 6-12 months in goats at a rate of 48.57%.

Muluneh *et al.* (2014) reported a cross sectional study was conducted with the objectives of determining the prevalence and risk factors associated with small ruminant major gastrointestinal nematodes in Dembia district, northwest Ethiopia from November 2013 to April 2014. A total of 384 randomly selected small ruminants (315 sheep and 69 goats) were examined using standard parasitological procedure. Sex, age and body condition of the animals were not associated with significant difference (P>0.05). The age wise prevalence was 44.3, 42.4% in young and adult animals respectively. In this study the parasite eggs detected were strongyle-type, hence, further laboratory examination is recommended to identify parasite species in order to design appropriate control measures.

Nabi *et al.* (2014) was conducted to delineate the epidemiology of gastrointestinal nematodes of goats in District Swat, Khyber Pakhtunkhwa. A total of 150 faecal samples were randomly collected from various age groups and of either sex of caprines. Overall prevalence of gastrointestinal nematodes in goats was 40.67%.

Mir *et al*. (2013) was survey of prevalence of haemonchosis in sheep was conducted in Jammu area of Jammu And Kashmir State. A total of 257 animals were examined of which 61 (23.73%) were found positive for *Haemonchus contortus* as revealed by necroscopic examination. Lower age groups were having more infection (36.48%).

Nizam (2013) was observed that prevalence was higher in age group of <1 year and lower in higher age groups. In the present study the maximum nematode infection (80.48%) was observed in age group of <1 year and lowest (23.80%) in age group of > 4 years.

Tsegabirhan *et al*. (2013) An epidemiological study was conducted in Woreda Alameta, Southern Tigrary to estimate the prevalence of Haemonchosis in small ruminants in four different hotels of Alameta twon from November 2011 to March 2012. During the study period, 613 abomasum of small ruminants, 355 sheep and 258 goats, were examined. The overall prevalence in this study was 38.6%, with a prevalence of 22.8%, and 15.8% were recorded for sheep and goats respectively. The highest prevalence was observed in >1.6 yrs, 33.9% compared to >1.6 yrs of age, 41% but there was no statistically significant difference (P>0.05) observed among risk factors of age.

Attindehou *et al.* (2012) was conducted was carried out from December 2010 to November 2011 in order to establish the epidemiology of *Haemonchus contortus* infections in small ruminants of Benin. A total of 756 abomasums, collected from randomly selected goats and sheep from all regions of Benin has been examined. An examination of the conjunctiva's colour has been associated with parasitic diagnosis to assess the degree of anaemia in animals. The study disclosed an endemic evolution of Haemonchosis. The overall prevalence was of 55.56% with a mean burden of 175 worms per infested animal. No significant influence could be attributed to host's species or age.

Negasi *et al*. (2012) was studied was conducted from November 2011 to March 2012 to determine the prevalence of gastrointestinal (GI) helminth infections and associated risk factors in sheep and goats in and around Mekelle town, Northern Ethiopia. A total of 390 small ruminant's faecal samples (240 sheep and150 goats) were collected and examined using standard parasitological procedures. The study revealed that the overall prevalence of helminthiasis was 35.33% in goats. Among age groups, higher prevalence (54.90%) was observed in young animals than adults (45.83%). Younger and animals tend to be more susceptible to helminthiasis as compared to adults. However, the difference in prevalence between the two age groups was not statically significant (x^2=2.481 and P>0.05).

Nuruzzaman *et al*. (2012) studied the prevalence of abomasal nematodes in relation to age, sex, breed and nutritional status of the goats were also observed. Age can affect the occurrence of parasites. However, prevalence of abomasal nematodes in goats were significantly (P<0.01) higher in young aged (84.61%) than adult aged (61.21%). Youngs were 3.30 times more susceptible than adults. In general, a high infection rate with abomasal nematodes was observed in goats during the study period. Findings suggested that higher worm burden per animal found in *Haemochus contortus* (6.02±0.0928) and lower in *Trichostrongylus axie* (0.04±0.14). From this study it was concluded that *Haemochus contortus* is more susceptible for geo-climatic condition in research area.

Qamar *et al.* (2009) was studied the epidemiology, serodiagnosis, economic losses and control of haemonchosis in sheep and goats in Lahore, Pakistan 2007-2008. It was designed to record the prevalence of haemonchosis in sheep and goats under different ecological and managerial conditions. A total 9600 goats were examined of these 3096 were found positive for haemonchosis so prevalence was 35.25%. A higher infection rate was recorded in goats higher prevalence (42.94%) was recorded in goats above 9 months than below 9 months (29.59%).

Mbae *et al*. (2004) studied 1106 sheep and goats in Kenya for nematode infections. Young animals were found more infected than older ones.

Maqsood *et al.* (1996) reported the 47.1% prevalence of haemonchosis in goats. As regards sex wise prevalence there was no difference between male and female goats. The prevalence of haemonchosis was higher in goats less than two years of age (67.1%; 47.8%) than above two years (40.4%; 33.3%).

2.12.2.ii. Effects of sex on the epidemiology of haemonchosis

AL-Hasnawy (2014) was conducted to investigate the infection rate in goats with haemonchosis in the Hilla city, Iraq, during the period from November 2012 to March 2013. The results showed that the *Haemonchus contortus* infection rate was 29.67% (27 of 91) in goats. Also, no significant variation (P>0.05) between sexes of infected goats were 39.53% in female, while they were 20.83% in males.

Muluneh *et al. (*2014) reported a cross sectional study was conducted with the objectives of determining the prevalence and risk factors associated with small ruminant major gastrointestinal nematodes in Dembia district, northwest Ethiopia from November 2013 to April 2014. A total of 384 randomly selected small ruminants (315 sheep and 69 goats) were examined using standard parasitological procedure. Sex of the animals were not associated with significant difference (P>0.05). The Sex wise prevalence was 46.2 and 42.3% in male and female animals respectively. In this study the parasite eggs detected were strongyle-type, hence, further laboratory examination is recommended to identify parasite species in order to design appropriate control measures.

Nabi *et al.* (2014) was conducted to delineate the epidemiology of gastrointestinal nematodes of goats in District Swat, Khyber Pakhtunkhwa. A total of 150 faecal samples were randomly collected from various age groups and of either sex of caprines. Overall prevalence of gastrointestinal nematodes in goats was 40.67%. Five species of nematodes were identified and included *Nematodirus spathiger, Haemonchus contortus, Trichostrongylus colubriformis*, *Strongyloides papillosus* and *Trichuris ovis*. Most prevalent species was *Nematodirus spathiger* (28.66%). Highest prevalence and mean eggs count per gram of faeces (EPG) were found in young animals (≤1year old) as compared to adults ($P<0.05$). Sex related prevalence indicates that infections were more common in males but association was not significant ($P>0.05$). No association between management practices and prevalence of GIT nematodes was detected but infection rate and mean EPG was higher in house hold animals as compared to commercially raised animals ($P>0.05$).

Demissie *et al.* (2013) was conducted from November, 2011 to April, 2012. One hundred and seventy four (174) goats abomasum were examined according to the standard procedures. The overall prevalence of abomasal nematode was 76.4% for goats. The parasitic species specific prevalence was 75.2, 9.8 and 14.2% for *Haemonchus* species, *Trichostrongylus axei* and *Teladorsagia circumcincta*, respectively in goats. The sex related prevalence in goats was 71.9, 5.7, 6.1% and 81.6, 21.6, 16.6% for *Haemonchus* species, *T. axei* and *T. circumcinecta*, respectively for male and female. The overall mean worm count was 6244.9 for goats. The sex related mean worm burden was significantly higher ($P<0.05$) in female than male for goats.

Mir *et al*. (2013) was survey of prevalence of haemonchosis in sheep was conducted in Jammu area of Jammu And Kashmir State. A total of 257 animals were examined of which 61 (23.73%) were found positive for *Haemonchus contortus* as revealed by necroscopic examination. Males were found to harbor more infection (27.43%) than females (20.83%).

Nizam (2013) was revealed that sex wise observations in the study, the males were more infected with gastrointestinal helminth parasites than the females in goats). In study the maximum nematode infection (58.75%) was observed in males as compared to females (54.44%). The influence of sex on the susceptibility of animals to infections could be attributed to genetic predisposition and differential susceptibility owing to hormonal control.

Tsegabirhan *et al*. (2013) An epidemiological study was conducted in Woreda Alameta, Southern Tigrary to estimate the prevalence of Haemonchosis in small ruminants in four different hotels of Alameta twon from November 2011 to March 2012. During the study period, 613 abomasum of small ruminants, 355 sheep and 258 goats, were examined. The overall prevalence in this study was 38.6%, with a prevalence of 15.8% were recorded for goats. There was no statistically significant variation in prevalence of *Haemonchus* among sex differences. The prevalence factor of sex was independence having almost similar prevalence in male (38.7%) and female (38.6%).

Fentahun and Luke (2012) was performed with an attempt to determine the prevalence and associated risk factors of haemonchosis in randomly selected slaughtered goats in restaurants and hotels in Gondar town, Amhara region, northwest Ethiopia from November 2011 to April 2012. A total of 49 goats were examined. Overall prevalence was 80.21%. The specific prevalence of *Haemonchus contortus* infection was 73.5% in goats. The prevalence of haemonchosis in males and females was 80.9% and 77%, respectively but, the difference is not statistically significant (2 = 0.583, P> 0.05).

Negasi *et al*. (2012) was studied was conducted from November 2011 to March 2012 to determine the prevalence of gastrointestinal (GI) helminth infections and associated risk factors in sheep and goats in and around Mekelle town, Northern Ethiopia. A total of 390 small ruminant's faecal samples (240 sheep and150 goats) were collected and examined using standard parasitological procedures. The study revealed that the overall prevalence of helminthiasis was 35.33% in goats. The higher prevalence of GI helminth infection was observed in female animals (53.35%) compared to males (34.58%). The difference was statistically significant (X^2= 10.965 and P<0.05).

Nuruzzaman *et al*. (2012) studied the prevalence of abomasal nematodes in relation to age, sex, breed and nutritional status of the goats were also observed. The results showed that the prevalence of abomasal nematodes was almost similar in females (74.07%) and male (73.91%) goats (odd ratio 1.008). Prevalence of *H. contortus* was higher in male (65.22%) with mean count of 7.00 per animal than female (51.58%) with mean count of 5.52 per animal but *T. axie* was higher in male (22.22%) than female (8.69%). There was no statistically significant difference observed the risk factor sex in relation to the prevalence of abomasal nematodes. However, there was no statistically significant difference (P>0.05) observed among the sex in relation to the prevalence and worm count of two abomasal nematodes. In general, a high infection rate with abomasal nematodes was observed in goats during the study period. Findings suggested that higher worm burden per animal found in *Haemochus contortus* (6.02±0.0928) and lower in *Trichostrongylus axie* (0.04±0.14). From this study it was concluded that *Haemochus contortus* is more susceptible for geo-climatic condition in research area.

Qamar *et al.* (2009) was studied the epidemiology, serodiagnosis, economic losses and control of haemonchosis in sheep and goats in Lahore, Pakistan 2007-2008. It was designed to record the prevalence of haemonchosis in goats under different ecological and managerial conditions. A total 9600 goats were examined of these 3096 were found positive for haemonchosis so prevalence was 35.25%. A higher infection rate was recorded in goats higher in males (38.63%) than females (34.47%).

Raza *et al.* (2009) was conducted to determine the prevalence of *Haemonchus contortus* in slaughtered goats at Multan abattoir. A total of 2607 goats were slaughtered and examined from 21 January 2007 to 20 February 2007 in Multan abattoir. In case of goats 811 out of 2607 (31-10%) goats were positive. Sex wise prevalence of *H. contortus* in goat prevalence in male was 29.91% (312/1043) and in female was 31.90% (499/1564).

Shahiduzzaman *et al.* (2003) was studied the seasonal influence on the occurrence of *Haemonchus contortus* on 672 slaughtered Black Bengal goats during one year period from 2002 to June 2003.An overall 65.63% goats had *H.contortus* infection and significantly (P<0.01) higher infection was recorded in female (70.43%) than male (58.61%).

Iqbal *et al.* (1993) was studied the prevalence of haemonchosis was 10.9% in slaughtered goats, respectively. There was no significant (P> 0.05) difference in the prevalence between male and female goats.

2.12.1.iii. Effects of breed on the epidemiology of haemonchosis in goat

Mir *et al*. (2013) was survey of prevalence of haemonchosis in small ruminant was conducted in Jammu area of Jammu And Kashmir State. A total of 257 animals were examined of which 61 (23.73%) were found positive for *Haemonchus contortus* as revealed by necroscopic examination. Exotic breeds were found to have more infection than local ones. The present information could be useful for the development of strategic treatments for Haemonchosis in sheep of this area of Jammu And Kashmir State.

Nuruzzaman *et al.* (2012) studied the prevalence of abomasal nematodes in relation to age, sex, breed and nutritional status of the goats were also observed. There was a significant (P<0.02) variation in breed susceptibility was observed affecting mostly Jamunapari goats (85.71%) compared to Black Bengal goats (72.08%). Concerning breed, the parasitic worm burden of 57.14% Jamunapari goat harbored adult worms of *Haemonchus contortus* with mean count of 5.14 per animal which was higher than the parasitic worm burden of 55.81% Black Bengal goat. Findings suggested that higher worm burden per animal found in *Haemochus contortus* (6.02±0.0928). From this study it was concluded that *Haemochus contortus* is more susceptible for geo-climatic condition in research area.

2.12.1.iv. Effects of body condition on the epidemiology of haemonchosis in goats

Muluneh *et al. (*2014) reported a cross sectional study was conducted with the objectives of determining the prevalence and risk factors associated with small ruminant major gastrointestinal nematodes in Dembia district, northwest Ethiopia from November 2013 to April 2014. A total of 384 randomly selected small ruminants (315 sheep and 69 goats) were examined using standard parasitological procedure. Sex, age and body condition of the animals were not associated with significant difference (p>0.05). Body condition score infection rate was 48.1, 37.1 and 43% in poor, medium and good body conditions respectively. In this study the parasite eggs detected were strongyle-type, hence, further laboratory examination is recommended to identify parasite species in order to design appropriate control measures.

Nabi *et al.* (2014) was conducted to delineate the epidemiology of gastrointestinal nematodes of goats in District Swat, Khyber Pakhtunkhwa. A total of 150 faecal samples were randomly collected from various age groups and of either sex of caprines. Overall prevalence of gastrointestinal nematodes in goats was 40.67%. Five species of nematodes were identified and included *Nematodirus spathiger*, *Haemonchus contortus*, *Trichostrongylus colubriformis*, *Strongyloides papillosus* and

Trichuris ovis. Most prevalent species was *Nematodirus spathiger* (28.66%). Highest prevalence and mean eggs count per gram of faeces (EPG) were found in young animals (≤1year old) as compared to adults ($P<0.05$). Sex related prevalence indicates that infections were more common in males but association was not significant ($P>0.05$). No association between management practices and prevalence of GIT nematodes was detected but infection rate and mean EPG was higher in house hold animals as compared to commercially raised animals ($P>0.05$). Body condition, faecal consistency, concurrent diseases and anaemia were not risk factor for the occurrence of nematodes in this study ($P>0.05$).

Gonfa *et al*. (2013) was carried out from November 2011 to March 2012 with the objective of determining the prevalence, species and worm burden of abomasal nematodes of sheep and goats slaughtered at Helmex export abattoir in Debre Zeit, central Ethiopia. A total of 199 sheep and 185 goats' abomasums were subsequently collected and examined for adult parasites. Of these, 333 (86.7%) were positive for one or more abomasal nematodes. The overall prevalence was 86.5% in goats. The recovered species were identified as *Haemonchus contortus*, *Trichostrongylus axei* and *Teladorsagia* species in both animals. Statistically significant difference ($P>0.05$) was not found between hosts and ages in prevalence of these parasites. However, statistically significant difference ($P<0.05$) was noticed between the level of prevalence and different body conditioned animals. The highest prevalence was in poor body condition (94.4%). The current study epitomized that the prevalence of nematodiasis were high and consequently; sustainable control programs should warrant.

Tsegabirhan *et al*. (2013) was observed statistically significant difference ($P< 0.05$) among body condition of animals in relation to the parasite was recorded in animals with poor body condition (71.5%), followed by medium body condition (36.7%) and the lowest was recorded in animals having good body condition (19.5%).

Fentahun and Luke (2012) was performed with an attempt to determine the prevalence and associated risk factors of haemonchosis in randomly selected slaughtered goats in restaurants and hotels in Gondar town, Amhara region, northwest Ethiopia from November 2011 to April 2012. A total of 49 goats were examined. Overall prevalence was 80.21%. The specific prevalence of *Haemonchus contortus* infection was 73.5% in goats. Concerning the prevalence of haemonchosis in different body conditioned animals, higher prevalence was observed in medium body conditioned (81.6%) than good body conditioned ones (75%). There was no significant difference (P>0.05) in prevalence of the disease between both groups.

Negasi *et al*. (2012) was studied was conducted from November 2011 to March 2012 to determine the prevalence of gastrointestinal (GI) helminth infections and associated risk factors in sheep and goats in and around Mekelle town, Northern Ethiopia. A total of 150 goats faecal samples were collected and examined using standard parasitological procedures. The higher prevalence of helminthiasis was observed in poor body condition animals (97.77%) compared to medium (60.71%) and good (35.63%) body conditioned animals. There was a statistical significant difference ($X^{2=}$66.080 and (P<0.05) between different body conditioned scores.

2.12.2. Effects of management practices on the epidemiology of haemonchosis

2.12.2.i. Husbandry system influence the epidemiology of haemonchosis

Blackie (2014) was studied the gastrointestinal nematode parasites infecting small ruminants (sheep and goats) in Ghana and the epidemiological factors influencing their prevalence are reviewed and discussed. Twelve nematode species belonging to six families have been reported to infect these livestock in the country with *Haemonchus contortus* being the most prevalent helminth parasite in both animals. Parasitic gastroenteritis is caused by mixed infection of several nematode species**.** Management/husbandry practices, climate and host influence are found to be the main factors that affect gastrointestinal nematode infections in sheep and goats.

Badran *et al.* (2012) was investigate the prevalence of gastrointestinal parasites (GIP) in goats and sheep kept under extensive and intensive management systems in the district of Jenin, Palestine, during the period from January to December 2010. Factors affecting diversity, distribution and intensity of infection by GIP were investigated. Data about farm history and breeding management were collected by means of a questionnaire. A total of 810 faecal samples from small ruminants composed of 285 and 525 samples from intensive and extensive rearing systems, respectively, were collected from eight villages (Yamoun, Bet qad, Merkah, Talfeet, Kfaret, Tarem, Jab`a and Aneen). A total of thirteen genera of the GIPs, included (eleven nematodes, one cestode (*Moniezia*) and one protozoan (*Eimeria*) were recovered. The results showed fewer diversity of GIP in intensive rearing system. The prevalence of GIPs in animals reared under extensive system (26.5%) was significantly higher (P< 0.01) than those reared under intensive system (7.9%). The prevalence values of GIPs differed significantly (P<0.01) between some villages. The highest prevalence of infection (30.8%) was in Tarem with a proportion of (21.1 %) and the lowest (7.7%) in Betqad with a proportion of (5.3%). The dominant parasite was *Eimeria* spp (81.1% prevalence and 34.2% proportion) of total parasites in the area. This was followed by *Dictyocaulus* spp (49.1% prevalence, 20.7% proportion) and *Haemonchus* spp (23.1% prevalence and 9.7% proportion). Results showed that, animals kept under intensive grazing system had lower prevalence of GIP with low diversity (*Eimeria* spp, *Dictyocaulus* spp, *Trichostrongylus* spp, *Neoscaris* spp, and *Ascaris spp* than animals kept under extensive grazing system (*Eimeria* spp, *Dictyocaulus* spp, *Haemonchus* spp, *Moniezia* spp, *Trichostrongylus* spp, *Strongylus* spp, *Neoscaris* spp, *Nematodirus* spp, *Strongyloides* spp, *Ascaris* spp, *Cooperia* spp, *Chabertia* spp and *Trichuris* spp).

Rateb *et al.* (2012) was undertaken to investigate the prevalence of gastrointestinal parasites (GIP) in goats and sheep kept under extensive and intensive management systems in the district of Jenin, Palestine, during the period from January to December 2010. Factors affecting diversity, distribution and intensity of infection by GIP were investigated. Data about farm history and breeding management were collected by means of a questionnaire. A total of 810 faecal samples from small ruminants composed of 285 and 525 samples from intensive and extensive rearing systems, respectively, were collected from eight villages (Yamoun, Bet qad, Merkah, Talfeet, Kfaret, Tarem, Jab`a and Aneen). A total of thirteen genera of the GIPs, included (eleven nematodes, one cestode (*Moniezia*) and one protozoan (*Eimeria*) were recovered. The results showed fewer diversity of GIP in intensive rearing system. The prevalence of GIPs in animals reared under extensive system (26.5%) was significantly higher (P<0.01) than those reared under intensive system (7.9%). The prevalence values of GIPs differed significantly (P< 0.01) between some villages. The highest prevalence of infection (30.8%) was in Tarem with a proportion of (21.1 %)

and the lowest (7.7%) in Betqad with a proportion of (5.3%). The dominant parasite was *Eimeria* spp (81.1% prevalence and 34.2% proportion) of total parasites in the area. This was followed by *Dictyocaulus* spp (49.1% prevalence, 20.7% proportion) and *Haemonchus* spp (23.1% prevalence and 9.7% proportion). Results showed that, animals kept under intensive grazing system had lower prevalence of GIP with low diversity (*Eimeria* spp, *Dictyocaulus* spp, *Trichostrongylus* spp, *Neoscaris* spp, and *Ascaris* spp than animals kept under extensive grazing system (*Eimeria* spp, *Dictyocaulus* spp, *Haemonchus* spp, *Moniezia* spp, *Trichostrongylus* spp, *Strongylus* spp, *Neoscaris* spp, *Nematodirus* spp, *Strongyloides* spp, *Ascaris* spp, *Cooperia* spp, *Chabertia* spp and *Trichuris* spp). The occurrence of parasites with zoonotic significance (*Eimeria* spp, *Dictyocaulus* spp and *Haemonchus* spp) is discussed.

Nor-Azlina *et al.* (2011) was conducted to investigate the effects selected management practices have on worm burden in goats as reflected by faecal egg counts. The faecal examination of six goat farms for the quantitative presence of strongyles was conducted in Terengganu. A questionnaire was developed and directed to six farmers on the management practices adopted on their farms. The management practices selected in the study was grazing time, mineral block supplementation, type of drug used, breed, and source of animal, grass type, additional feed, and drenching personnel. The data analysis was done through systematic approaches using t-test, Spearman correlation and ANOVA. Afternoon grazing reduced the mean FEC nearly five-fold compared to morning grazing and mineral block supplementation reduced FEC two-fold compared to unsupplemented goats ($P<0.05$).

Rabbi *et al.* (2011) was studied the parasitism in goats in relation to different feeding systems, 1110 goats from different areas of Jaypurhat, Tangail, Netrakona and Mymensingh districts were examined. By fecal sample examination, 76.5% goats were found to be infected with one or more species of endoparasites. Prevalence of helminths and protozoa was significantly ($P<0.01$) highest in extensive system (86.1%) followed by semi-intensive (76.3%) and intensive system (57.5%). Goats of extensive and semi-intensive systems were 4.6 and 2.4 times more susceptible to helminth infection than those of intensive system.

Tariq *et al.* (2010) reported the diverse agro-climatic conditions, animal husbandry practices and pasture management, largely determine the type, incidence and severity of various parasitic diseases.

Mohanta *et al.* (2007) reported the diverse agro-climatic conditions, animal husbandry practices and pasture management, largely determine the type, incidence and severity of various parasitic diseases.

Regassa *et al.* (2006) reported that the prevalence and the severity of infection of GIPs have been shown to vary considerably among locations due to differences in environmental conditions and management practices.

Magona and Musisi (2002) reported that the prevalence and the severity of infection of GIPs have been shown to vary considerably among locations due to differences in environmental conditions and management practices.

Urquhart *et al.* (1996) reported that animal management practice considered as important factor in the contamination of the pasture with eggs and infective larvae of gastro-intestinal nematodes especially, when the climate conditions are optimal for development of infective larvae.

2.12.2.ii. Effects of floor of housing on the epidemiology of haemonchosis

Hasan *et al.* (2011) was carried out to measure the prevalence of ecto and endopatasites in semiscavenging Black Bengal goat (*Capra hircus*) at Pahartali Thana under Chittagong district, Bangladesh during the period of February to May/2006. The overall prevalence of gastrointestinal helminths in goat were 63.41% (N=317). Goat maintained on muddy floor was infected more with parasitic infestation than slatted floor and this may be explained as due to low level of hygiene and favored re-infestation.

Jugessur *et al.* (1998) was conducted a survey and reported that 35.3% of the infected goats had above 300 epg in faeces. It was observed goat maintained on muddy floor was infected more with parasitic infestation than slatted floor and this may be explained as due to low level of hygiene and favored re-infestation.

Devendra and Mc Leroy (1982) was reported poor housing can cause adverse effects in goats resulting in pneumonia and increased parasitic infestation.

2.12.2.iii. Effects of deworming status of goats on the epidemiology of haemonchosis

Schoenian (2013) was conducted Ivermectin as well as albendazole and fenbendezol (both benzimidazoles) have produced the highest levels of resistance, and resistance with levamisole and moxidectin is increasing.

Nolan (2004) was reviewed resistance to these drugs is high because each one uses a specific mechanistic pathway to kill *H. contortus*. For example, ivermectin binds to glutamate-gated channels in the worm's nervous system, opening them, paralyzing the worm and killing them through starvation.

Taylor *et al.* (2002) was studied the failure of anthelmintics to control GIT nematodes may also be due to reasons other than resistance, such as poor maintenance of drenching equipment, and under-dosing due to errors in assessing body mass.

Githigia *et al.* (2001) was studied the effectiveness of grazing management in controlling gastro-intestinal nematodes in weaned kids on pasture though the dose and move strategy (method) and reached to the results that weaning kid at the beginning of July and moving them before the expected mid-summer rise in herbage infection to a clean pasture will prevent gastro-intestinal nematode infections and achieve good production whether the move is accompanied by anthelmintic treatment or not.

Hertzberg *et al.* (2000); Chandrawathani *et al.* (2003); Melo *et al.* (2003) were reported the misuse and or widespread intensive use of sometimes poor quality synthetic or semi-synthetic anthelmintics, inappropriate route of administration and massive re-exposure has lead to development of high level multiple anthelmintic resistance against the three main families of anthelmintic drugs, namely, Benzimidazoles, Macrocyclic lactones and Imidazothiazoles.

Waller (1999) goats with regular anthelmintic treatment was the lowest prevalence rate due to continued use of anthelmintics has had the effect of increasing the frequency of resistant alleles in parasite populations due to the selective effect of the drugs, and anthelmintic resistance has become sufficiently widespread and serious as to threaten the viability of sustainable small ruminant production in many countries.

Machen *et al.* (1998) was observed actions that cause increased resistance include frequent dosing, under dosing to save money, inappropriate administration, wrong anthelmintic choices, and massive re-exposure to the parasites.

Assoku (1981) was evident that routine prophylactic drenching at regular intervals with different anthelmintics has a significant lowering effect on the total worm burden.

2.12.2.iii. Effects of feeding system of goats on the epidemiology of haemonchosis

Nor-Azlina *et al.* (2011) was conducted to investigate the effects selected management practices have on worm burden in goats as reflected by faecal egg counts. The faecal examination of six goat farms for the quantitative presence of strongyles was conducted in Terengganu. Afternoon grazing reduced the mean FEC nearly five-fold compared to morning grazing and mineral block supplementation reduced FEC two-fold compared to unsupplemented goats ($P<0.05$).

Bilal *et al.* (2009) was reported that the higher incidence of worm infestation in grazed animals as compared to stall fed animals might be due to picking of worm eggs shed by the infected animals during grazing through faeces.

Hsiang *et al.* (1990) studied 4534 faecal samples, collected in Taiwan over a three year period from randomly selected dairy goats for parasites. The most frequent parasites found were *Oesophagostomum* spp. (19%), *Haemonchus contortus* (17.3%), *Strongyloides papillosus* (8.5%), *Ostertagia ostertagi* (7.1%) and *Trichostrongylus colubriformis* (6.8%). It was also observed goats with access to pasture were more commonly infected than goats which fed indoors (penned goats).

2.12.2.iv. Effects of herd-size of goats on the epidemiology of haemonchosis

Hasan *et al.* (2011) was reported large flock size was more infected to parasitic infestation (both by ecto- and endoparasites) than the smaller ones and this is due to direct contact, overcrowding and unhygienic condition of goat farm.

2.12.3. Epidemiology of haemonchosis related to environmental factors

Attindehou *et al.* (2012) was conducted was carried out from December 2010 to November 2011 in order to establish the epidemiology of *Haemonchus contortus* infections in small ruminants of Benin. A total of 756 abomasums, collected from randomly selected goats and sheep from all regions of Benin has been examined. An examination of the conjunctiva's colour has been associated with parasitic diagnosis to assess the degree of anaemia in animals. The study disclosed an endemic evolution of Haemonchosis. The overall prevalence was of 55.56% with a mean burden of 175 worms per infested animal. The prevalence of Haemonchosis was higher in wet seasons (79.41%) than in dry (36.06 %). The worm's burden was also higher in rainy seasons than dry elsewhere, a strong correlation ($P<0.001$) was found between the conjunctiva colour and the worm burden but with a reverse influence of the season. In rainy seasons, degrees of anaemia have been low even though worm burdens were high. Inversely, moderate worm burdens induced detectable anaemia during dry seasons.

Musongong *et al.* (2011) was studied the prevalence and intensity of *Haemonchus contortus* in two breeds of small ruminants namely Borno Red goats and Borno White sheep in Maiduguri, an arid zone of Nigeria, were investigated in the rainy season (May - September) of 2010. A total of 60 abomasa were purchased from the central abattoir in Maiduguri. Thereafter they were processed in the laboratory for total worm count. Results showed that both breeds of small ruminants were infected with *H. contortus* during the rainy season and both prevalence and intensity of infection in both breeds were highest during the month of August. However significantly ($t < 0.05$) more sheep, 22 out of 27 (81.5%), than goats, 18 out of 33 (54%), were infected and the mean monthly intensities of infection were 136.59±35.15 worms for sheep and 41.85±12.48 worms for goats.

Nizam (2013) was reported the seasonal prevalence of helminth infection revealed the highest infection in summer (73.46%) and lowest in winter (32.35%) whereas in spring (68.18%) and 51.16% in autumn were recorded.

Nasreen *et al.* (2011) was studied that the prevalence of gastrointestinal nematodes of goats (n=1065) in and around Hyderabad using qualitative and quantitative coprological examinations. Results revealed that 43.10% (459) goats were infected with different species of nematodes including *Haemonchus contortus* (14.65%) *Trichuris ovis* (8.17%), T*richostrongylus axei* (7.61%), *Trichostrongylus colubriformis* (6.76%), *Oesphagostomum columbianum* (5.35%), *Ostertagia circumcincta* (5.35%), *Chabertia ovina* (4.79%) and *Strongyloides papillosus* (4.51%). Infections with mixed species of nematodes were recorded in 6.54% (n=30/459; *T. ovis* + *H. contortus*), 5.23% (n=24/459; *C. ovina* + *H. contortus*), 5.88% (n=27/459; *S. papillosus* + *C. ovina*), and 12.42% (n=57/459; *O. circumcincta* + *T. ovis*) goats. The prevalence, nature and intensity of the helminthiasis in goats warrant an immediate attention to devise strategies for its control to reduce the production losses.

Tariq *et al.* (2010) investigate the seasonal epidemiological prevalence of gastro-intestinal nematodes (GINs) of goats with respect to sex and age of the host in the Kashmir valley. A total of 1267 goats were examined. The overall prevalence of GIN infection in these animals was 54.3%. The different parasites reported with their respective prevalences (%) were*: Haemonchus contortus* (48.3); *Bunostomum trigonocephalum* (30.1); *Chabertia ovina* (29.8); *Ostertagia circumcincta* (29.8); *Nematodirus spathiger* (25.2); *Trichostrongylus* spp. (25.1); *Oesophagostomum columbianum* (23.5); *Trichuris ovis* (19.0); and *Marshallagia marshalli* (16.6). Infection rate was found maximum in summer and lowest in winter. No significant changes were observed in the GIN infection in goats among male and female. With the increase in host age, prevalence of infection decreased significantly.

Maposa (2009) was conducted in four areas in the communal area of Gweru District in the Midlands Province, Zimbabwe. The study was conducted at Mkoba, Mangwande, Chiwundura and Nsukamini. The objective of the study was to determine the prevalence of nematode infection in communal goats in Gweru District, and whether or not the prevalence was related to age, sex, breed or the season. The study was important as it would help in evaluating current strategies used in nematode control and designing low cost control strategies. One hundred and ninety-eight (198) communal goats made up of 49 males and 149 females ranging in age from one month to over twelve months were sampled. Of these, 100 were sampled during the wet season and the remaining 98 during the dry season. One hundred and fifteen (115) or 58% had significant egg counts per gram (epg) of faeces. Among the goats that had significant epg, 31 were males and 84 were females. All age groups were affected. The most common parasites encountered were *Haemonchus, Trichostrongylus, Teladorsagia and Oesophagostomum. Haemonchus* was the dominant species during the wet season. The proportion of goats that had a significant EPG during the wet season was significantly higher than during the dry season (X2=5.311; P≤0.05). There was no statistical significant difference in prevalence among the different age groups (X2=1.270; P≤0.05) and between males and females (X2=0.696; P≤0.05).

Mbuh *et al.* (2008) reported that certain endo and ectoparasites that were abundant and caused problems on the pastures to both animals and farmers. *Haemonchus contortus* was the most prevalent species with a prevalence of 94.23%. The highest prevalence was noted during August and there was a significant difference (P< 0.05) from the other months.

Qamar *et al*. (2009) was studied the epidemiology, serodiagnosis, economic losses and control of haemonchosis in sheep and goats in Lahore, Pakistan 2007-2008. It was designed to record the prevalence of haemonchosis in sheep and goats under different ecological and managerial conditions. A total 9600 goats were examined of these 3096 were found positive for haemonchosis so prevalence was 35.25%. It was observed epidemiological studies of Haemonchosis in sheep and goats at slaughterhouses, livestock farms and veterinary hospitals under the different climatic conditions existing in Punjab province (Pakistan). Infection rate of haemonchosis was 35.44%, 38.04% and 36.83%, respectively in slaughtered sheep and goats, sheep and goats at livestock farms and at veterinary hospitals. Overall the highest (43.69%) seasonal prevalence in all types of sheep and goats was recorded during summer; followed by autumn (38.46%), spring (37.12%), while the lowest (28.79%) was recorded during winter. It was also noted that temperature, humidity and rainfall play very important role in the causation and spread of disease, the highest prevalence was noted during summer, where the temperature, humidity and rainfall were quite favorable for the development and hatching of larvae of *Haemonchus contortus*. It was also noticed that there was maximum grazing in that season. He also studied that seasonal change might alter the

Haemonchus epidemiology so the effectiveness of control strategies must be taken into consideration. He also suggested that the higher number of *Haemonchus contortus* eggs were shed in faeces of infected animals from July to October.

Ramadan (2009) studied that the weather conditions of rainy summer season are favorable for survival and transmission of gastrointestinal nematodes in sheep flocks. The third infective larvae (L_3) are available on pasture throughout of year and play important role in the epidemiology of gastrointestinal nematodes. The L_4 of gastrointestinal nematodes showed prone to inhibit/arrest during cold dry months of the year (dry season).

O'Connor *et al.* (2008) conducted an experiment (3×4×2×3) in programmable incubators to investigate interaction between the effects of rainfall amount, rainfall distribution and evaporation rate on development of *Haemonchus contortus* to L_3. Sheep faeces containing *haemonchus contortus* eggs were incubated on sterilised soil under variable temperatures typical of summer in the Northern Tablelands of NSW, Australia. Simulated rainfall was applied in 1 of 3 amounts (12, 24 or 32 mm) and 4 distributions (a single event on the day after deposition, or the same total amount split in 2, 3 or 4 equal events over 2, 3 or 4 days, respectively). Samples were incubated at either a low or high rate of evaporation (Low: 2.1–3.4 mm/day and High: 3.8–6.1 mm/day), and faeces and soil were destructively sampled at 4, 7 and 14 days post deposition. Recovery of L_3 from the soil (extra-pellet L_3) increased over time (up to 0.52% at day 14) and with each increment of rainfall (12 mm: <0.01%; 24 mm: 0.10%; 32 mm: 0.45%) but was reduced under the high evaporation rate (0.01%) compared with the low evaporation rate (0.31%). All rainfall amounts yielded significantly different recoveries of L_3 under Low evaporation rates but there was no difference between the 12 and 24 mm treatments under high evaporation rate. The distribution of simulated rainfall did not significantly affect recovery of infective larvae. Faecal moisture content was positively associated with L_3 recovery, as was the ratio of cumulative precipitation and cumulative evaporation (P/E), particularly when measured in the first 4 days post deposition. The results showed that evaporation rate plays a significant role in regulating the influence of rainfall amount on the success of L_3 transmission.

Pathak and Pal (2008) was studied on the prevalence of gastrointestinal parasites in goats revealed that the percentage of overall prevalence of infection was 85.22%. The prevalence of different parasites encountered were *Paramphistomum* spp. (80.68%), *Cotylophoron* spp. (45.45%), *Moniezia* spp. (17.04%), *Avitellina* spp. (3.40%), *Haemonchus* sp. (26.13%), *Trichostrongylus* spp (5.68%), *Cooperia* spp. (3.40%), *Oesophagostomum* spp. (30.68%), *Bunostomum* sp. (5.68%) and *Trichuris* sp. (27.27%). Seasonal prevalence was highest in monsoon (94.60%), moderate in summer (87.50%) and lowest in winter.

Silva *et al.* (2008) studied the vertical migration of *Haemonchus contortus* third stage larvae (L_3) on Brachiaria decumbens grass, as well as at verifying whether larval numbers on pasture varies over the day due to climatic conditions. Feces containing *haemonchus contortus* L_3 were deposited on the soil in the middle of herbage which was initially 30 cm high Haemonchus Seven days later, samples of different herbage strata (0–10, 10–20 and >20 cm), remaining feces and a layer of approximately 1 cm soil were collected. Tests were carried out in four periods: September 2006, December 2006, March 2007, and June 2007. Samples were collected at sunrise, mid-day, sunset, and mid-night. The humidity and temperature conditions observed in different months influenced larval migration from the feces to the grass. In September, December and March, it rained after fecal deposition on pasture, which favored migration of larvae from the feces to the herbage. Conversely, in June 2007, when there was no rainfall after fecal deposition and temperatures were lower, L_3 were mainly recovered from feces. As regards the vertical migration of larvae, the numbers of *Haemonchus contortus* L_3 in the forage strata remained relatively constant over the day. This indicated that there is no determined period in which sheep on pasture are at higher risk of infection. Finally, in all collection periods a considerable amount of third stage larvae were observed on the herbage top, which is the first plant part consumed by animal.

Van Dijk *et al.* (2008) studied the influence of temperature and moisture on the free-living stages of gastrointestinal nematodes, and evidence for global climate change is mounting, serious attempts to relate altered incidence or seasonal patterns of disease to climate change are lacking. In Great Britain, veterinary surveillance laboratory diagnoses of ovine parasitic gastroenteritis (PGE) have been categorized in species groups and recorded since 1975. Here we present a detailed analysis of these historical data. Over the past 5–10 years, highly significant increases in the overall rate of diagnosis of PGE were observed for all species categories. After identifying and analyzing possible sources of bias, the effect of climate change on parasite epidemiology proved the most likely explanation for the observed patterns, although other hypotheses could not be refused. Seasonal rates of diagnosis suggest that, in line with increases in temperature, fewer larvae of *Teladorsagia* and *Trichostrongylus* species survive the winter and spring at pasture, while the windows of transmission of these species, and of *Haemonchus contortus*, have extended into the autumn. For all species categories significant differences in rates of diagnosis, and in the seasonality of disease, were identified between regions. Nematodiaosis showed a pronounced peak in spring and early summer in Scotland while in the Southwest, where fewer diagnoses were made, it also appeared regularly at other times of year. The data presented serve as a baseline against which future changes can be measured.

Chaudary *et al.* (2007) reported the prevalence and seasonal trend of the *Haemonchus contortus* in sheep and goats from December 2004 to January 2006. Faecal samples collected from 968 sheep and 961 goats of different breeds were examined by the modified McMaster technique. Results revealed that the infection was significantly (P<0.05) higher in sheep compared to goats. The highest rate of infection was recorded during rainy season (July-October) whereas, the lowest infection during December to May. In sheep, the highest log faecal egg counts (LFECs) were recorded in Islamabad, followed by Attock, Jhelum and Chakwal. However, in goats the LFECs trend was the highest in Islamabad, followed by Jhelum, Attock and Chakwal districts. A significant (P<0.05) variability in LFECs was noted between sheep and goat breeds from site to site, while no significant difference was observed between breeds at the same site. Hairy (Jattal) goats and Salt-Range (Latti) sheep breeds exhibited significantly reduced LFECs level along with higher packed cell volume (PCV) and haemoglobin (Hb) levels compared to other breeds.

Chaudary *et al*. (2007) was carried out to investigate the prevalence and seasonal trend of the *Haemonchus contortus* in sheep and goats in the Potohar areas of northern

Punjab, Pakistan from December 2004 to January 2006. Faecal samples collected from 968 sheep and 961 goats of different breeds were examined by the modified McMaster technique using saturated solution of sodium chloride. Results revealed that the infection was significantly ($P<0.05$) higher in sheep compared to goats. The peak infection level was recorded during rainy season (July-October). On the other hand, low infection level was noted from December up to May.

Nwosu *et al.* (2007) carried out a survey to determine the prevalence and seasonal abundance of the egg and adult stages of nematode parasites of sheep and goats in the semi-arid zone of north-eastern Nigeria between January and December 2002. Faecal samples collected from 102 sheep and 147 goats and examined by the modified McMaster revealed that 44 (43.1%) and 82 (55.8%) of the samples, respectively contained at least one nematode egg type. Out of the 75 goats examined at necropsy, 39(52%) contained adult nematode species. Seven genera of adult nematodes including *Strongyloides*, *Trichostrongylus*, *Haemonchus*, *Trichuris*, *Cooperia*, *Oesophagostomum* and *Bunostomum* species were encountered during the study. *Bunostomum* species were recorded only insheep. Adult worm burdens were generally low and showed seasonal variation that corresponded with the rainfall pattern in the study area during the period. *Haemonchus* and *Trichostrongylus* species attained peak counts together in both goats (June). The results suggest that *Haemonchus*, *Trichostrongylus* and *Strongyloides* species may be the major contributors to small ruminant helminthiasis in the study area.

O`Connor *et al*. (2006) reported the main factors which affect the development and survive of infective larvae in pasture undoubtedly are temperature and moisture (relative humidity), other factors most likely mediated by modulation of this microclimate.

Regassa *et al*. (2006) reported that the prevalence and the severity of infection of GIPs have been shown to vary considerably among locations due to differences in environmental conditions and management practices.

Iqbal *et al.* (2005) studied the epidemiology of gastrointestinal nematodes of sheep and reported that the availability of infective larvae in the pasture was increased during the monsoon season. This may be due to the favourable temperature and humidity was existed for development and survival of pre-parasitic stages of these parasites.

Troell *et al*. (2005) was studied the effects of cold storage of infective third-stage larvae (L_3) of different isolates of the parasitic nematode *Haemonchus contortus* were studied with respect to infectivity, pre-patent period and propensity for larval arrestment. Two complementary experiments were conducted with 2 groups of lambs, each animal being inoculated with 2000 L_3 of either Swedish or Kenyan origin. In a first experiment, L_3s were cold treated at 5°Ċ for 9 months prior to infection, whereas in a second experiment larvae were newly hatched. Individual faecal egg counts (FECs), and worm burdens were determined for each experiment. The results showed that the greatest differences were associated with the pre-treatment of larvae. The pre-patent period and the FECs differed significantly between the experiments but not between the isolates used in each experiment. However, the extent of hypobiosis was significantly different between the two isolates when fresh larvae were used (36% Kenyan isolate and 70% Swedish). The storage of H. contortus at 5°Ċ had no apparent effect on the infectivity of L_3s, as high establishment ranging from 43 to 74% were observed, irrespective of isolates used. This study showed that *H. contortus* exhibited similar phenotypic traits regardless of geographical origin. Thus, there was limited evidence for adaptations to temperate climatic conditions.

Waller and Chandrawathani (2005) reported that *Haemonchus contortus* is the most important parasite of small ruminants (sheep and goats). This is particularly more so now, with the development of high levels of resistance to both the broad and narrow spectrum anthelmintic drugs in *Haemonchus contortus* throughout the world. Epidemiological studies revealed that the lower environmental limits for haemonchosis to occur in sheep, as being a mean monthly temperature of 18ºC and approximately 50mm rainfall. Thus *Haemonchus contortus* is a problem parasite restricted to the warm, wet countries where sheep and goats are raised. Thus the need for sustainable control strategies for *Haemonchus contortus* is becoming much more pressing.

Waller *et al*. (2005) was describe the lower environmental limits for haemonchosis to occur in sheep, as being a mean monthly temperature of 18ºC and approximately 50 mm rainfall. Thus it has been generally recognized that *H. contortus* is a problem parasite restricted to the warm, wet countries where sheep and goats are raised. However, recent evidence shows that this parasite is apparently common even in northern Europe. Thus the need for sustainable control strategies for *H. contortus* is becoming much more pressing. This report highlights two examples of sustainable and highly efficient control programmes for *H. contortus,* that can be implemented in regions at the extremes of its geographic range (Malaysia and Sweden), where the authors have had direct involvement.

Waller *et al.* (2004) studied that the enhanced larval survival during winter leads to increased larval availability during spring and summer season. The decrease in haemonchosis during summer could be attributed to decreased larval survival during winter and spring at higher temperatures. Higher summer temperatures increase the proportion of ingested larvae that develop into adults and cause haemonchosis in the following months, rather than they enter into hypobiosis.

Shahiduzzaman *et al.* (2003) was studied the seasonal influence on the occurrence of *Haemonchus contortus* on 672 slaughtered Black Bengal goats during one year period from 2002 to June 2003.An overall 65.63% goats had *H.contortus* infection and significantly ($P<0.01$) higher infection was recorded in female (70.43%) than male (58.61%).A positive correlation between the occurrence of *H. contortus* infection and climatic factors was recorded. Significantly ($P<0.01$) highest infection rate of *H.contortus* was recorded during rainy (72.57%) season in comparison to Summer (66.46%) and winter (51.54%) seasons. The infection was recorded at the peak in July (84.42%) and lowest in January (46.15%). The load of *H.contortus* per abomasums was recorded in July (41.25) and the minimum in March (5.52). In case of sex ratio of the parasites always the female (60.73%) were found to be dominated over the males (39.27%) parasites.

Magona and Musisi (2002) reported that the prevalence and the severity of infection of GIPs have been shown to vary considerably among locations due to differences in environmental conditions and management practices.

Maqbool *et al.* (1997) conducted an epidemiological study haemonchosis in slaughtered and live goats under local climatic conditions. The overall infection rate was 18.18% and 17.54% in live and slaughtered goats. In slaughtered animals, the highest month wise prevalence was reported during March (28.57%) whereas the lowest in July (7.69%). In live animals, the peak prevalence was observed in April (28.20%) while the lowest during August (12.43%). In slaughtered animals, the spring season was most strongly associated with the occurrence of disease (24.56%) followed by winter (16.76%), summer (15.33%) and the lowest during autumn (14.18%). In live animals, the highest Prevalence was noted during spring (24.81%), followed by summer (17.02%), then autumn (16.96%) and the lowest during winter (16.72%).

Urquhart *et al*. (1996) reported that animal management practice considered as important factor in the contamination of the pasture with eggs and infective larvae of gastro-intestinal nematodes especially, when the climate conditions are optimal for development of infective larvae.

Wanyangu *et al.* (1995) conducted analysis for the periods of years with climatic conditions suitable for prolonged survival on pasture and hence increased chances of transmission of *Haemonchus contortus* L_3 larvae to livestock on different agro-climatic zones of Kenya. Data on mean total monthly rainfall mean maximum and mean minimum monthly temperature covering a span of 30 years from 81 sites was analysed. Based on the results of analysis obtained, a strategic anthelmintic control programme for Kenya and the East African regions with similar climate potential are suggested. In wetter areas, all grazing livestock were to be treated twice during the period of short rains (November-December) at 3- week interval, and again just before the onset of rainy season (late February). In drier areas, effective strategic anthelmintic control of *Haemonchus contortus* could be achieved by treating all livestock immediately after the long rains (May-June) and after the short rains (January-February).

Besier and Dunsmore (1993) reported that rainfall play very important role in the spread of disease i.e., spread of *Haemonchus contortus* larvae from one place to another. High temperature high humidity during summer is very helpful in the causation of disease. The highest larval count on pasture was seen during summer. Environmental conditions are favorable for propagation and development of larvae.The results showed that infected animals harboured *Haemonchus contortus* infection with varied incidence in all areas throughout the year. It demonstrated that there were substantial worm burdens of *Haemonchus contortus* in all the animals of the study areas.

Yadav and Tandon (1989) was studied twelve hundred and twenty-eight goats *(Capra hircus* L.) from a sub-tropical and humid zone of India, were examined for gastrointestinal nematodes. The species encountered in the region were: *Haemonchus contortus, Bunostomum trigonocephalum, Oesophagostomum columbianum, Trichuris globulosa, O. aspersum,* and *T. ovis.* The overall infection rate was 86.8%. Among various species found, *H. contortus* emerged as the most prevalent, although *B. trigonocephalum* and *O. columbianum* were also significantly in evidence. The seasonal fluctuation in infection was assessed by monitoring the faecal egg count of 1638 goats slaughtered during the 1-year period. The maximum values for the prevalence and overall mean eggs per gram of faeces (EPG) were observed after the heavy rainfall season and remained at a relatively high level from July to December. *H. contortus* and O. *columbianum* appear to be of major importance as parasites in the goats of this climatic zone.

Gupta *et al.* (1988) also reported that higher infection rate was probably due to warm and humid environmental temperatures ranging between 19°C and 37°C in the study area.

Asanji (1988) was studied the incidence of haemonchosis in sheep and goats in Sierra Leone showed a seasonal variation with a high peak in the dry season (October to January) and a low one from March to May. Mean relative densities were significantly higher in young hosts and showed two peaks, a high one from August to December and a low one from April to June while the mean relative densities of old hosts were low and exhibited an irregular seasonal pattern with no defined peaks. The peak seasons in young hosts coincided approximately with the dry and rainy seasons. Male hosts showed an overall higher but not a significant mean relative density than females but for most of the months mean relative densities of infection of female hosts were not significantly higher than those of males.

Armour (1986) reported that the accumulation of *Haemonchus* infective stages (L_3) from generations of adult parasites is accelerated at higher temperatures, leading to higher parasite burden during summer and thus increased risk of haemonchosis from summer to onwards.

2.13. Effects of study area on prevalence of haemonchosis in goat

AL-Hasnawy (2014) was conducted to investigate the infection rate in goats with haemonchosis in the Hilla city, Iraq, and showed that the *Haemonchus contortus* infection rate was 29.67% (27 of 91) in goats.

Teshale and Aragaw (2014) was conducted during during November, 2013 to March, 2014 to identify the species and to determine the burden of abomasal nematodes of small ruminants slaughtered in Bahir Dar town. A total of 115 goats were collected and examined according to the standard procedures. The prevalence of *Haemonchus* spp was 43.5% in goats.

Demissie *et al.* (2013) was conducted from November, 2011 to April, 2012. One hundred and seventy four (174) goats abomasum were examined according to the standard procedures. The prevalence of *Haemonchus* species was 76.4% for goats.

Garedaghi and Bahavarnia (2013) was carried out to determine the prevalence of abomasal nematodes of goats slaughtered in Tabriz town and observed were 73.1 % for *Haemonchus* spp.

Nuruzzaman *et al*. (2012) was studied the prevalence, species composition and worm burden of abomasal nematodes of goats slaughtered at different abattoir of Thakurgaon district, Bangladessh, The specific prevalence rate for *Haemonchus contortus* (58.00%).

2.14. Effects of examination procedure on the prevalence of haemonchosis in goat

Nabi *et al.* (2014) was recorded overall prevalence of gastrointestinal nematodes in goats was 40.67% during coproscopy.

Khajuria *et al.* (2013) was studied a total of 960 faecal samples of goats of stationary flocks of the middle agro-climatic zone of Jammu province were examined, out of which 67.24 % animals were positive for helminthic infection during coproscopy findings.

Singh *et al*. (2013) was reported the prevalence of gastrointestinal parasites in goats of Mathura region. A total of 240 faecal samples collected from three different farms were examined by direct smear, Willi's floatation and sedimentation techniques. Quantitative examination was done by McMaster's technique. Out of 240 samples processed 165 samples were found positive for gastrointestinal parasites. The overall prevalence was 68.75% during coproscopy findings.

Fentahun and Luke (2012) was reported 80.21% *Haemonchus* infection in randomly selected restaurants and hotels of Gondar Town, Ethiopia during postmortem examination.

Nuruzzaman *et al.* (2012) was 58% from Thakurgaon, Bangladesh and **Tefera *et al.* (2012)** from in and around Bedelle, South-western Ethiopia who reported the prevalence of *Heamonchus* spp. was 65% in slaughtered goats at post mortem examination.

Kumsa and Wossene (2006) was studied 82.9% *Haemonchus* infection in goats of Ogaden region slaughtered at Debrezeit Elfora abattoir during post mortem examination.

Shahiduzzaman *et al*. (2003) was observed the *Haemonchus* spp infection 65.63% from Mymenshingh, Bangladesh;

Hailelul (2002) was reported 54.76% *Haemonchus* infection in goats in and around Wollaita Soddo in necropsy findings.

Abebe and Esayas (2001) was recorded 100% *Haemonchus* infection in goats in the arid and semi arid zone of eastern confronted by amazingly very high prevalence rate of Ethiopia in necropsy findings.

Ahmed (1988) was observed 88.23% prevalence of *Haemonchus* spp in goats East wollega zone at Mechara settlement area in necropsy.

Demissie *et al.* (2013); Garedaghi and Bahavarnia (2013); Gupta *et al.* (2013) and Fentahun and Luke (2012) were found 75.2%, 73.1%, 77.83% and 73.5% *Haemonchus* spp infection respectively from slaughtered goats in different parts of the world during post mortem examination.

2.15. Effects of degree of infection on prevalence of haemonchosis in goat (Coproscopy)

Nasreen *et al.* (2011) had observed 51.4, 38.3 and 10.2% goats light, moderate and heavy infections, respectively the total infected 459 goats.

Tefera *et al.* (2009) was recorded 10.95% massively, 48.52% moderately, and 40.53% were lightly affected goats with gastro-intestinal parasites.

2.16. Effects of degree of infection on prevalence of haemonchosis in goat on abomasum examination (Necropsy)

Teshale and Aragaw (2014) was found 100% light infection by *Haemonchus* spp, whereas moderate and heavy degree of infection was not recorded in Northwest Ethiopia.

Almalaik *et al.* (2008) where majority of the goats were affected with light to moderate degree of infection.

Kumsa and Wossene (2006) was recorded majority of goats harboring adult abomasal nematodes with light to moderate degree of infection whereas only small proportions were with heavy degree of infection.

2.17. Morphology of female *Haemonchus* spp

2.17.1. Major vulvar morph types of female *Haemonchus* spp

Akkeri *et al.* (2013) was examined to determine the type of vulvar morphology in female *Haemonchus* worms collected from the abomasa of goats slaughtered for human consumption in Béja Abattoir in Tunisia with a Mediterranean type of climate. For the purpose, a total of 1662 female *Haemonchus* worms from abomasa of goats were thoroughly examined for the types of their vulvar flap. In goats a total of 1662 female worms were differentiated into 27.7%, linguiform, 65.8% knobbed and 6.4% smooth vulvar morph types.

Kumsa *et al.* (2008) was carried out to determine the type of vulvar process of 3187 and 2386 female *Haemonchus* worms recovered from naturally infected goats, during the period from August 2003 to March 2004. The study revealed that out of the total female worms from goats 53.8% linguiform, 18.5% knobbed and 27.6% smooth vulvar morph types were identified. Significant variations ($P<0.05$) were observed in proportions between the three major vulvar morph types in different months of the study period in goats.

Demissie *et al.* (2013) was conducted from November, 2011 to April, 2012. Two hundred and twenty two sheep and 174 goats' abomasum were examined according to the standard procedures. Female *Haemonchus* species vulvar morphology was characterized and linguiform vulvar morphology was the most and knobbed type vulva morphology was the least frequently identified vulvar type both from sheep and goats' worms with higher proportions of linguiform vulva from goats. However, this difference in vulvar morphology was not statistically significant ($P>0.05$). It was concluded that the variation in prevalence and vulvar morphotype was almost similar with little deviations between sheep and goats.

Gharamah *et al.* (2012) was studied some morphological characters of *H.contortus* in goats and sheep from the Kelantan State, Peninsular Malaysia. The the knobbed was predominant in *H. contortus* females recovered from goats (50%).

Gharamah *et al.* (2011) was investigated the population, host variation and Vulvar flap morphology of female *Haemonchus contortus* worms goats from two

Governorates in Yemen. Observations on female vulvar flap showed that linguiform morphs were predominant in goats (50%).

Kumsa (2009) was conducted to determine the prevalence, morphological characteristics and efficacy of albendazole and tetramisole against Ogaden isolate of *H. contortus* from August 2003 to March 2004. The overall prevalence of *Haemonchus* species was 82.93% goats. In goats, 53.83% linguiform, 18.45% knobbed and 27.61%, smooth vulvar morphs were observed. The study unveiled the coexistence and sympatry of two or three *Haemonchus* species in a single host that should be considered in the control strategy. Albendazole and tetramisole showed 100% efficacy against Ogaden isolate *H. contortus.*

Rahman and Hamid (2007) was studied the large stomach worm, *Haemonchus contortus* is an important pathogen of goats (*Capra hircus*). It was described the characteristics of vulvar morphology of *H. contortus* adults from the goats. Female *Haemonchus* worms recovered from goats for vulvar morph study, 26% linguiform, 64% knobbed and 10% smooth were recorded. The smooth morph was relatively rare in *H. contortus* for 10% in goats whereas knobbed and linguiform morphs were numerically well balanced with a slight predominance of knobbed females.

Thomas *et al*. (2007) was carried out to characterize vulvar morphs of female *Haemonchus* worms. Out of 448 female *Haemonchus* recovered from goats, 43.8 % had linguiform vulvar flaps, 27.2 % knobbed and 29 % smooth morph type

Eseta (2004) was conducted from August 2003 to March 2004 with an attempt to determine the prevalence, morphological characteristics and susceptibility of Ogaden isolate of *H. contortus* to Albendazole and Tetramisole. During the study period a total of 82 goats of Ogaden origin were examined. Out of 2386 female *Haemonchus* worms recovered from goats out of female *Haemonchus*, 53.83% linguiform, 18.45% knobbed and 27.61% smooth were recorded. Statistically significant difference ($P<0.05$) was observed among the three major vulvar flaps between different months of the study period in goats.

Riggs (2001) was examined effects on biology and morphology, *Haemonchus placei* infections. Sixty-three (63%) percent of females examined for vulvar flap morphology had knob-like vulvar flaps while the remaining 37% had linguiform vulvar flaps.

Jacquiet *et al.* (1995) was studied the four species of ruminants (dromedary, zebu cattle, sheep and goat) in arid areas of Mauritania harboured *Haemonchus* spp as the most frequent internal parasite. This was a rare situation where the three putative species, *H. longistipes* (dromedary), (zebu cattle) and *H. contortus* (sheep and goat) occurred sympatrically. The study was undertaken on hosts slaughtered at the Nouakchott abattoir, on the basis of monthly collection of worms. Traits of vulvar morphology are considered as markers of ecological adaptation and were studied. The knobbed and smooth female morphs (in equal proportions) were the most frequent in *H. longistipes*, the knobbed morph out-numbered the other morphs in *H. placei*, and all 3 morphs were present in sheep and goats with the linguiform form being predominant. The ecological, morphological and genetical studies showed that *H. longistipes*, *H. placei* and *H. contortus* could be arranged in increasing order of variability.

Mckenna (1971) was studied populations of *Haemonchus contortus* from 97 naturally infected sheep from 37 New Zealand localities were examined with particular reference to the incidence of the three female vulvar forms linguiform, knobbed, and smooth, and to the male spicular dimensions. On the basis of the former criteria two morphologically distinct populations were noted. In infections received from all North Island districts and the Nelson-Westland districts of the South Island, linguiform females predominated. The mean percentages of the three female morphs from these infections were: linguiform 85.6% (range 72-100%), knobbed 0.9% (0-5%), and smooth 13.5% (0-27%). In South Island infections received from the Otago-Canterbury districts, smooth females were more common. The mean percentages of the three morphs from these districts were: linguiform 26.5% (range 11-50%), knobbed 1.2% (0-3%), and smooth 72.3% (48-89%).

2.17.2. Linguiform subtypes of vulvar flap morph of adult female *Haemonchus* spp

Akkeri *et al.* (2013) was studied subclassification of linguiform from goats, of the total of 461 linguiform vulvar flap female worms, 48% LA type, 13.8% LB type, 21.6% LC type, 4.4% LD type and 12.3% LI linguiform subtypes were detected. The LA sub linguiform type was the most predominant in goats. An interesting finding of the their study was the documentation of a new type (LD) of sublinguiform vulvar flap type in female *Haemonchus* worms for the first time, from the Mediterranean type of climate in Tunisia

Kumsa *et al*. (2008) was carried out to determine the sub-classification of the linguiform female worms from goats revealed 27.4 % LA, 17.5% LB, and 6.6% LC and 2.3% LI subtypes were identified. Within the linguiform vulvar flap types, the A subtype linguiform showed statistically significant ($P<0.05$) fluctuation during the months of study period in goat.

Thomas *et al*. (2007) was studied a total of 196 linguiform female *Haemonchus* from goats were classified into 11.2 % LA, 12.2 % LB, 44.9 % LC and 31.6 % LI. Similar findings were observed in both host species regarding the worm burden, prevalence of infection and morphological pattern of *Haemonchus* species. Generally a high infection rate with abomasal nematodes was observed in goats of the study area.

Eseta (2004) was carried out a total of 1285 linguiform female *Haemonchus* spp from goat were identified as 27.35 % LA, 17.54% LB, and 6.63% LC and 2.31% LI. Within the linguiform morphotypes, the LA type linguiform was noted to exhibit monthly fluctuation ($P<0.05$) during the study period.

CHAPTER THREE

MATERIALS AND METHODS

The present study was to evaluate the prevalence of haemonchosis in goats under the host and different management practices in Rajshahi and Noagon district of Bangladesh and to study the morphology of *Haemonchus* spp during the the period from March, 2011 to December, 2013. The study area conducted at the Rajshahi and Noagon district which were districts in North-western Bangladesh and a part of the Rajshahi Division and the Parasitology laboratory in the Department of Animal Husbandry and Veterinary Science, University of Rajshahi. The Rajshahi district is situated between latitude 24 and 40°N and longitude 88 and 50 °E. Annual average temperature of this district is maximum 37.8°C, minimum 11.2°C. Annual rainfall is 1862 mm. The area of Rajshahi district is 2407.01 sq. km. Rajshahi district is bounded by Naogon district on the north, Natore district on the east, Chapai Noawabganj district on the west and the river Padma to the south. Metropolitan city Rajshahi is known as the silk city for the National Silk Board (In Bengali: Jatio Resham Board). The city stands on the bank of the river Padma. The area of the Rajshahi city is 96.69 sq km with a population of 646716. The Naogon district is situated between latitude 24°48.3′ N and longitude 88°57′ E. The area of Naogon district is total area of about 275.73 sq. km.

3.1. Selection of the Study Area

Greater Rajshahi district namely Rajshahi and Noagon were selected for the study. The main considerations in selecting the study area were as follows:

i. A large number of Black Bengal (local) and cross-bred goats were raised in greater Rajshahi.
ii. The study area is well communicated with Rajshahi University, which helped the researcher for collecting necessary data.
iii. Previously, no study of this type of research was conducted in this region.

Photograph 1: Map of Bangladesh where circle has been shown the study area.

3.2. Data collection procedure

Questionnaire survey was done with a well-structured prepared questionnaire format which was refined through informal and formal surveys (Thrusfield, 2007). It has been considered to design in a simple manner to get accurate information from the farmers, farm owner/farm attendant and abattoir in the study area. The researcher has conducted the experiment with the help of a farm register, butcher and other documents from goat farm as well as visual examination of experimental goats. Random cross-sectional survey was done during this research period. A total of 50 farmers, government, commercial and mini farms, veterinary hospital, various pasture lands, and slaughter houses present in the study areas were selected during this study period. The farmers, farm owner/attendants and butchers were interviwed and the main points included in the questionnaire were managemental systems i,e., husbandry system, deworming status, feeding system, type of housing (Appendix I). Furthermore, disscuss with them in which diseases or problems were generally outbreak and if possible given suggestions for goat development.

3.3. Study design and selection of animals

The present study was designed to assess the month-wise prevalence of haemonchosis of goats in district of Rajshahi and Noagon, Bangladesh and was conducted at laboratory, Animal Husbandry and Veterinary Science, University of Rajshahi during the period of one year (March, 2011 to February 2012) for epidemiological studies and next one year (January, 2013 to December, 2013) for the identification of the vulvar morphology of adult female *Haemonchus* spp in the study area. In this cross-sectional study, a total 720 goats were randomly selected from the villages, farms, pastures, veterinary hospitals, abattoirs and examined for *Haemonchus* infection [faecal examination (363), abomasum examination (357)]. Seasonal prevalence were studied throughout the year dividing into three seasons, winter (Nov-Feb.), Summer (March-June) and Rainy (July-Oct.) season.

3.4. Factors have been considered for the Study

Several factors were considered for the study and these are mentioned below:

3.4.1. Host related factors

3.4.1.a. Age of goat

Age groups were categorized following groups on the basis of farmer response, birth registration kept by the farmers, also age determination by dentition and farm attendants and observations made during sampling.

The age of goats were categorized in to following groups:

Group – I: Kid (<6 months) (n=124),

Group – II: Young (6 to 12 months) (n =153)

Group - III: Adult (>12 to < 24 months) (n=250) and

Group – IV: Older (> 24 months) (n=193)

Photograph 2: Kid (<6 months of age) of different breed.

Photograph 3: Young (6 to 12 months of age) goats.

Photograph 4: Adult (>12 to <24 months of age) goats.

Photograph 5: Older (>24 months of age) goats.

3.4.1.b. Sex of goat

Sex was determined by the findings of the external genitalia of selected goats. Female (n=404) [(Pregnant =50, Non-pregnant=354)] and male (n=316) goats were randomly selected for sample collection in the study area.

Photograph 6: Showing the doe/she goats at the study area.

Photograph 7: Male/he goats under the experiment.

3.4.1. c. Breed of goat

The country has a native goat breed commonly known as the Black Bengal goat and exotic breeds such as the Sirohi, Beetal and Jamnapari and crossbreds between the Black Bengal goat and exotics. Black Bengal goats are found all over the country. They can be classified into three sub populations; Bangladesh West (BBW), Bangladesh Central (BBC) and Bangladesh East (BBH); according to their geographical distribution. The exotic breeds and crossbreds are concentrated in the western part of the country and in some specific areas of central and eastern Bangladesh. Sirohi and Beetal bucks are imported by the farmers privately and used mainly for crossbreeding purposes. In the absence of any census, it is very difficult to know the exact population number of each population or breed. However, Black Bengal goats are clearly predominant (Faruque, 2003-2014). In this study total 378, local (Black Bengal) and 342, cross-bred goats were randomly selected.

Photograph 8: Experimental Black Bengal (local) goat (Solid black).

Photograph 9: Black Bengal brown bezoar.

Photograph 10: Cross-bred goats in the study area.

3.4.1.d. Body condition of goat

Body condition score (BCS) is an estimate of the muscle and fat development of an animal. BCS is thus an estimation of muscle and fat development of an animal and is correlated with the direct measurement of back fat depth or the proportion of fat in the animal body providing a better estimate than body weight alone. BCS is also a subjective way to evaluate the nutritional status of a flock and acts as a potential indicator for goat owners to increase the production efficiency in their flock. Body condition is a field based method of scoring the tissue over the lumbar vertebrae of goats. The body condition score was determined according to Kripali *et al*. (2010). It is also important to note that BCS could vary according to the physiological status of the animal. In order to record the health condition the lumbar transverse processes of the goats were used as landmark.

The body condition of the goats were divided in to three groups such as-

Group I: Poor (n= 318)

Group II: Medium (n=145) and

Group III: Good (n= 257)

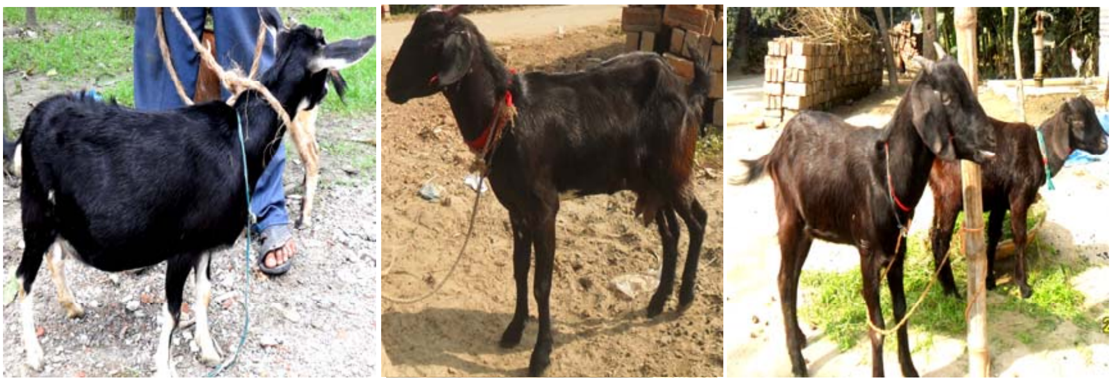
Where,

Poor = Marked emaciated and easily visible lumbar transverse process.

Medium = Ribs are easily visible, little fat covered dorsal spines rarely visible and less visible lumbar vertebral process.

Good = Animals are smooth and well covered but fat deposits are not marked.

Photograph 11: Poor body condition of goat under the study area.



Photograph 12: Medium body condition of goats in the study area.

Photograph 13: Good body condition of goats under the study area.

3.4.2. Management factors related to epidemiology of goats

General management of goat: The farmers were kept the goat in semi-intensive and intensive care. In village condition, the goats were rearing at open field, bank of rivers, shade of the tree, banana garden. The goats were eaten road side grasses, leaves of jackfruit, banana and water from canals, rivers and drain etc. In extensive system, goats are allowed to graze freely in the fields. In our country, there is scarcity of pasture and goats usually graze in the side of cultivable land, by the side of roads and some other fallow lands. They have no idea about the strategic treatment against helminth infections. In fact, deworming is seldom done in village goats in Bangladesh reared under extensive system. In this system, animals are usually malnourished with poor vigor.

3.4.2.1. Husbandry system of goats

This system was divided into three categories as follows-

3.4.2.1. a. Intensive husbandry system

This method is suitable in urban areas where there is scarcity of land. In this method goats are confined exclusively in sheds and are fed on leaves (Jackfruit, mango and banana) or cutting grass from fields and concentrates such as wheat, maize and pea etc. In this study total (n=131) goats were randomly selected during the study.

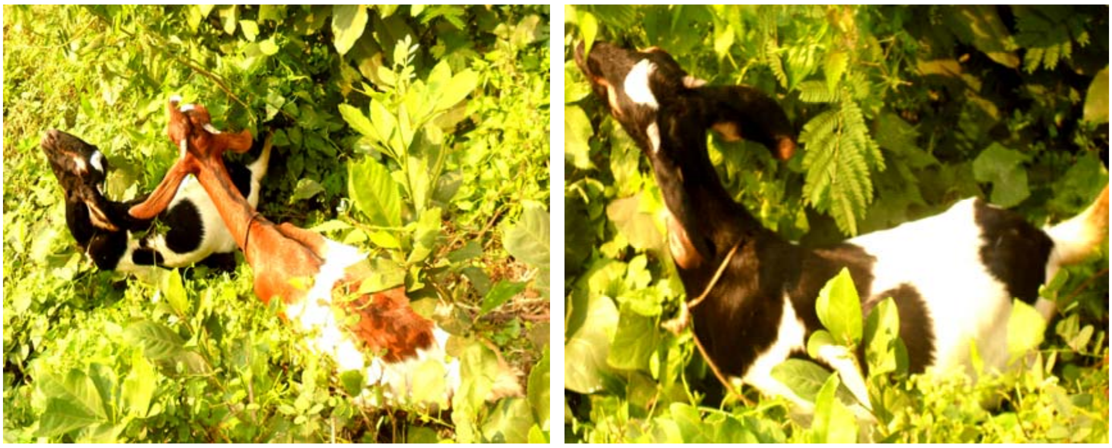
Figure 14: Goat feeding with jackfruit leave (left) and concentrate (right) in intensive husbandry system.

Photograph 15: Slatted housing (left), muddy housing (middle) and muddy floor with straw bedding (in winter season) of intensive husbandry system.

3.4.2.1. b. Semi-intensive husbandry system

This method represents varying degrees of compromise between extensive and intensive production. In this system goats were allowed to go out of the shed for a few hours daily. A total (n=247) goats were selected for this study.

Photograph 16: Goats with concentrate feeding (left) and grazing pasture (right) in semi-intensive husbandry system.



Photograph 17: Goats with browsing leaves.

Photograph 18: Goats grazing on pasture.

Photograph 19: Goat Improvement Farm Rajabarihat, Rajshahi (left) and Naricalbaria Goat Farm, RU Campus (right) in semi-intensive husbandry system.

3.4.2.1. c. Extensive husbandry system

This system can be adopted if grazing land is available where goats are allowed to browse on free range and provided with shelter during night. In this study total (n=342) goats were randomly selected during the study.

Photograph 20: Grazing goats in extensive husbandry system.

3.4.2.2. Housing system on the basis of floor type: Floor of housing was divided in to following two categories**:**

3.4.2.a. Muddy floor housing

In this system, floor of goat housings are made up soil. About 362 numbers of goats were randomly selected from muddy floor houses in the study area.

Photograph 21: Muddy floor housing at village condition.

3.4.2.2. b. Slatted or woody housing

In this type, floor of houses were made up of wood. In this housing system about 352 goats were selected during the study period.

Photograph 22: Slatted (woody) floor housing in Naricalbaria goat farm (left) and Rajabarihat goat improvement farm (right) at Rajshahi.

3.4.2.3. De-worming status of goats

This status was done by the use of the anthelmintic drugs against the parasitic diseases of the selected goats of the study area.

Deworming status of the goats were categorized in to three:

i. Regular de-worming

In this group of goat were regularly treated with anthelmintics. In this purpose 152, goats were selected.

ii. Irregular de-worming

In this status, anthelmintics were used in the goats irregularly or frequently. About 186, goats were selected for this study.

iii. None de-worming

Goats of this group were not given anthelmintics. In this study, 382 goats were selected.

3.4.2.4. Feeding system of goat

Goats were fed by the following two groups:

3.4.2.4.a. Goat with Stall-feeding (Zero-grazing)

In this system, goats are confined in houses and food (straw) was cut and carried to those goats. Household wastes such as vegetables, bark of banana and jackfruits were used as supplements. Fodder crops are sometimes grown for the goats and concentrates such as wheat bran, maize, rice polish etc. were also provided. Total 131, goats were randomly selected for this type of feeding system during the study period.

Photograph 23: Stall feeding goat with straw (left), liquid food (middle) and wheat bran (right).

Photograph 24: Stall- feeding with vegetables waste (left) and cutting grass (right).

3.4.2.4.b. Goats with grazing

Grazing is a type of feeding, in which a herbivore feeds on plants (such as grasses), and also on other multicellular autotrophs (such as algae). Under a continuous grazing system animals are allowed to graze the pasture throughout the grazing season. About 589 goats were selected for grazing on pasture. As for the grazing time, two categories were involved; namely Morning grazing (from 8 am to 10 am) and Afternoon grazing (from 4 pm to 6 pm).

Grazing on Morning: About 350, goats were selected for morning grazing.

Grazing on Afternoon: Total number of goats were selected in this type of grazing, 239.

Photograph 25: Goats grazing on pasture

3.4.2.5. Herd size of goats: There are three groups of goats involved in this study

Group I: Small (1-5): A total 225 number of goats were selected.

Group II: Medium (6-10): 350 goats were selected in this group.

Group III: Large (>10): The selected goats were 145.

Photograph 26: Small herd-size of goat.

Photograph 27: Medium herd-size of goat.

Photograph 28: Large herd-size of goat.

Photograph 29: Goats infected with haemonchosis.

3.4.3. Environmental factors related to epidemiology of haemonchosis

Factors that affect the survival and growth of *Haemonchus* organism in the climatic condition of the study area which influence the epidemiology of haemonchosis.

3.4.3.1. Recorded the meteorological data

Meteorological data including temperature (maximum/minimum), relative humidity and total rainfall was obtained from Meteorological station, Shampur, Rajshahi.

The data regarding temperature, humidity and rain fall was collected from local meteorological office, Shampur, Rajshahi. In the beginning of the experiment i.e., during March, 2011, the monthly mean minimum temperature was 19.1°C while mean maximum temperature was 33.1°C the highest mean maximum temperature was recorded in May

2011, which was 33.3°C and highest mean minimum temperature during the month of July 2011, 29.8°C and the lowest minimum temperature was January, 2012, 11.7°C. In extreme cold months i,e, December, 2011 and January, 2012. The mean maximum temperature were 11.7°C and 13.0 °C respectively while the mean minimum temperature 18.5°C in December, 2011 and 5.5°C in the month of January, 2012. During the rainy months i,e July and August, 2011. The mean maximum temperature were 32.9°C and 31.5°C respectively while the minimum mean temperature was 26.7°C in July,2011 and 26.3°C in August, 2011 (Table -1) The maximum humidity was recorded as the lowest in the month of March, 2011 that was 65%. In the month of August, 2011 humidity was recorded 88% and in the month of July, 2011 the results of relative humidity was 86%. The highest humidity was recorded 88% in the month of August, 2011 (Table -1). The total rainfall during the year 2011-2012 was 1477.6 mm. The months of maximum rainfall were August 2011, 454.8 mm, followed by July, 2011, 341.1mm, September 202.7 mm, May, 2011,187.4 mm. In the month of January, 2012 the total rainfall was recorded 5.5mm, while in February, 2011, 0.6mm. In the month of December, 2011, virtually no rainfall occurred.

Table 1: Month-wise maximum, minimum and mean temperature, relative humidity and total rainfall of the study area

Month of collection of sample during study period	Maximum Temperature (°C)	Minimum Temperature (°C)	Mean temperature (°C)	Average relative humidity (%)	Total Rainfall (mm)
March-2011	33.1	19.1	26.1	65	11.0
April-2011	34.1	25.2	27.3	72	93.4
May-2011	33.9	26.7	28.9	82	187.4
June-2011	33.5	26.4	29.4	85	341.1
July-2011	32.9	26.7	29.8	86	146.0
August-2011	31.5	26.3	28.9	88	454.8
September-2011	32.5	23.5	29.3	87	202.7
October-2011	32.3	17.6	27.9	83	34.1
November-2011	28.6	17.6	23.1	81	1.0
December-2011	23.7	13.0	18.5	84	Nill
January-2012	22.8	11.7	17.5	79	5.5
February-2012	27.8	12.5	20.1	66	0.6
Overall	30.6	20.6	25.6	79.8	148.1

The season-wise maximum temperature, 33.5°C while minimum temperature, 22.4°C and mean temperature, 29°C which was highest value recorded in summer of the study area. Whereas the mean relative humidity, 66% and mean total rainfall was 158 mm recorded in summer.The highest mean relative humidity, 86%, mean total rainfall 209.4mm was recorded in rainy season followed by summer. In winter, mean temperature was 14.5°C, mean relative humidity, 75% and mean total rainfall was 1.77 mm (Table-2).

Table 2: Season-wise maximum, minimum and mean temperature, relative humidity and total rainfall of the study area

Season of study	Maximum temperature (°C)	Minimum temperature (°C)	Mean temperature (°C)	Mean relative humidity (%)	Mean rainfall (mm)
Summer	33.5	22.4	29.0	66	158
Rainy season	32.3	26.7	27.4	86	209.4
Winter	25.3	13.8	14.5	75	1.77
Overall	33.6	20.9	23.6	76	123.1

3.4.3.2. Month of the study: Monthly prevalence was studied throughout the year dividing in to twelve months during the study period.

March: n= 52, April: n=57, May: n=62, June: n=56

July: n=61, August: n=64, September: n=64, October: n=63

November: n=59, December: n=60, January: n=60, February: n=62

3.4.3.3. Season: Seasonal prevalence were studied throughout the year dividing in to three seasons,

Winter (Nov-Feb.) season: (n=242),

Summer (March-June) season: (n=234) and

Rainy season (July-Oct.): (n=244)

3.5. Examination procedure of haemonchosis

i. Coproscopy: This was done by the examination of faecal sample collected from the selected live goats of the study area for the presence of eggs of *Haemonchus* spp. For this purpose total (n= 363) in which 180 goats in Rajshahi and 183 in Noagon District were randomly selected during the study period.

ii. Necropsy: In this examination, abomasum was collected from randomly selected slaughtered goats (n=357) where 175 from Rajshahi and 182 from Noagon district from the abattoirs of the study areas on the study period. This was done for the identification of the adult and immatute stages of the *Haemonchus* spp for final diagnosis of the haemonchosis in the study area.

3.6. Methodology

Cross-sectional study method was followed in this study. Faecal samples were collected directly from the rectum of the each animal or during defecation with strict sanitation and placed in air and water tight vials and then taken to the laboratory. In the laboratory the samples were subjected to direct smear, modified floatation and McMaster and to identify and egg count of gastro-intestinal tract (GIT) parasites following the standard procedures. Positive faecal samples were subjected to McMaster egg counting technique and the degree of infection was categorized based on Soulsby (1982) and Urquhart, *et al.,* (1996). The animals were then categorized as lightly, moderately and severely (massively) infected according to their egg per gram Gram of faces (EPG) counts.

Egg counts from 50-799, 800-1200 and over 1200 eggs per gram of faeces were considered as light, moderate and massive infection respectively.

Infection category of the affected goats (live) (n-182) were grouped into three:

Light infection : n=88

Moderate infection : n=75

Heavey (massive) infection : n=19

Postmortem examination was also performed to identify adult parasites (Soulsby, 1982 and Urquhart *et al.,* 1996). Positive abomasums were subjected to counting of *Haemonchus* worms and the degree of infection was categorized based on Merck (2014). The infection was then categorized as light, moderate and heavy (massive) category according to their number of *Haemonchus* worm counts.

Worms counts from 200-500, >500-1500 and over 1500 per abomasum were considered as light, moderate and heavy infection respectively.

Degree of infection of the affected goats (slaughtered) (n=234) were grouped into three:

Light : n= 67

Moderate : n= 127

Heavy : n= 40

3.6.1. Sample Size and Sampling Method

Simple random sampling strategy was followed to collect faeces and abomasums from the individual goats. The sample size was decided based on formula described by Thrusfield (2005) with 95% confidence interval at 5% desired absolute precision and by assuming the expected prevalence of 50%. The estimated sample size was 720.

3.6.2. Collection and examination of faecal samples of goats for eggs/larvae

Accurate and the proper examination of faeces provide evidence for, or at times an accurate identification of most of the parasites that inhabit the host and discharge their eggs along with the faeces.

3.6.2. a. Collection procedure and preservation of faeces

Faecal samples were collected by a two-finger procedure from the rectum of goats and were collected in suitable airtight containers, such as screw-cap bottles and plastic bags, and labeled carefully with the host's sex, age and month of collection. 5 gms of faecal samples were collected each time and were kept in refrigerator before the further analysis. The samples collected from the remote areas were preserved in 4% formalin and then transported to the laboratory. The monthly collected faecal samples were brought to the laboratory of parasitology in the Department of Animal Husbandry and Veterinary Science (AHVS), University of Rajshahi (RU) for the identification of *Haemonchus* spp.

Preservatives:

Preparation of 4% formalin:

Commercial formaldehyde (40%): 4ml

Distilled water : 96ml.

Some other fixative used in present study includes 10% Formalin which is having the following composition

Formalin (40% Formaldehyde) : 10ml

Distilled water : 90ml

Photograph 30: Collection of faecal sample from rectum of experimental goat.

Photograph 31: Collected faecal sample in the Parasitology laboratory at AHVS.

3.6.2.b. Techniques for the identification of haemonchosis:

For the examination of *Haemonchus* ova, larvae and worms, the following techniques were used.

3.6.2.b.i. Examination of faecal sample: Adult *Haemonchus* worms are usually present in the abomasums of goats. The adult worm lays eggs in the abomasums and then passed with the faeces of the goats in to the external environment. Under favourable condition egg undergo development and then reaches the infective stage. For these reason, faeces of the goat shpuod be examined for the identification of egg of the *Haemonchus* spp.

3.6. 2.b.i. A. Macroscopic (gross) examination of faeces

The color, consistency, presence of blood, mucous, tapeworm segments and dead worms were looked before proper examination of faecal sample. Before examining the faecal samples microscopically, the macroscopic examination was done by naked eyes. The gross examination sometimes revealed adult parasites. This method was used as per Soulsby (1982). Examination of faeces for helminth parasite eggs may vary from a simple direct smear to more complex methods involving centrifugation and the use of floatation techniques. The faeces of the goats is a dark coloured with a peculiar smell and contains a lot of vegetable fibres, grains, plant hairs, spores and animal debris that resembles the parasitic forms (pseudoparasites), thus become difficult for the proper examination of the infection.

3.6.2.b.i.B. Microscopic examination of faeces

Qualitative analysis was carried out by direct microscopic examination and flotation technique while quantitative analysis was carried out by McMaster egg counting techniques (Zajac and Conboy, 2006)

3.6.2.b. i. B. a). Examination of faeces by Direct smear method:

This method was found useful only in the cases of heavy infections. This is suitable for rapid examination of large numbers of faecal sample.

Procedure:

A small portion of faecal matter was directly placed on a grease free slide by a glass rod and a drop of water or saline was added to make a uniform suspension. All the debris was removed. Then a cover slip was placed onto the smear and the slide was examined under low power microscope (10X) for the presence of *Haemonchus* spp eggs (Rahman *et al.,* 1996). *Haemonchus* eggs were identified on the basis of morphology (Soulsby, 1982; Urquhart, 2000; Zajac *et al.,* 2006).

Photograph 32: Instruments and appliances used during faecal sample examination.

Photograph 33: Direct smear method of faecal sample (left) and observation of the egg of *Haemonchus* spp under compound microscope in the parasitology laboratory

3.6.2.b. i. B. b). Faeces examined by Centrifugation floatation method

This method is very valuable method for detecting parasitic ova and larvae even in light infection. Light infection was invariably detected by this method. This method is based on the principle that lighter eggs float on to the surface of saturated solution and the eggs were easily skimmed out of the surface film.

The most commonly used floatation media were:

1. Saturated solution of common salt (NaCl)
2. Zinc sulphate 32% solution
3. Saturated sugar solution
4. Saturated solution of sodium nitrate

Composition of saturated salt solution

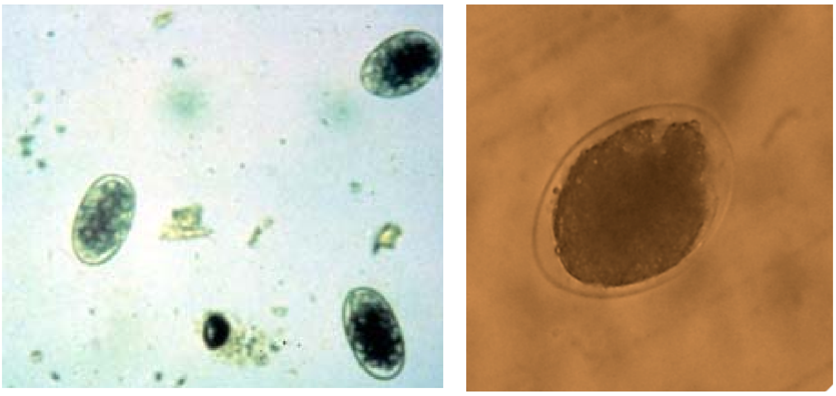
Sodium chloride	: 348 gm
Distilled water	: 1000 ml

Procedure: One gram of faeces was weighing by the weight tools. Faecal pellets were crushed with the pestle and morter and was thoroughly mixed with 10ml of tap water (preferably lukewarm water) and then centrifuged for one minute at 2,500 rpm The supernatant fluid was carefully poured off or pipette off and fresh tap water was added with the sediment which shaken well and centrifugation was repeated until the supernatant fluid was clear (2-3 times centrifugation were usually sufficient). The last supernatant fluid was removed and about 2 ml of sodium chloride (NaCl) solution (specific gravity 1.200) was added, sediment was then broken up by shaking very well and sufficient additional NaCl solution was added to fill the centrifuge tube up to the rim. A 22 mm cover glass was placed on the top of the tube and then centrifuged for one minute at 2,500 rpm. The cover glass was then taken out, and was mounted on a cleen slide down and examined under microscope (Rahman *et al.,* 1996). *Haemonchus* eggs were identified on the basis of morphology (Soulsby, 1982; Urquhart, 2000; Zajac *et al.,* 2006).

Photograph 34: Weighing of faecal sample (left) and making suspension with distilled water (right).

Photograph 35: Centrifuge machine (left) and observation of eggs of *Haemonchus* spp under compound microscope with low power objective (right).

Photograph 36: Light Microscope, Olympus, Germany (left) and observation of eggs of *Haemonchus* spp under light microscope with low power objective (right) in parasitological laboratory at AHVS.



Photograph 37: Egg of *Haemonchus* spp (10x, left) and (6x eye-piece objective, right, immature stage) with light microscope.

Photograph 38: Egg of *Haemonchus* spp (40x, left) and mature egg (6x objective) with light microscope.

3.6.2.b. i. c). Mc Master egg counting technique

The faecal egg counts were of great importance in experimental and diagnostic work in which the comparison of counts in various goats provides a great information on worm burden and only those animals having a high number of eggs per gram (EPG) of faeces used for hematological and biochemical studies. A number of methods have been suggested to determine eggs per grams of faeces but only Mc Master egg counting technique was employed for counting of eggs.

Mc Master counting technique

This was done by modified Mc Master counting chamber as described by Urquhart *et al*. (1996).

Principle:

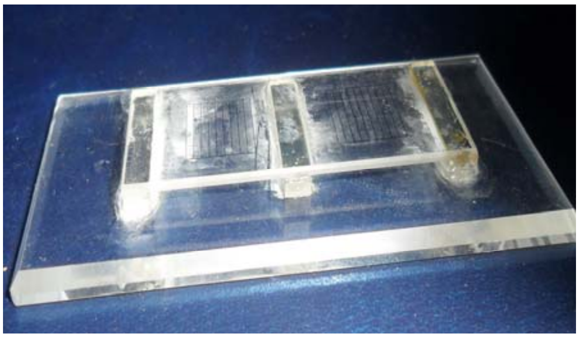
The Mc Master counting technique is a quantitative technique to determine the number of eggs of *Haemonchus* spp present per gram of faeces (EPG). The Mc Master technique uses a counting chamber which enables a known volume of faecal suspension (2x0.15ml) to be examined microscopically. A flotation fluid (Nacl saturated solution) is used to separate eggs from faecal material in a counting chamber (Mc Master) with two compartments.

Application

The Mc Master technique is used for demonstrating and counting helminth eggs in faecal samples. It is the most widely employed method for this purpose. Its use to quantify levels of infection is limited by the factors governing egg excretion.

Equipments:

- Beakers or plastic containers
- Balance
- A tea strainer or sieve
- Measuring cylinder
- Stirring device
- Pasteur pipettes
- Floatation fluid (Saturated salt solution)
- Mc Master Slide
- Light Microscope




Photograph 39: Mc Master slide (left) and Mc Master slide with filled chamber (right) under microscope.

Photograph 40: Counting of *Haemonchus* spp egg under light microscope using Mc Master slide.

Procedure for McMaster's egg counting technique

In this technique 3 gm of faecal sample were taken and 42 ml of floatation solution is added to the sample and thoroughly mixed so that it forms a homogenous mixture. The solution is then transferred through a sieve in order to remove the coarse particles and filled in test tube and centrifuged at 2000 rpm for 2 minutes. The supernatant was poured off and the sediment was agitated again and filled the tube to the previous level with floatation (NaCl) solution. The tube was inverted many times and fluid solution was poured in both chambers of Mc Master slide with the help of pipette and no fluid was left in the pipette, as the eggs would rise quickly in the floatation fluid. The slide was allowed to stand for 5 minutes to allow the eggs to float. The Mc Master slide has two chambers, each with a grid etched onto the upper surface. When filled with a suspension of faeces in flotation fluid, much of the debris will sink while eggs float to the surface, where they can easily be seen and those under the grid counted.

The eggs in the two chambers were counted using low power objectives (´10). One chamber of slide was examined and numbers of eggs were multiplied by 100 to determine eggs per gram (EPG). The number of eggs per gram of feces was calculated by using the following formula.

$$\textbf{Number in one gm} = \frac{\text{Number in two chambers}}{0.3} \times \text{dilution factor}$$

$$\textbf{Dilution factor} = \frac{\text{Total volume of suspension in ml}}{\text{Total volume of feces}}$$

3.6.2.b.ii. Examination of abomasums: *Haemonchus* spp usually harbour in the abomasum of animal. For the identification of haemonchosis adult and immature worms should be separated and identified on the basis of morphological characteristics of the collected worm. For this purpose, abomasums of the examined goat ought to be examined.

3.6.2.b.ii. A. Collection of abomasum

At necropsy, abomasa were collected after slaughtering and evisceration of the goat in nearby slaughter houses in the study area. Abomasum was collected from randomly selected slaughtered goats (n=357) from the abattoirs of the study areas on the study period. The date of collection, the number of total and infected animals was recorded, the age, sex of such animals, month and season of sample collection was also maintained. The monthly collected abomasa were brought to the laboratory of Animal Husbandry and Veterinary Science, University of Rajshahi for the identification of *Haemonchus* spp.

Photograph 41: Slaughtered goat (left) and stomach (right).

Photograph 42: Collected labelled abomasums from slaughtered goats.

3.6.2.b. ii. B. Worm recovery and identification

Following slaughter and evisceration, the entire abomasa of goats slaughtered at abattoirs during the study period were collected and examined as described by Hansen and Perry, 1990; Kassai, 1999 and MAFF (Ministry of Agriculture Fisheries and Food) (1977). The abomasa were placed in a plastic container and transported to the laboratory of Parasitology, Department of Animal Husbandry and Veterinary Science, University of Rajshahi. The entire washings from the abomasa were completely examined individually for worms. The *Haemonchus* spp present were identified and counted (Soulsby, 1982; Hansen and Perry, 1990; Valderrabano *et al.,* 2001).

Procedure:

(a) During the post-mortem examination, ligate the abomasum with string and separate it from omasum and duodenum.

(b) Place the abomasum in a tray. Open the abomasum along the greater curvature so that its contents fall into the tray: empty the abomasal contents into the total content plastic bucket.

(c) Wash the empty abomasum thoroughly in the tray several times, paying particular attention to cleaning between the folds of the mucous membrane. Add the washings to the total contents plastic bucket.

(d) For goats make the total volume of contents and washings in the total contents plastic bucket up to 2 litres with water.

(e) Using the tooth pick or stick, stire vigorously until all food material, mucus and water are thoroughly mixed.

(f) Transfer a total of 200 ml of the contents to the wash jar in 5 steps of 40 ml per step, using the ladle container and stirring the mixture continuously.

(g) Fill the wash jar with water. Screw the lid on securely. Invert the jar and shake it till most of the fluid is shaken out. Repeat this process until all faecal culturing matter is removed.

(h) Add water to make the volume in the wash plastic bucket up to 50 ml (for convenience).

(i) Pour small volumes into petri dishes.

(j) Add a few drops of iodine solution to the sample in each petri dish. Mix the iodine with the sample and allow to stands for 35 minutes, during which time the worms will stain deeply with iodine.

(k) Count the number of each *Haemonchus* spp present in the sample. Repeat the process for each petridish and add the worm counts for all dishes.

3.6.2.b.ii.C. Counting of worms

The total number of worms counted in the 20 ml sub-sample was then multiplied by 10 to get the total number of worms present in the abomasums assuming that an original volume of 2 litres was used. Among 234 affected abomasi about 14 abomasal contents (7 from Noagon and 7 from Rajshahi district) of goats were examined for the further experiment and total 17250 adult worms (n= 8510, Rajshahi and n=8740, Noagon) were counted to know the male and female ratio of the *Haemonchus* spp within the abomasums of goat.

Photograph 43: Examination of abomasal content (left) and observation of *Haemonchus* spp.

Photograph 44: Mucosa of abomasum containing numerous reddish coloured *Haemonchus* spp.

Photograph 45: Petridish containing *Haemonchus* spp in saline recovered from abomasum of goat

3.6.2.b.ii. D. Processing of collected worm

The nematodes after recovered from the infected organ were processed as per the following steps.

Fixation: The nematodes on collection were transferred immediately to normal saline to free them of any foreign material or debris, if any kept in water for a long period, their cuticle is likely to burst and damage the specimen. They were then killed and fixed in hot 70% alcohol. Care was taken to prevent distortion of specimen during fixation. Hot 10% or 4% formalin can also be used for fixation of nematodes.

Large nematodes were dropped into acetic alcohol (1 part of glacial acetic acid and 3 parts of 95% alcohol), which result in a little less shrinkage than alcohol alone. The heated solution causes worms to straighten instantly and die in that position, thus avoiding the curled and distorted specimens obtained when using cold fixatives.

(ii) Preservation: The nematodes were preserved in 70% alcohol or 4% formalin or 10% formalin. If the material is to be stored for sometime (month or longer) before being used, it is recommended that 70% alcohol to which 5% glycerine has been added.

Preservatives and fixatives used

(a) 70% Alcohol

Composition:

Absolute Alcohol: 70 ml

Distilled Water : 30 ml

(b) 4% formalin

Composition:

Formalin (40% formaldehyde): 4 ml

Distilled Water : 96ml

(iii) Storage: Each vial material should contain a note bearing the following information (a) scientific name of the host from which nematode was collected (b) locality from were host is collected (c) location of nematode parasite within host (d) fixative reagent used (e) date of autopsy (f) authors and Specimens name.

(iv) Clearing of collected worms: The almost impervious cuticle of adult nematodes makes it extremely difficult to prepare them as whole mounts by the methods used for flukes and tapeworms. The methods were generally studied microscopically almost entirely as cleared, unstained specimens in various media. Glycerin was found as good clearing agent for small parasites but its action was slow. The nematodes were generally cleared by putting them into lactophenol in a cavity block for 30 minutes to 2 hours. Lactophenol helps in quick clearing.

Composition of Lactophenol

Distilled water : 20 ml

Glycerine : 40 ml

Lactic acid : 20 ml

Phenol (melted crystals) : 20ml

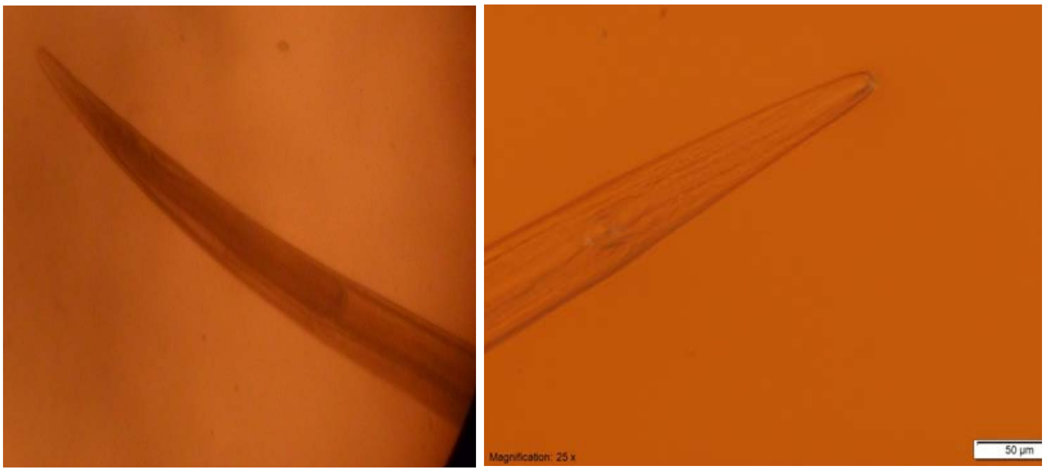
The solution was kept in a brown bottle or in a dark place, because exposure of light causes it to turn yellow.

3.6.2.b.ii. E. Sex determination from the collected *Haemonchus* spp

Female *Haemonchus* spp were collected under a dissecting microscope and then washed under tap water to remove adhered feed residues from their body. Morphological identification was made as described by Taylor *et al.* (2007). During the study period a total of 1086 female *Haemonchus* spp from goats were examined under Sterio-microscope at Central Science laboratory of Rajshahi University to determine the type of cuticular process in the region of the vulva. From 10 to 20 female *Haemonchus* spp per abomasum were examined for type of cuticular process in the region of vulva as described by Le Jambre and Whitlock (1968). A total 520 female worms were were examined microscopically for differentiation into linguiform, knobbed and smooth forms as recommended by Das and Whtlock (1960) and described by Tod (1965). The majority of worms were studied as fresh samples, whereas some were studied as preserved samples in 70% ethanol alcohol inside individually labeled universal bottles, until they were examined for the types of their vulvar process. A total 6390 adult male *Haemonchus* spp were identified by the findings of bursa in the tail end of the worm.

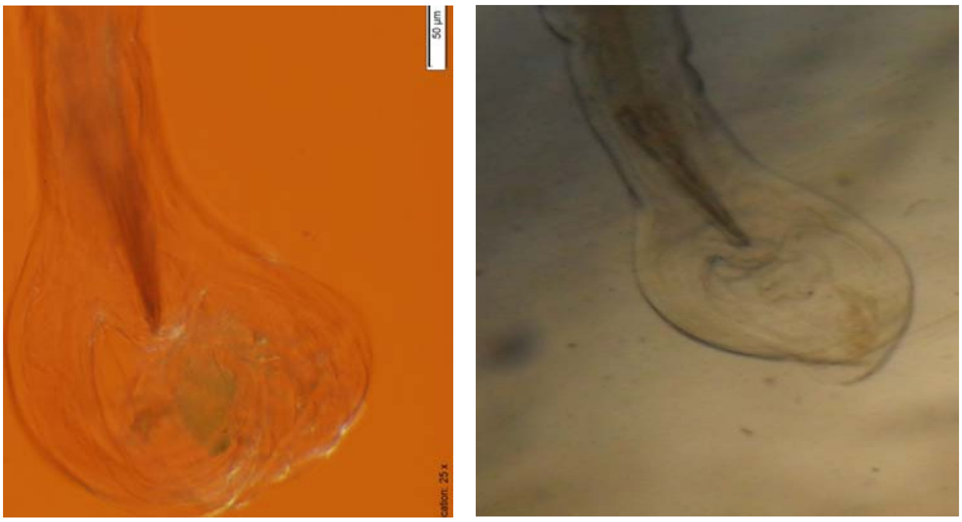
Photograph 46: Sterio-microscope (left) and taking photograph (right) at Central Science laboratory, Rajshahi University.

Photograph 47: Anterior end of adult female *Haemonchus* spp (25x) under Sterio-microscope.



Photograph 48: Anterior end of adult male *Haemonchus* spp (25x**)**.

Photograph 49: Vulvar flap (posterior region) of adult female *Haemonchus* spp and uterus contain numerous eggs (10x with light microscope).



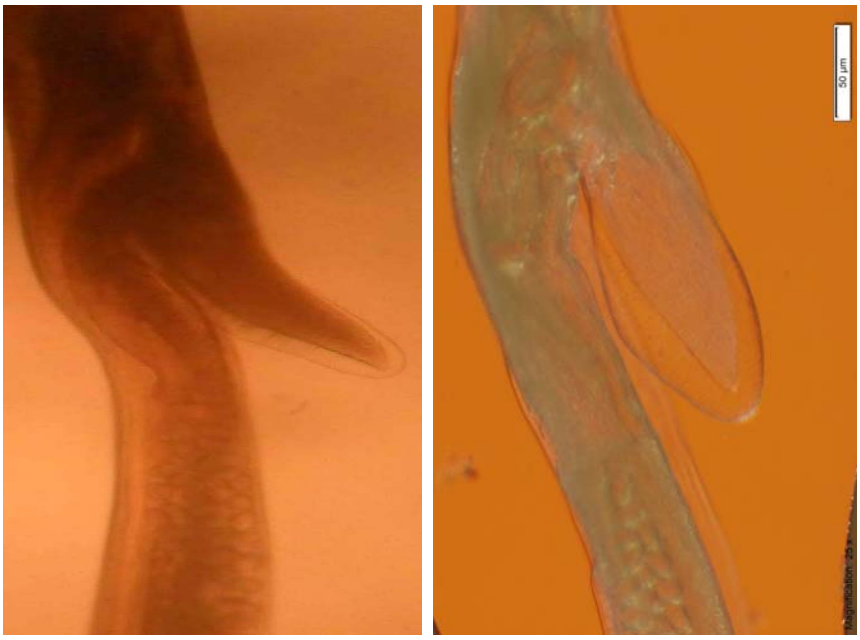
Photograph 50: Bursa (posterior region) of adult male *Haemonchus* spp (25x with Sterio-microscope, left and 10x with light microscope).

3.6.2.b.ii. F. Vulvar type determination:

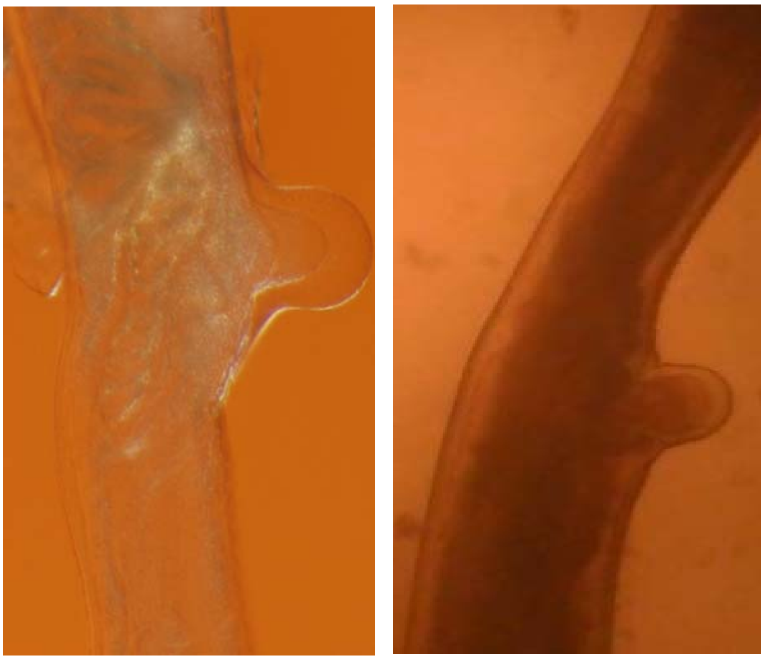
Prior to vulvar type determination, each female *Haemonchus* worm was cleared in lactophenol blue as a temporary mount on a glass slide. Then, under the sterio-microscope at Central Science laboratorty, Rajshahi University, the female *Haemonchus* worms collected from each animal were classified (Rose, 1966; Jacquiet *et al.*, 1995) according to their vulvar type as:

Linguiform - with a supravulvar flap
Knobbed - with knob-like vulvar process and
Smooth-without any vulvar process.

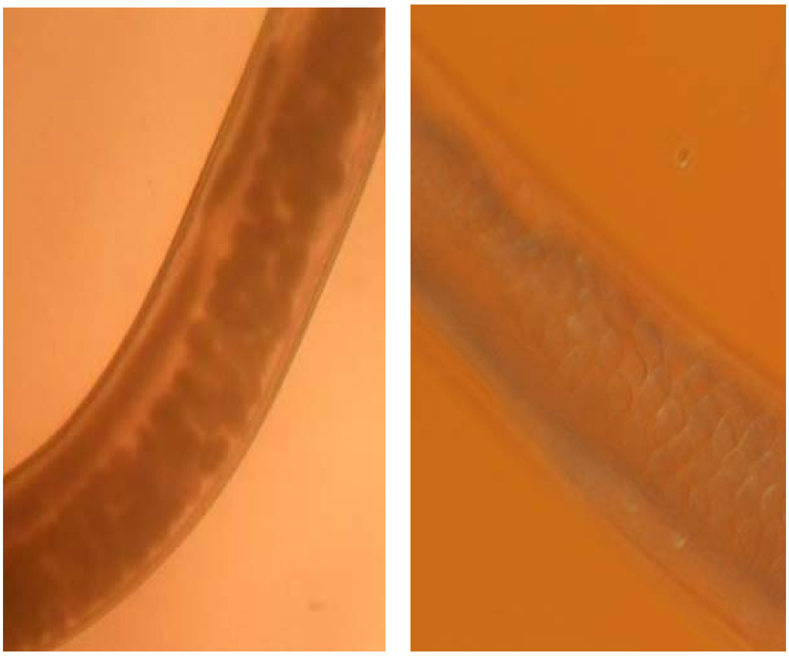
Furthermore, each linguiform female *Haemonchus contortus* was classified into sublinguiform types (A, B, C and I) as described by Le Jambre and Whitlock (1968).
Linguiform A (LA) has one cuticular inflation,
Llinguiform B (LB) has no cuticular inflations,
Linguiform C (LC) has two cuticular inflations,
Linguiform I (LI) the cuticular inflation arises from the linguiform process.



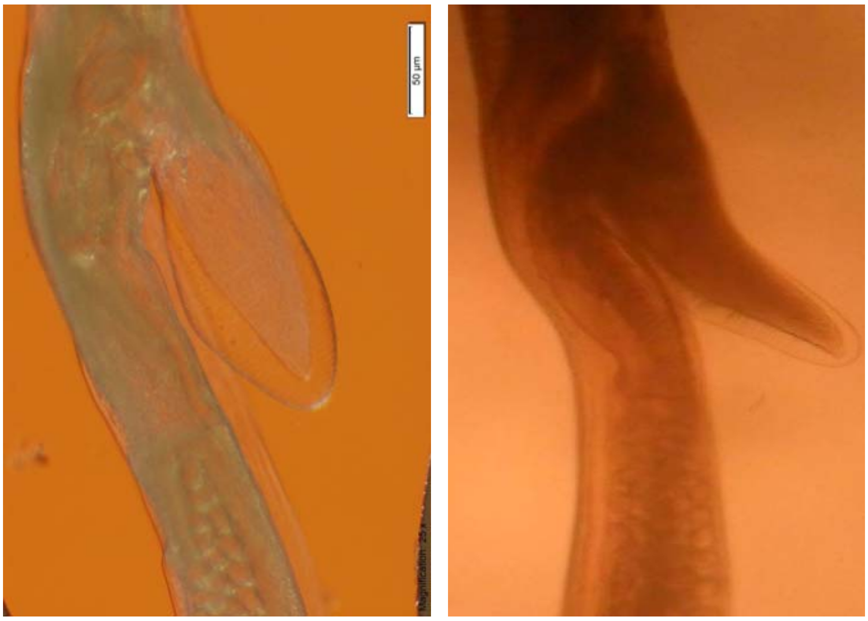
Photograph 51: Linguiform vulvar morph type of *Haemonchus* spp (10x, light microscope, left) (25x, Sterio-microscope, right).



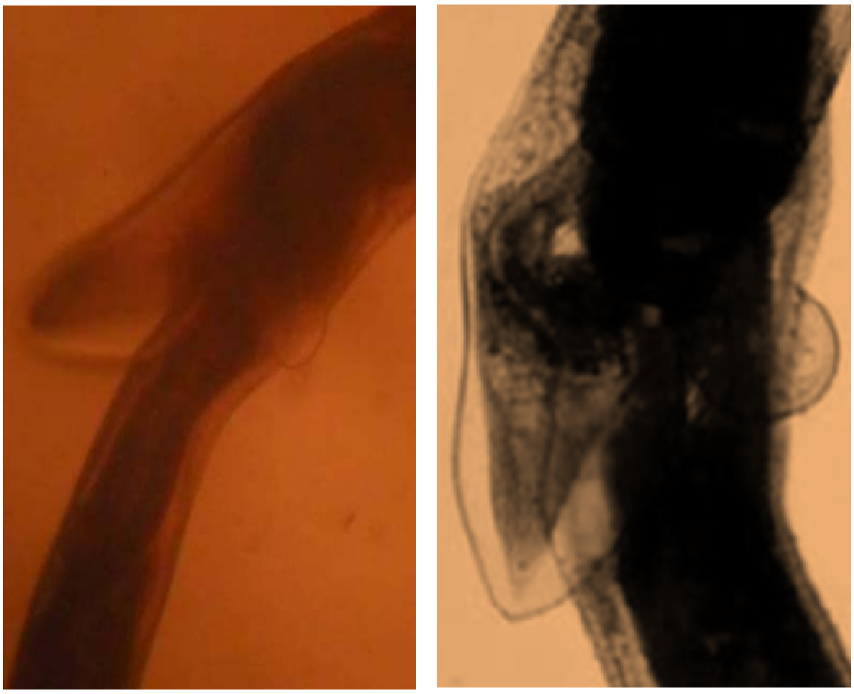
Photograph 52: Knobbed like vulvar morph type *Haemonchus* spp (25x with Sterio-microscope, left and 10x with light microscope, right).



Photograph 53: Smooth vulvar morph type of *Haemonchus* spp (10x with light microscope, left and 25x with Stereomicroscope, right).



Photograph 54: Sublinguiform-B (LB) type of *Haemonchus* spp (25x, left and 10x, right).



Photograph 55: Sublinguiform-A (LA) type of (10x, left with light microscope and 25x with Stereomicroscope, right).

3.7. Statistical analysis

All the data that were collected entered to MS excel sheet and analyzed by using SPSS version 19. Descriptive statistics was used to determine the prevalence of the haemonchosis and Chi-square test (χ^2) was used to look the significant difference between age, sex, breed, body condition, rearing system and deworming status and housing system with haemonchosis of goats. The monthly averages for each weather factor were calculated. The mean were compared by Duncan Multiple Range Test (DMRT) by Steel and Torrie, (1980). The analysis of Variance (ANOVA) was done by using one way cross cross classification for significant difference. The weather conditions were correlated with the occurrence of the disease. The major vulvar morphotypes and the subtypes of the linguiform morphotypes of the *Haemonchus sp* in goats for the studied areas were compared by Chi-square test (χ^2) was used to look the significant difference. In all the analyses, confidence level was held at 95% and $P<0.05$ were set for significance.

CHAPTER FOUR

RESULTS

Epidemiology of haemonchosis

The study was conducted from March 2011 to December 2013; the surveys of Rajshahi and Noagon districts of Bangladesh were carried out to identify the occurrence of prevalence host, management and environmental factors as well as female *Haemonchus* spp study. The details are given as under following headings:

4.1. Overall prevalence of haemonchosis

A total of 720 samples were examined for the identification of haemonchosis. Among the collected samples, about 416 were found positive for *Haemonchus* spp infection. The overall prevalence of haemonchosis was 57.8% (Table 3).

Table 3: Overall prevalence of haemonchosis in the study area of goat

No of examined sample (n=)	No of positive sample (n=)	Prevalence of haemonchosis (%)
720	416	57.8

n= Number of observation, %= Percentage

4.2. Risk factors of haemonchosis in goats

In the present study out of the different potential risk factors such as age, sex, breed, body condition and farm management factors in addition to the environmental factors were studied. These factors were considered in chi-square statistical analysis test to find out their effects on the frequency of haemonchosis in goats. The Analysis of Variance (ANOVA) was done by using cross classification for the significant difference ($P<0.05$).

4.2.a. Host related risk factors affecting *Haemonchus* spp infection rate

Out of the four potential host related risk factors considered (Table 9) age and body condition were found to be significantly ($P<0.001$) influenced while sex of the goats were least significant ($P<0.05$) rate of prevalence of haemonchosis in goats but there was no significant different ($P>0.05$) was found in breed of goats.

4.2.a.i. Effects of age of goat on the prevalence of haemonchosis

The prevalence rate of haemonchosis was found to be highest in young (6 to 12 months), 88.5% compared to adult (>12 to <24 months), 69.6% followed by older (>24 months) goats. The lowest prevalence rate was observed in kids (>6 months) (Table 4 & figure 1).

In the Chi-square test and Analysis of Variance (ANOVA), the result showed that there was significant association between *Haemonchus* spp infection and age group of goats (P-value= 0.000). (Table 4 & 9).

Table 4: Effects of age on the prevalence of haemonchosis in goat

Age group of goats	No. of sample examined (n=)	No. of positive sample (n=)	% of haemonchosis	Chi-square value	Significance level
Kid (<6 months)	124	27	21.8	28.813	.000 (***)
Young (6 to 12 months)	153	135	88.5		
Adult (>12 to <24 months)	250	174	69.6		
Older (>24 months)	193	80	41.5		
Grand Total	720	416	57.8		

n= Number of observation, ***Significant at 0. 1% level (P<0.001)

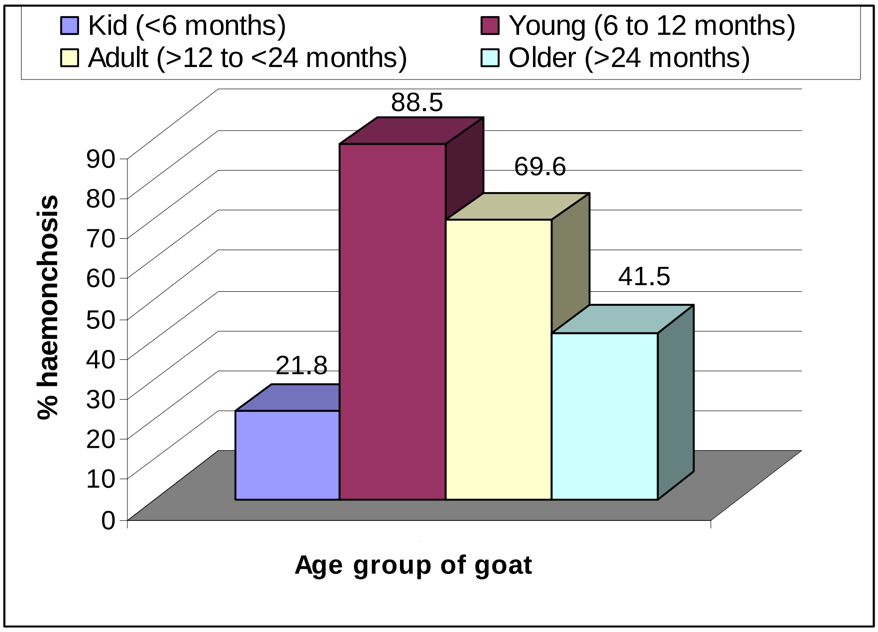


Figure 1: Bar -chart representation of the prevalence of haemonchosis on age group of goat.

4.2.a.ii. Effects of sex of goats on the prevalence of haemonchosis

Goats of female group had a significantly high *Haemonchus* spp infection rate (63.9%) as compared to male group (50.0%). The Chi-square test and Analysis of Variance (ANOVA), the result also conclude that sex of goats were significantly (P<0.05) higher significance (Table 5, 9 & figure 2).

Table 5: Effects of sex on the prevalence of haemonchosis in goat

Sex of goat	No. of sample examined (n=)	No. of positive sample	% of haemonchosis	Chi-square value	Significance Level
Male	316	158	50.0	8.202	0.011*
Female	404	258	63.9		
Total	720	416	57.8		

n= Number of observation, **Significant at 5% level (P<0.05)

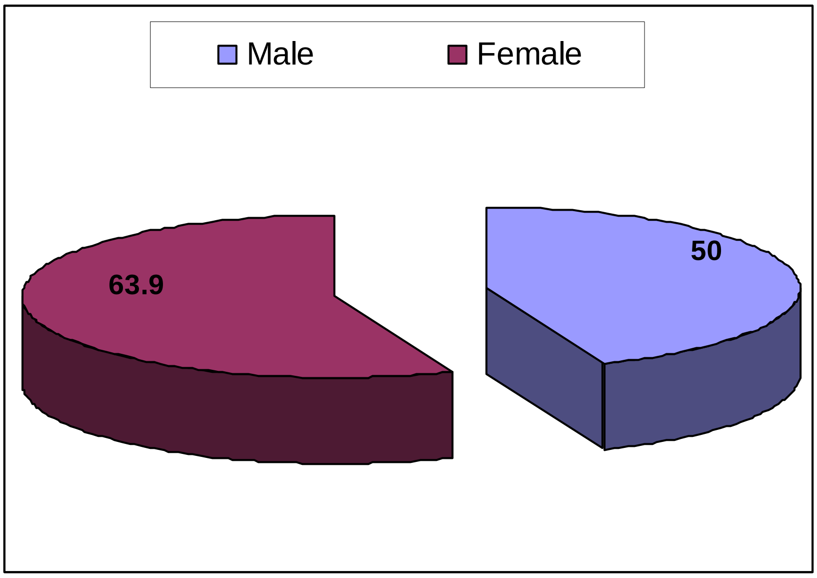


Figure 2: Pie-chart representation of the prevalence of haemonchosis in the sex of goat.

Effects pregnancy status of female goat on the prevalence of haemonchosis in goat

Among the female goat, pregnant goats had higher infection rate, 76.0% (38/50) than that of non-pregnant, 62.2% (220/354) goats (Table 7 & figure 4). The Chi-square test also conclude that type pregnant female goat were significantly (P=0.011) higher significance than non pregnant goats (Table 6 & figure 3).

Table 6: Effects of pregnancy status of female goat on the prevalence of haemonchosis in goat

Pregnancy status of female goat	No. of sample examined (n=)	No. of positive sample	% of haemonchosis	Chi-square value	Significance Level
Pregnant	50	38	76.0	7.569	.011 *
Non-pregnant	354	220	62.2		
Total	404	258	63.9		

n= Total number of observation, *Significant at 5% level (P<0.05)

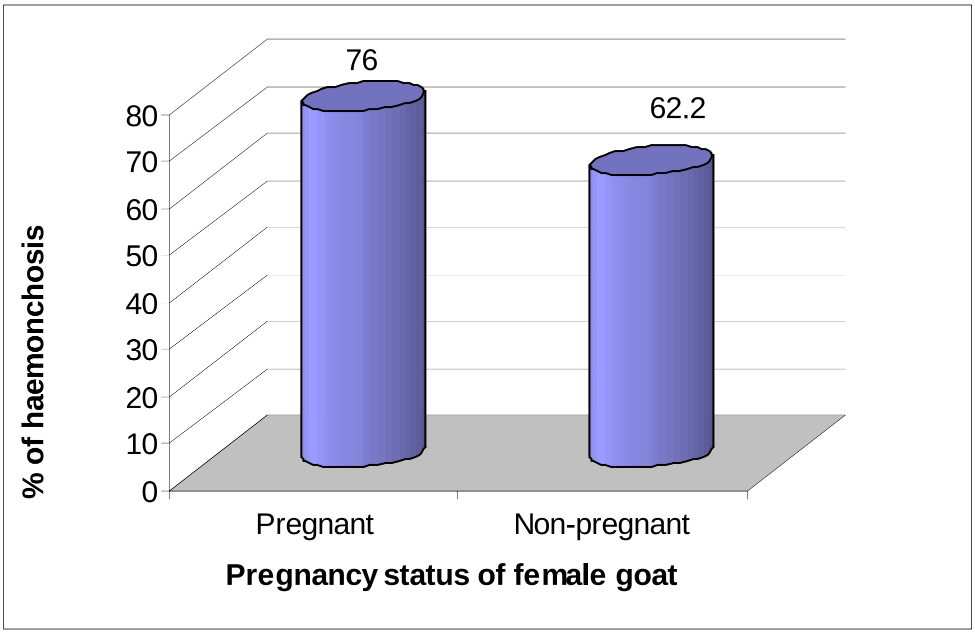


Figure 3: Bar-chart representation the prevalence of haemonchosis in the type of female goat.

4.2.a.iii. Effects of breed on the prevalence of haemonchosis in goats

The present study also revealed that goats of cross-bred group had higher, 60.0% *Haemonchus* spp infection rate compared to local-bred group, 55.6%. The Chi-square test and Analysis of Variance (ANOVA), the result showed that there was no significant association between *Haemonchus* spp infection and breed of animals (P-value=0.205) (Table 7, 9 & figure 4).

Table 7: Effects of breed on the prevalence of haemonchosis in goat

Breed of goat	No. of sample examined (n=)	No. of positive sample	% of haemonchosis	Chi-square value	Significance Level
Black Bengal	378	210	55.6	1.610	.205(NS)
Cross-bred	342	206	60.0		
Total	720	416	57.8		

n= Number of observation, NS= Non significant

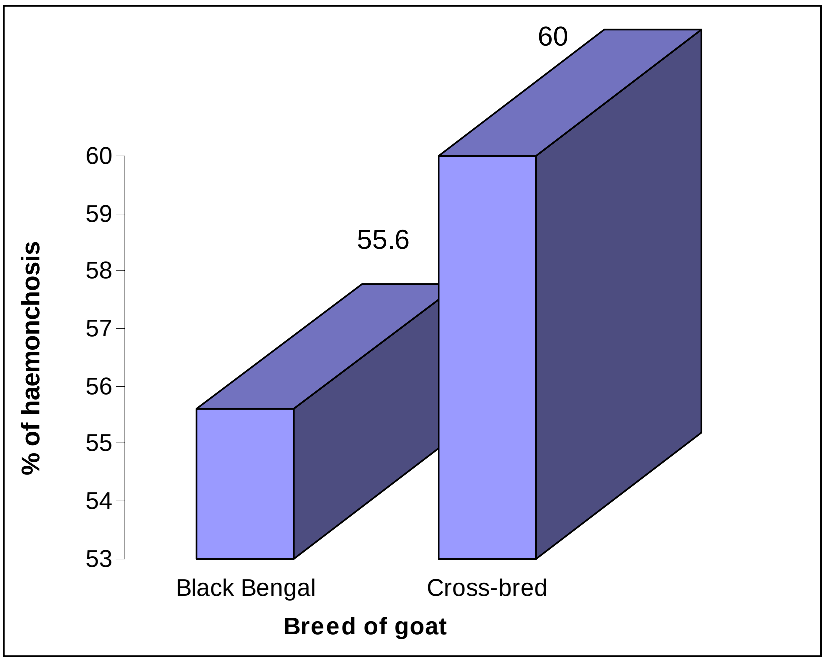


Figure 4: Bar-chart representation of the prevalence of haemonchosis on different breeds of goat.

4.2.a.iv. Effects of body condition on the prevalence of haemonchosis in goats

Goats of good body condition group had a significantly low *Haemonchus* infection rate, 39.3% as compared to poor body condition group 82.8% followed by medium, 61.3% (Table 8 & figure 5). The Chi square test and Analysis of Variance (ANOVA), result also revealed that haemonchosis was significantly (P<0.001) influenced by the body condition of goats (Table 8 & 9).

Table 8: Effect of body condition on the prevalence of haemonchosis in goats

Body condition of goat	No. of sample examined (n=)	No. of positive sample (n=)	% of haemonchosis	Chi-square value	Significance Level
Good	257	101	39.3	35.647	.000 (***)
Medium	318	195	61.3		
Poor	145	120	82.8		
Grand total	720	416	57.8		

n=Number of observation, ***Significant at 0.1% level (P<0.001)

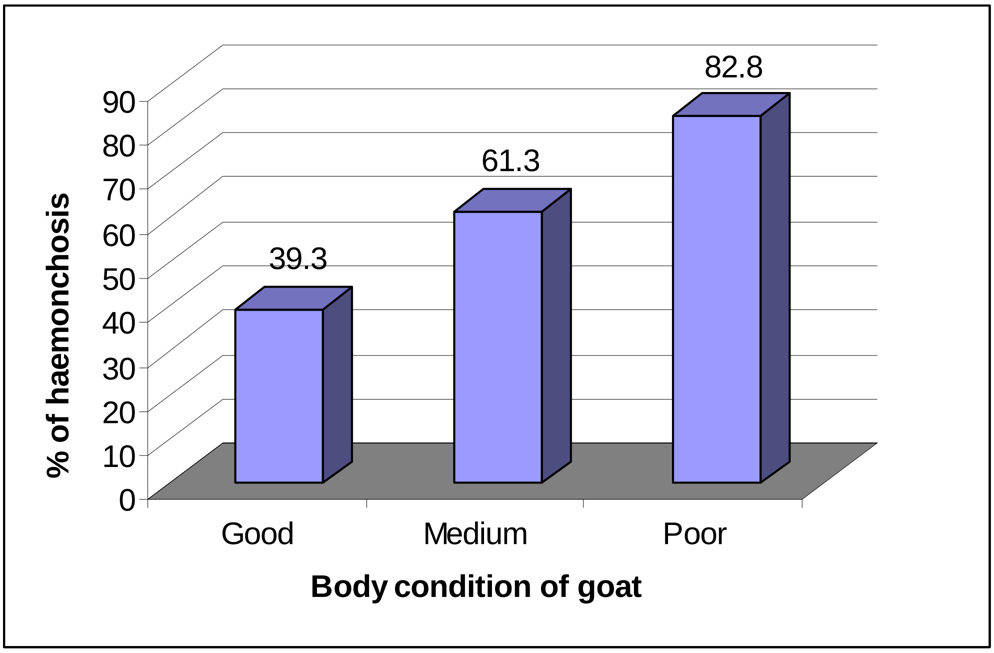


Figure 5: Bar-chart representation of the prevalence of haemonchosis on body condition of goat.

Table 9: Analysis of Variance (ANOVA) for the prevalence of haemonchosis in the influence of age, sex, breed and body condition of goat

Host related factors	Sources of variation	Sum of squares	df	Mean square	F value	Level of significance
Age	Between groups Within groups Total	5.653 135.612 141.265	1	5.653 .189	29.910	.000 (***)
Sex	Between groups Within groups Total	2.439 113.872 116.311	1	2.439 .242	10.079	.005 (***)
Breed	Between groups Within groups Total	.402 179.148 179.550	1	.402 .250	1.608	.205 (NS)
Body condition	Between groups Within groups Total	27.852 451.480 479.332	2	13.921 .629	22.131	.000 (***)

df= Degree of Freedom, NS= Non significant, ***Significant at 0.1% level (P<0.001), F=Factorial value

4.2.b. Management related factors affecting prevalence of haemonchosis in goats

4.2.b. i. Effects on husbandry system on haemonchosis in goat

The present study indicated that haemonchosis was significantly (P=0.001) influenced by the different husbandry system of goats. Goats managed under intensive husbandry system had a significantly low *Haemonchus* spp infection rate 15.3% as compared to goats under extensive husbandry system, 71.6% followed by semi-intensive, 61.1% husbandry system (Table 10, 16 & figure 6).

Table 10: Effects of husbandry system on the prevalence of haemonchosis

Husbandry system	No. of sample examined (n=)	No. of positive sample (n=)	% of haemonchosis	Chi-square value	Significance Level
Intensive	131	20	15.3	11.014	.001 (***)
Semi-intensive	247	151	61.1		
Extensive	342	245	71.6		
Grand total	720	416	57.8		

n=Number of observation, ***Significant at 0.1% level (P= 0.001)

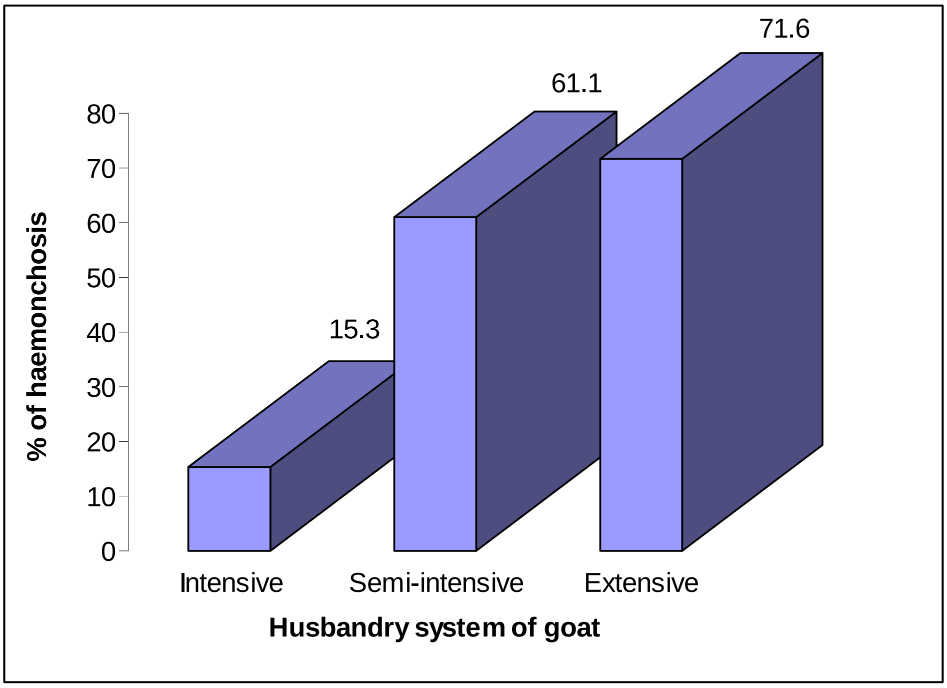


Figure 6: Bar-chart representation of the prevalence of haemonchosis on different husbandry system of goats.

4.2.b. ii. Effects of floor of housing on the prevalence of haemonchosis in goat

In the present study it was found that haemonchosis was highly significantly (P<0.001) influenced by the floor of housing of goats. Goats housed in slatted (woody) floor had a significantly low, 38.0% *Haemonchus* spp infection rate as compared to housed in muddy floor, 62.0% (Table 11, 16 & figure 7).

Table 11: Effects of floor of housing on the prevalence of haemonchosis in goat

Floor of housing	No. of sample examined (n=)	No. of positive sample (n=)	% of haemonchosis	Chi-square value	Significance value
Muddy floor	362	258	62.0	58.583	.000 (***)
Woody (Slatted) floor	358	158	38.0		
Grand total	720	416	57.8		

n= Total number of observation, ***Significance at 0.1% level (P<0.001)

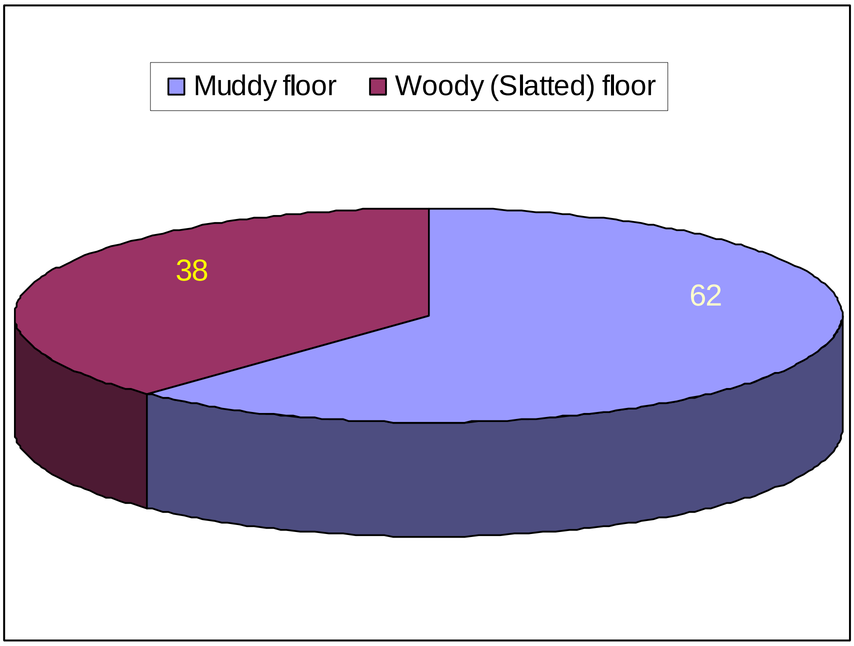


Figure 7: Pie-chart representation of the prevalence of haemonchosis in goat on floor of housing**.**

4.2.b. iii. Effects of de-worming status on the prevalence of haemonchosis of goats

The result also revealed that haemonchosis was significantly (P<0.001) influenced by the management practice like de-worming status of the goats before sample collection. Goats without anthelmintic treatment (none) had a higher, 71.5%

prevalence followed by those given anthelmintics as irregular basis, 56.5% and least 25% prevalence in those given anthelmintic regularly (Table 12, 16 & figure 8).

Table 12: Effects of de-worming status on the prevalence of haemonchosis in goat

De-worming status of goat	No. of sample examined (n=)	No. of affected sample (n=)	% of haemonchosis	Chi-square value	Significance Level
Regular	152	38	25.0	62.023	.000 (***)
Irregular	186	105	56.5		
None	382	273	71.5		
Total	720	416	57.8		

n= Number of observation, ***Significant at 0.1% level (P<0.001)

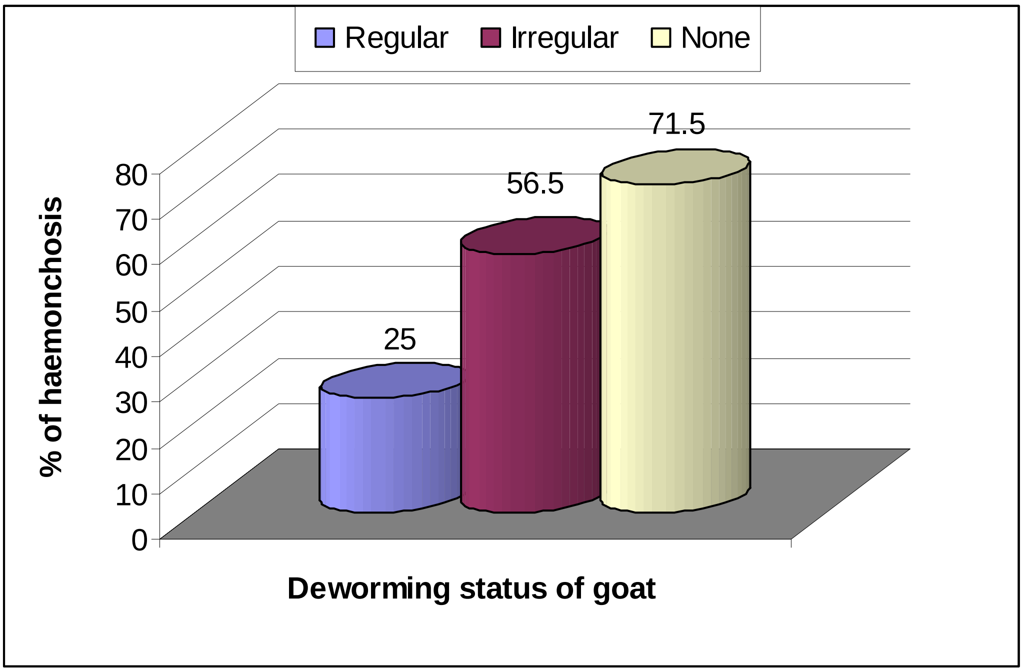


Figure 8: Graphical representation of the prevalence of haemonchosis in different de-worming status of goats.

4.2.b.iv. Effects of feeding system of goat on the prevalence of haemonchosis in goat

The present study indicated that haemonchosis was significantly (P<0.001) influenced by the feeding system of goats. Grazing feeding was the highest prevalence, 67.2% (396/589) than stall-feeding, 15.3% (20/131) (Table 13, 16 & figure 9).

Table 13: Effects of feeding system of goat on the prevalence of haemonchosis in goat

Feeding system of goat	No. of sample examined (n=)	No. of affected sample (n=)	% of haemonchosis	Chi-square value	Significance Level
Stall-feeding	131	20	15.3	34.112	.000 (***)
Grazing	589	396	67.2		
Total	720	416	57.8		

n= Number of observation, ***Significant at 0.1% level (P<0.001)

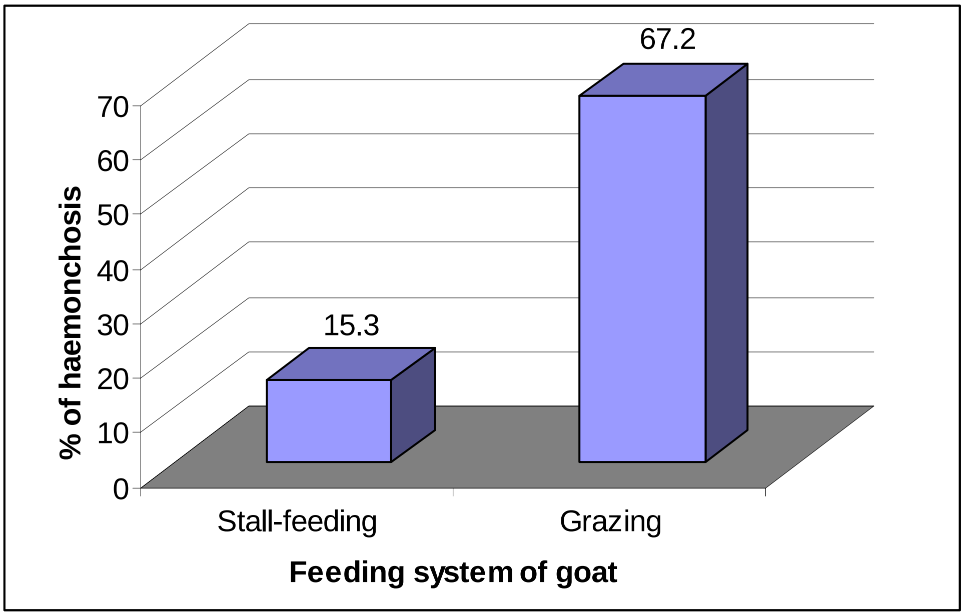


Figure 9: Bar-chart representation of the prevalence of haemonchosis in goat on feeding system.

Effects of period of grazing of feeding system of goat on the prevalence of haemonchosis

The present study observed the morning grazing practice had higher prevalence 77.1% (270/350) compared to the afternoon grazing, 52.7% (126/239) among the grazing period of goats. The result was also significantly (P<0.01) influenced by the period of grazing animal (Table 14 & figure 10).

Table 14: Effects of period grazing on feeding system of goat on the prevalence of haemonchosis in goat

Period of grazing	No. of sample examined (n=)	No. of affected sample (n=)	% of haemonchosis	Chi-square value	Significance Level
Morning	350	270	77.1	12.277	.001**
Afternoon	239	126	52.7		
Total	589	396	57.8		

n= Total number of observation, **Significant at 1% level (P<0.01)

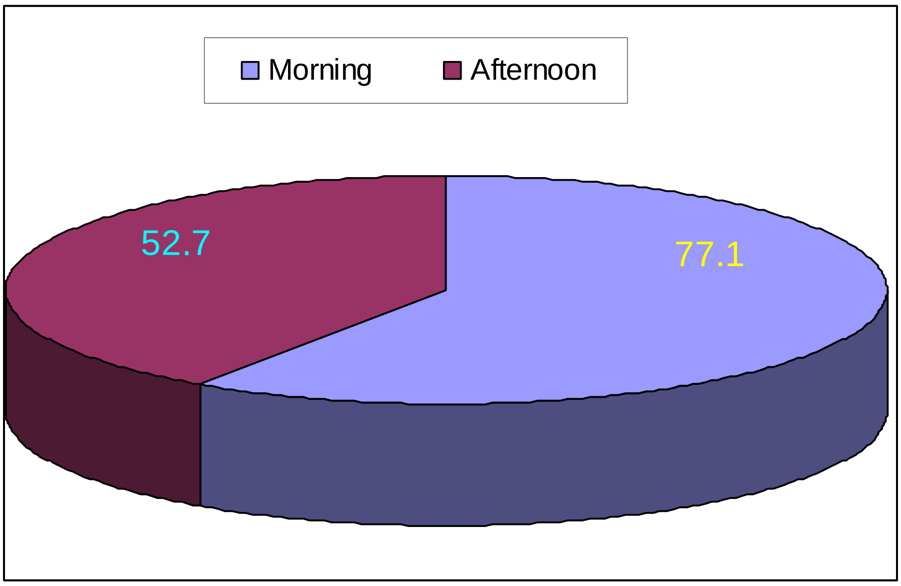


Figure 10: Pie-chart representation of the prevalence of haemonchosis in goats on period of grazing.

4.2.b. v. Effects of herd-size on the prevalence of haemonchosis in goats

The present study indicated that haemonchosis was significantly (P<0.001) influenced by the herd size of goats. Goats with small (1-5) herd group had a significantly low *Haemonchus* infection rate (38.2%) as compared to medium (6-10) herd group (64.2%) of goats whereas the large (above 10) herd group had the highest prevalence of *Haemonchus* infection (Table-15, 16 & figure 11).

Table 15: Effects of herd size on the prevalence of haemonchosis in goat

Herd size of goat	No. of sample examined (n=)	No. of affected sample (n=)	% of haemonchosis	Chi-square value	Significance Level
Small (1-5)	225	86	38.2	55.086	.000 (***)
Medium (6-10)	350	225	64.2		
Large (>10)	145	105	72.4		
Grand total	720	416	57.8		

n= Number of observation, ***Significant at 0.01% level (P<0.001)

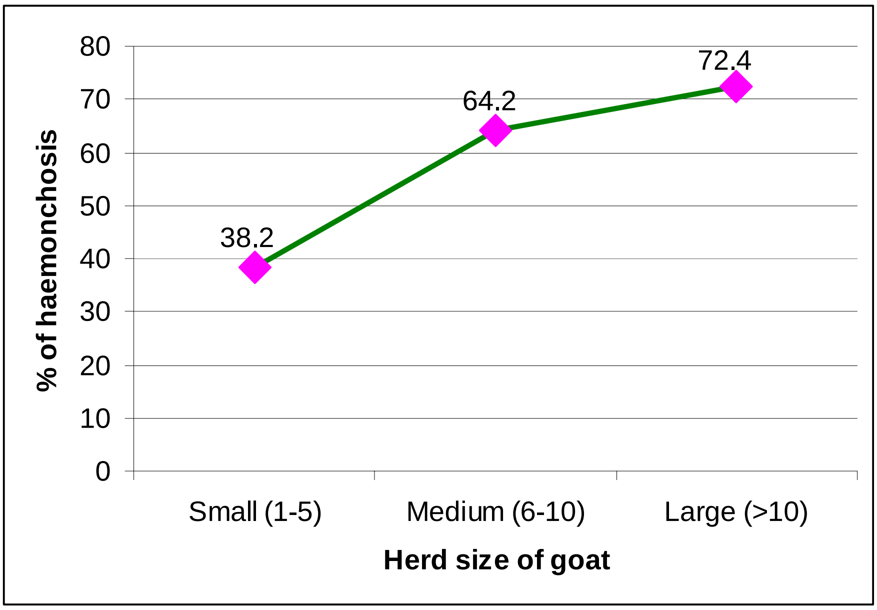


Figure 11: Line-chart representation of the prevalence of haemonchosis in different herd size group of goat.

Table 16. Analysis of Variance (ANOVA) for prevalence of haemonchosis by management practices of goats

Management factor	Sources of variation	Sum of squares	df	Mean square	F value	Significance Level
Husbandry system	Between groups Within groups Total	20.345 567.756 588.101	2	10.173 .791	12.860	.001 (***)
Floor of housing	Between groups Within groups Total	8.583 166.411 174.994	1	8.589 .232	37.021	.000 (***)
De-worming status	Between groups Within groups Total	37.889 438.610 476.499	2	18.944 .611	31.004	.000 (***)
Feeding system	Between groups Within groups Total	14.378 175.609 189.987	2	7.189 .245	29.343	***
Herd size	Between groups Within groups Total	11.022 143.665 154.687	2	5.504 .200	27.52	***

df= Degree of Freedom, ***Significant at 0.1% level (P<0.001), F= Factorial value

4.2.c. Environmental related factors affecting *Haemonchus* spp infection in goats

4.2.c.i. Effects of temperature, relative humidity and total rainfall on the prevalence of haemonchosis in goat of the study area

In this study, the highest mean temperature, 29.8°C was recorded in month of July, 2011 and lowest, 17.5°C in January, 2012, followed by 20.1°C in December, 2011. In the month of August, 2011 humidity was recorded 88% and in the month of July, 2011 the results of relative humidity was 86%. The highest humidity was recorded 88% in the month of August, 2011 followed by 87% in September and 86% in July, 2011. The month of maximum rainfall were August 2011, 454.8 mm, followed by

July, 2011, 341.1mm, September 202.7 mm, May, 2011,187.4 mm. In the month of January, 2012 the total rainfall was recorded 5.5mm, while in February, 2011, 0.6mm. In the month of December, 2011, virtually no rainfall was occurred. The overall mean temperature was 25.6°C, relative humidity 79.8%, rainfall 148.1 mm whereas total rainfall during the year 2011-2012 was 1477.6 mm (Table 17 & figure 12).

Table 17: Effects of mean temperature, relative humidity and total rainfall on the prevalence of haemonchosis in relation to month of the study area in year of 2011-2012 in Rajshahi.

Month of Collection of sample during study period	Mean temperature (°C)	Relative humidity (%)	Total Rainfall (mm)	Percent of Infection (%)
March-2011	26.1	65	11.0	50.0^{de}
April-2011	27.3	72	93.4	49.1^{e}
May-2011	28.9	82	187.4	61.3^{cd}
June-2011	29.4	85	341.1	61.9^{bcd}
July-2011	29.8	86	146.0	82.1^{a}
August-2011	28.9	88	454.8	79.7^{ab}
September-2011	29.3	87	202.7	71.9^{abc}
October-2011	27.9	83	34.1	73.3^{abc}
November-2011	23.1	81	1.0	55.0^{cde}
December-2011	18.5	84	Nill	40.0^{ef}
January-2012	17.5	79	5.5	28.3^{f}
February-2012	20.1	66	0.6	38.7^{ef}
Overall	25.6	79.8	148.1	57.8

Nill=absent, abcdef with different superscript letter in the same column different significantly with each other ($P<0.001$) by DMRT.

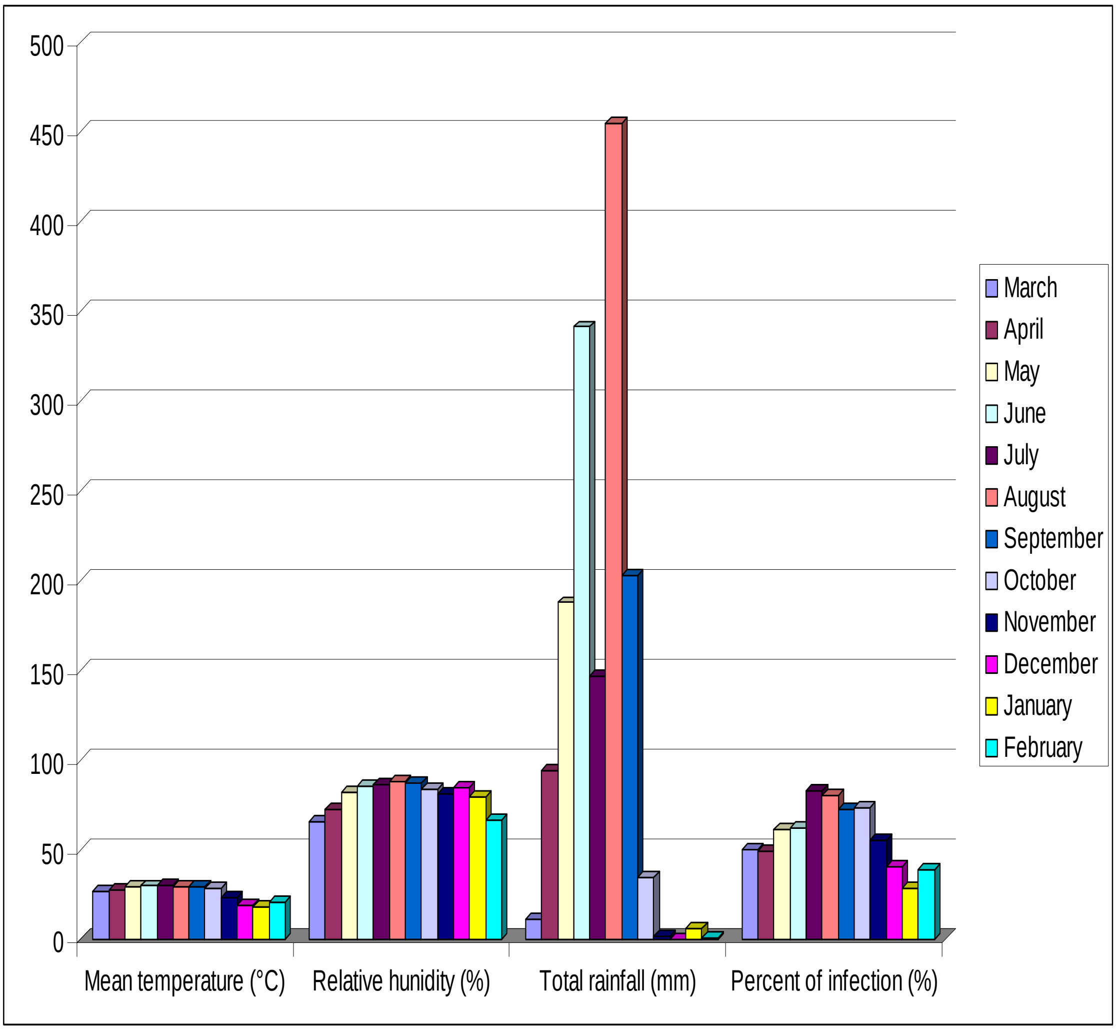


Figure 12: **G**raphical representation of the monthly value of mean temperature, relative humidity and total rainfall of study period.

4.2.c.ii. Effects of month of the study on the epidemiology of haemonchosis

The highest prevalence of haemonchosis was recorded in the month of July (82.1%) while the lowest (28.3%) during January. It was noticed that peak of *Haemonchus* spp infection in live and slaughtered goats were recorded in the month of July with the infection rate of 82.2%. In the chi square test and Analysis of Variance (ANOVA), the result also revealed that haemonchosis was highly significantly (P=0.0001) influenced by the month of study (Table-18, 20 & figure 13).

Table 18: Effects of month on the prevalence of haemonchosis in goat

Month of study	Total no. of sample examined (n=)	Total no. of Positive sample (n=)	Percent of haemonchosis (%)	Chi-square value	Significance level
March-2011	52	26	50.0	79.707	(.000) ***
April-2011	57	28	49.1		
May-2011	62	38	61.3		
June-2011	56	46	61.9		
July-2011	61	45	82.1		
August-2011	64	51	79.7		
September-2011	64	46	71.9		
October-2011	63	39	73.3		
November-2011	59	32	55.0		
December-2011	60	24	40.0		
January-2012	60	17	38.7		
February-2012	62	24	28.3		
Total	720	416	57.8		

n= Number of observation, ***Significant at 0.1% level (P<0.001)

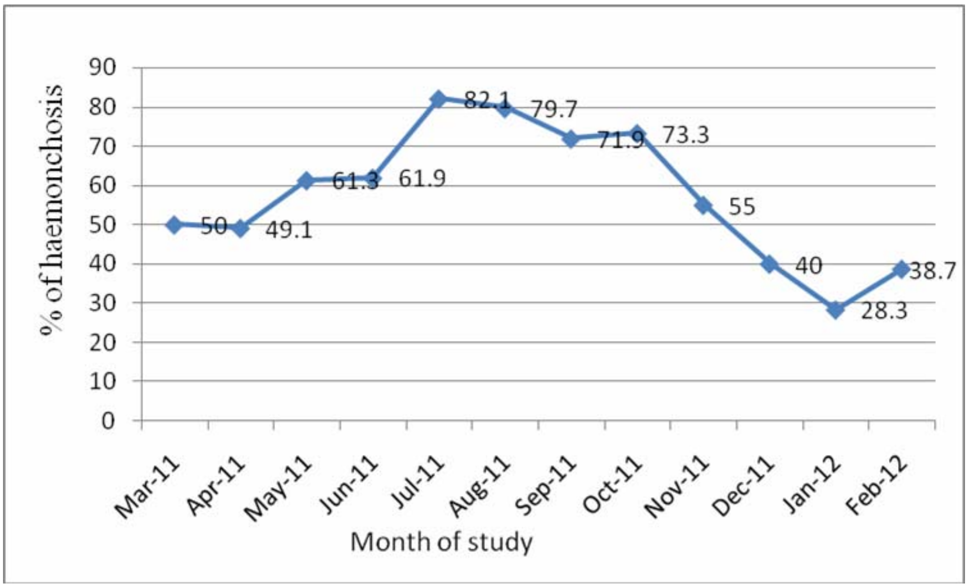


Figure 13: Line-chart representation of the monthly prevalence of haemonchosis in goats of study period.

4.2.c. ii. Effects of season on the epidemiology of haemonchosis in the study area

Among the season, the highest prevalence was recorded during Rainy (76.6%) followed by Summer (56.0%) season, whereas the lowest prevalence (40.5%) was recorded during winter season. The result revealed that prevalence of haemonchosis was highly significantly (P=0.0001) influenced by the season of the study (Table-19, 20 & figure 14).

Table 19: Effects of season on the prevalence of haemonchosis in goat

Season of the study	No. of sample examined (n=)	No. of positive sample (n=)	% of haemonchosis	Chi-square value	Significance level
Summer	234	131	56.0	65.520	.000 (***)
Rainy season	244	187	76.6		
Winter	242	98	40.5		
Total	720	416	57.8		

n= Number of observation, ***Significant at 0.1% level (P<0.001)

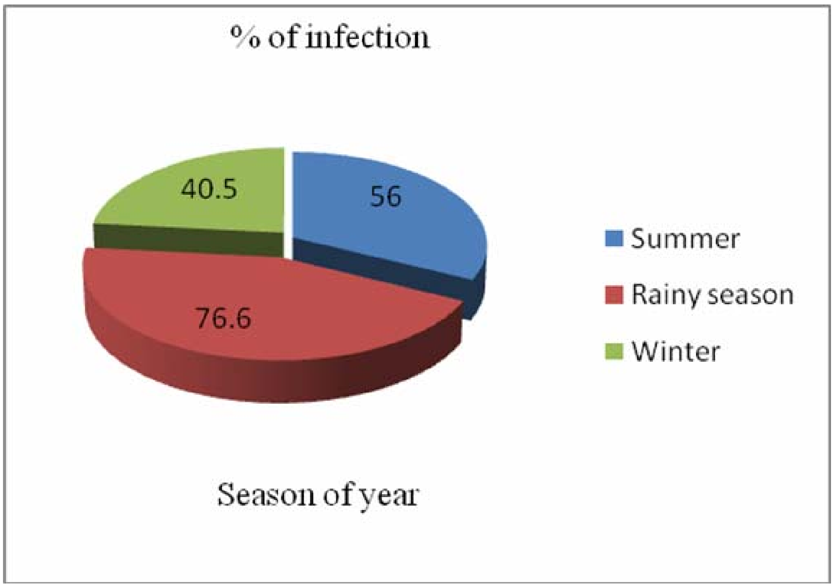


Figure 14: Pie-chart representation of season-wise prevalence of haemonchosis in goats studied.

Table 20. Analysis of Variance (ANOVA) for prevalence of haemonchosis on month and season of the study area

Dependable variable	Sources of variation	Sum of Squares	df	Mean Square	F	Significance level
Month	Between Groups	203.802	1	203.802	17.553	
	Within Groups	8336.398		11.611		.000 (***)
	Total	8540.200				
Season	Between Groups	8.059	1	8.059	12.360	
	Within Groups	467.853		.652		.000 (***)
	Total	475.911				

df= Degree of Freedom, F= Factorial value ***Significant at 0.1% level (P<0.001)

4.3. Effects of study area on prevalence of haemonchosis in goat

Prevalence of haemonchosis did not vary significantly (P>0.05) between the study sites. The prevalence was found 55.6% in Rajshahi district and it was 60.0% in Noagon district (Table 21 & figure 15).

Table 21: Effects of study area on prevalence of haemonchosis in goats

Study area	No of sample Examined (n=)	No of *Haemonchus* infected goats (n=)	Infected (%)	Chi-square value	Significance level
Rajshahi district	360	200	55.6	1.611	.205(NS)
Noagon district	360	216	60.0		
Total	720	416	57.8		

n= Number of observation, NS = Not significant (P>0.05)

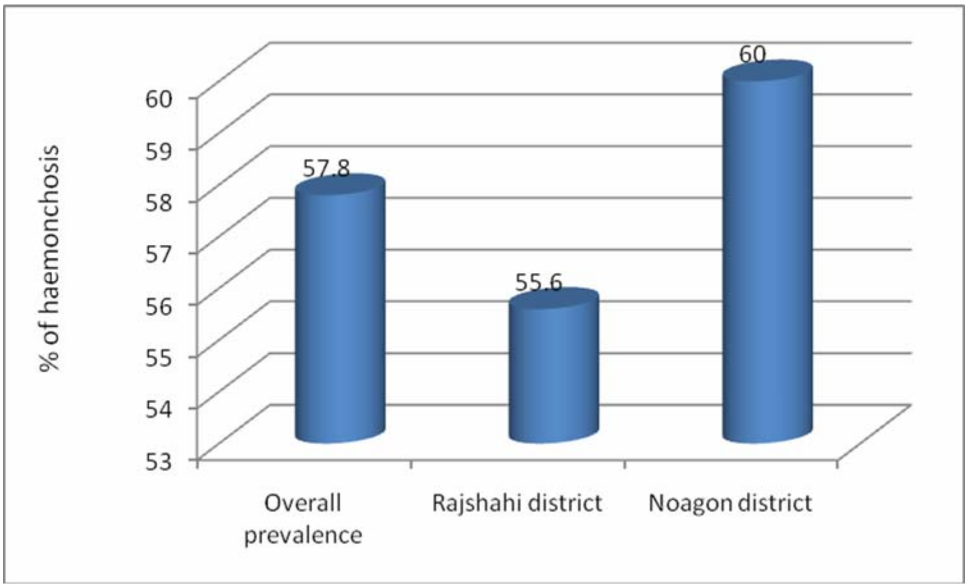


Figure 15: Graphical representation of the overall prevalence of haemonchosis in goat of both Rajshahi and Noagon district.

4.4: Effects of examination procedure on the prevalence of haemonchosis in goat

A total of 720 samples (363 faecal samples and 357 abomasa) were examined, of which 416 were harbouring *Haemonchus* spp infection. In necropsy, prevalence was observed the higher, 65.5% (234 out of 357, abomasal sample) compared to coproscopy, 50.1% (182 out of 363 faecal sample) shown in. The result also revealed that prevalence of haemonchosis was significantly (P<0.01) influenced by the examination pattern of the study (Table 22 & figure 16).

Table 22: Effects of examination procedure on the prevalence of haemonchosis in goat

Type of examination procedure	Type of goat examined	No of sample Examined (n=)	No of *Haemonchus* infected sample (n=)	% of haemonchosis	Chi-square value	Significnce level
Coproscopy	Live	363	182	50.1	17.517	.012 **
Necropsy	Slaughtered	357	234	65.5		
Total		720	416	57.8		

n= Number of observation **significant at 1% level (P<0.01)

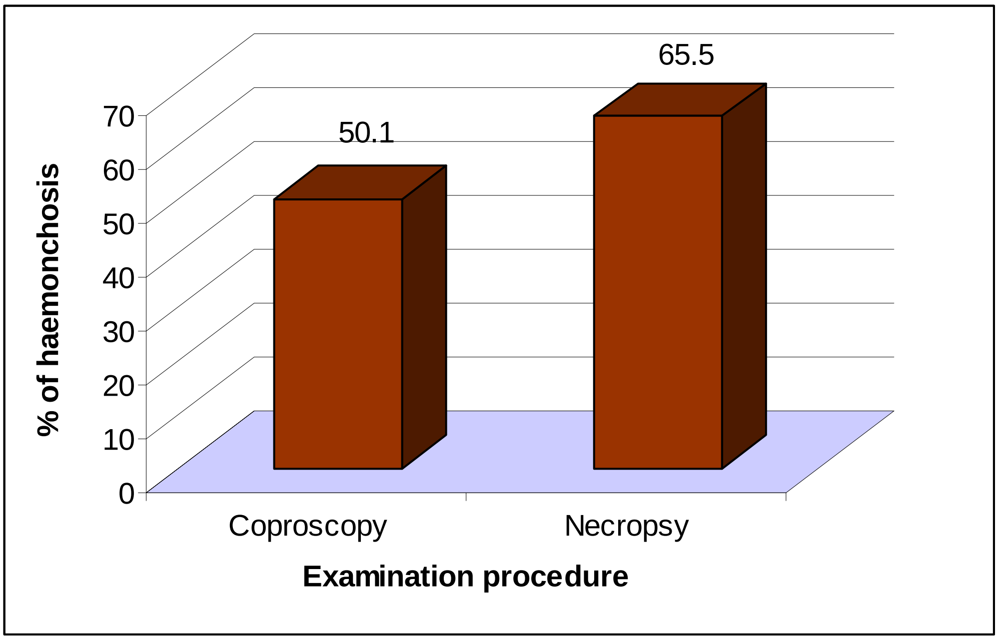


Figure 16: Bar-chart representation of the prevalence of haemonchosis in goat on methods of examination.

4.4.a. Effects of degree of infection on prevalence of haemonchosis in goat on faecal sample examination (Coproscopy)

In this study, light infection 48.4% (88/182) were higher followed by moderate, 41.2% (75/182) compared to 10.4% (19 out of 182) heavy infection depending on Egg Per Gram (EPG) of faeces counted by the Mc Master slide during faecal sample examination of goats. The result was highly significant (P<0.001) difference among the degree of infection shown in (Table 23 & figure 17).

Table 23: Effects of degree of infection on prevalence of haemonchosis in live goats (Coproscopy)

Total No. of examined live goats (n=)	Degree of infection	No of goats infected with *Haemonchus* spp (n=)	% of haemonchosis	Chi-square value	Significance level
363	Light (50-799) EPG	88	48.4	27.521	.000 (***)
	Moderate (800-1200) EPG	75	41.2		
	Heavy (>1200) EPG	19	10.4		
Total		182	50.1		

n= Number of examination, EPG = Egg Per Gram, ***Significant at 0.1% level (P<0.001).

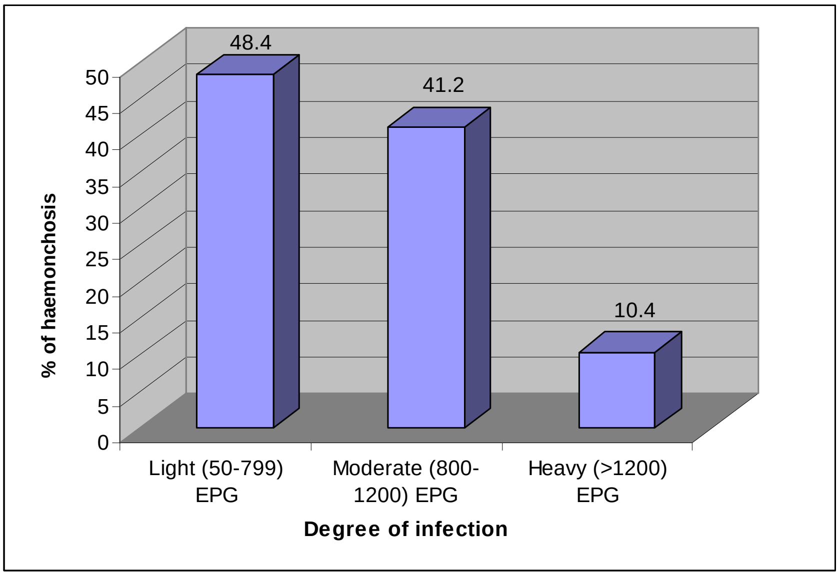


Figure 17: Bar-chart representation of the prevalence of haemonchosis in affeted goat among the infection category in coproscopy.

4.4.b. Effects of degree of infection on prevalence of haemonchosis in goat on abomasum examination (Necropsy)

In this study, moderate infection was higher 54.2% (127/357) than light 28.6% (67/357) infection followed by heavy, 17.0% (40/357) degree of infection was identified by counting of adult *Haemonchus* spp during necropsy findings. The chi-square test was revealed highly significant (P<0.001) difference among the infection category of affected goats (Table 24 & figure 18).

Table 24: Effects of degree of infection on prevalence of haemonchosis in slaughtered goats (Necropsy)

Total No. of examined slaughtered goats (n=)	**Degree of infection (on the presence of *Haemonchus* spp**	**No of goats infected with *Haemonchus* spp (n=)**	**% of haemon-chosis**	**Chi-square value**	**Significance level**
357	Light (200-500)	67	28.6	23.568	.000 (***)
	Moderate (>500 to 1500)	127	54.2		
	Heavy (1500 to 2000)	40	17.0		
Total		234			

n= Number of examination, ***Significant at 0.1% level (P<0.001).

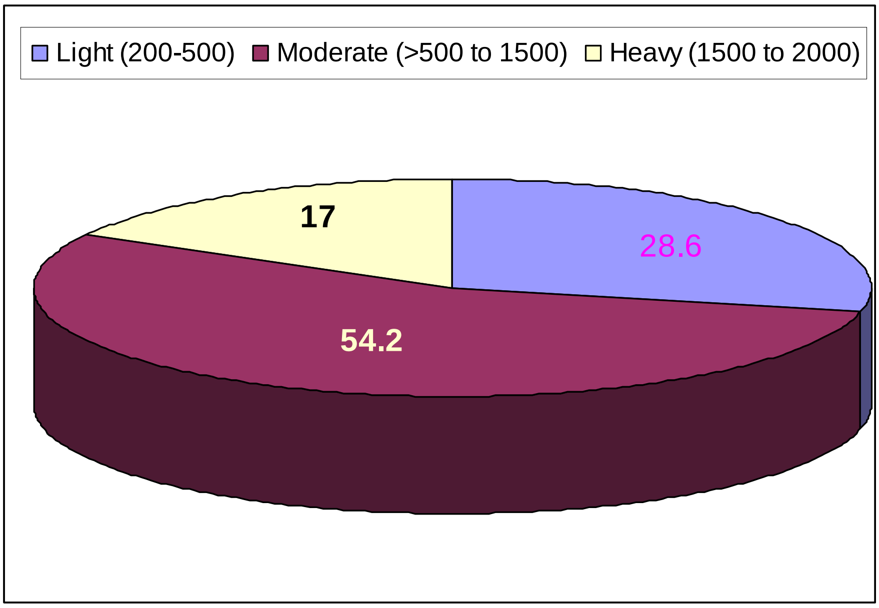


Figure 18: Pie-chart representation of the prevalence of haemonchosis among the degree of infection in the necropsy examination of goat.

4.5. Morphology of *Haemonchus* spp

4.5.a. Total worm (*Haemonchus* spp) burden in the abomasum of goat

In this study, a total 17,250 adult *Haemonchus* spp were collected from fourteen positively infected abomasa of goats in the study area. Among the collected *Haemonchus* spp, 8,510 from seven goats in Rajshahi and 8,740 from seven goats in Noagon district of Bangladesh (Table 25).

Table 25: Total worm burden and male female ratio in the affected abomaum of goats in the study area

Study area	Total no.of Worms	No. of female *Haemonchus* spp	% of female *Haemonchus* spp	No. of male *Haemonchus* spp	% of male *Haemonchus* spp	Male/Female Ratio of *Haemonchus* spp
Rajshahi (n=8510)	1440	880	61.11	560	38.99	1:0.63
	1170	720	61.54	450	38.46	1:0.42
	1240	800	64.52	440	35.48	1:0.55
	1360	950	69.85	410	30.15	1:0.43
	1050	580	55.24	470	44.76	1:0.81
	1560	980	62.82	580	37.18	1:0.59
	690	370	53.62	320	46.38	1:0.86
	8510	5280	64.07	3230	37.96	1:0.61
Noagon (n=8740)	1470	880	59.86	590	40.13	1:0.67
	1180	750	63.56	430	36.44	1:0.57
	1650	1020	61.18	630	38.18	1:0.62
	1800	1250	69.44	550	30.56	1:0.44
	850	540	63.53	310	36.47	1:0.57
	530	280	52.83	250	47.16	1:0.89
	1260	860	68.25	400	31.75	1:0.47
Total	8740	5580	63.840	3160	36.14	1:0.57
Grand total	17250	10860	62.95	6390	37.05	1:0.59

n= Number of observation

4.5.b. Overall sex (Male: Female) ratio of collected *Haemonchus* spp:

From the collected worms, female *Haemonchus* spp was found in 63.0% (10860 out of 17250) whereas 37.0% (6390 out of 17250) in male worms. The percentage of female *Haemonchus* spp were 63.0% significantly (P<0.001) higher than male, 37.0% (Table 26 & figure 19).

Table 26: The overall percentage of male and female *Haemonchus* spp collected in the abomasum of goat

Sex of *Haemonchus* worm	No. of worm collected (n=)	% of *Haemonchus* spp	Chi-square value	Significance level
Male	10860	37.0	25.624	.000 (***)
Female	6390	63.0		
Total	17250	100		

n= Number of observation, ***Significant at 0.1% level (P<0.001)

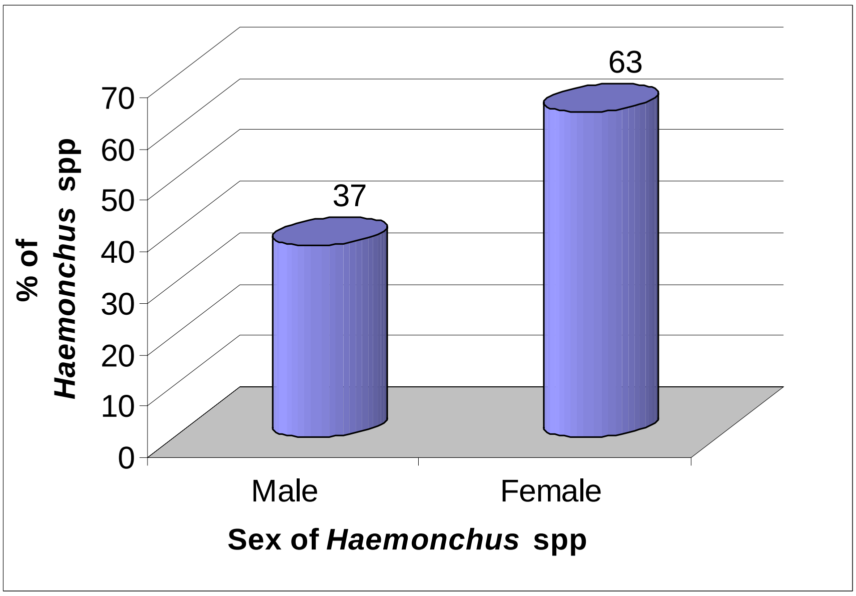


Figure 19: Bar-chart representation in the percentage of male and female *Haemonchus* spp from collected the abomasum of goats in both study area.

4.5. d. Overall prevalence vulvar flap morph type of *Haemonchus* spp

The study revealed that out of total 520 female *Haemonchus* spp from goats 33.5% linguiform, 20.4% smooth and 46.1% knobbed major vulvar morph types were identified. Statistically significant (P<0.001) fluctuation was observed among three major vulvar flap morph types in the study area (Table 27 & figure 20).

Table 27: Overall prevalence of major vulvar morph types of adult female *Haemonchus* spp

Total no. of adult female worms examined (n=)	Major vulvar morph types of *Haemonchus* spp	No.of female *Haemonchus* spp (n=)	% of identified female *Haemonchus* spp	Ch square Value	Significance level
520	Linguiform	174	33.5	22.288	.000 (***)
	Smooth	106	20.4		
	Knobbed	240	46.1		

n= Number of observation, **=Significant at 0.1% level (P<0.001).

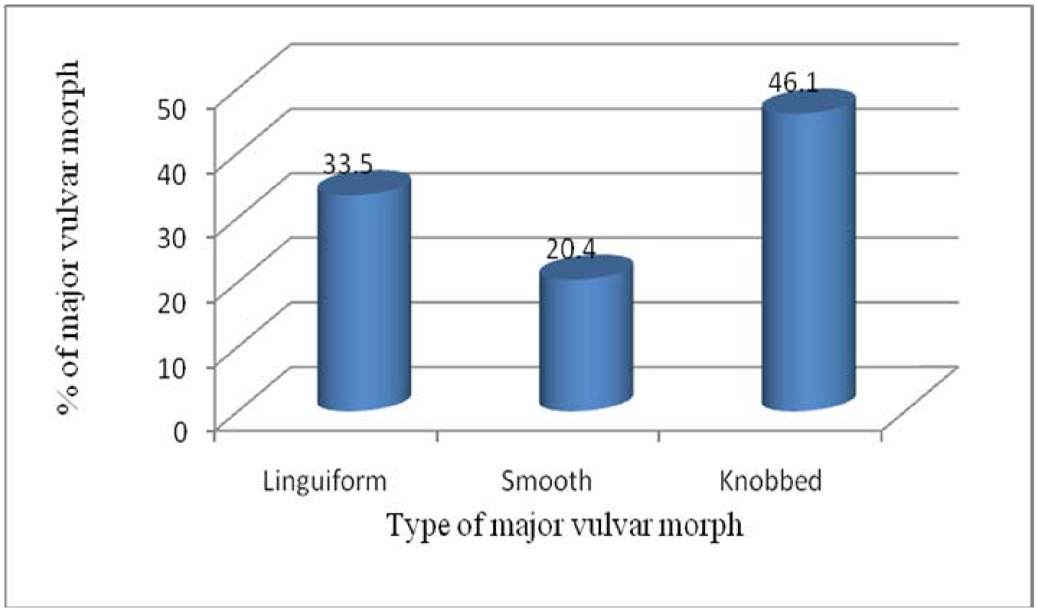


Figure 20: Graphical representation in the major vulvar flap morph of female *Haemonchus* spp percentage in the abomasum of goat in both study area.

4.6.a. Prevalence of major vulvar flap morphology of goat in two district of the study area

The study revealed that out of total 260 adult female *Haemonchus* spp worms from goats 43.0% linguiform, 21.1% smooth and 35.8% knobbed vulvar morphs were identified in Rajshahi district. Whereas in Noagon district, among 260 adult female

Haemonchus spp from goats 23.8% linguiform, 19.6% smooth and 56.5% knobbed vulvar morphs were found. In the Rajshahi linguiform type vulvar morphs were predominant but knobbed type in Noagon district.

In the chi square test, statistically significant (P<0.001) fluctuation was observed among three major vulvar flap morph types in both of the study area (Table 28 & figure 21).

Table 28: Prevalence of major vulvar morphs of female *Haemonchus* spp in both study area

Study area	Major Vulvar morph type of *Haemonchus* spp	No. of female *Haemonchus* spp	% of identified female *Haemonchus* spp	Chi-square value	Significance level
Rajshahi (n=260)	Linguiform	112	43.0	25.236	.000 (***)
	Smooth	55	21.1		
	Knobbed	93	35.8		
Noagon (n=260)	Linguiform	62	23.8	27.563	.000 (***)
	Smooth	51	19.6		
	Knobbed	147	56.5		

n= Number of observation, ***=Significant at 0.1% level (P<0.001).

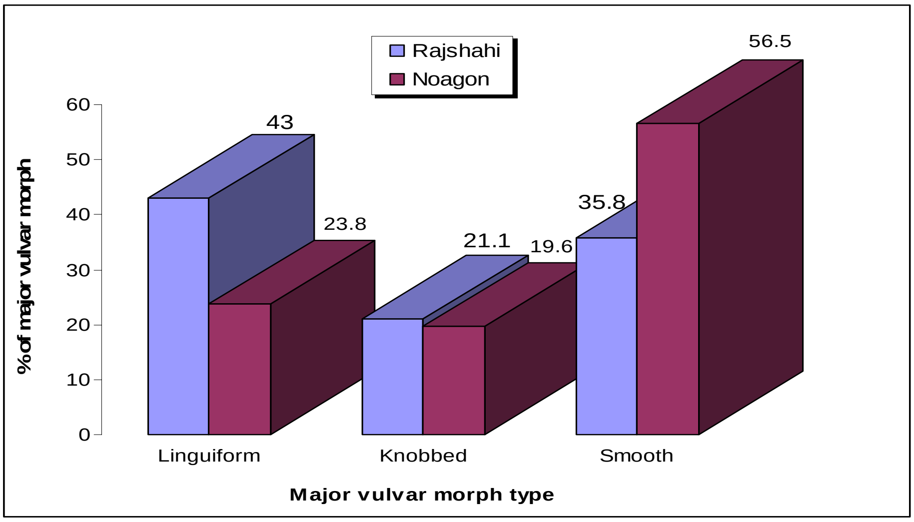


Figure 21: Bar-chart representation in the major vulvar flap morph types of female *Haemonchus* spp percentage in the abomasum of goats in both district.

4.6.b. Overall percentage of sub-types of vulvar flap morphology of female *Haemonchus* spp

Further classification of 174 linguiform vulvar flap female *Haemonchus*s spp from goats revealed overall proportions was LA type, 3.4% and LB type, 96.6% linguiform subtypes. The result also revealed that female *Haemonchus* spp was highly significantly (P<0.001) influenced between the linguiform subtypes of female *Haemonchus* spp in the study area (Table 29 & figure 22).

Table 29: Percentage of linguiform subtypes of vulvar flap of female *Haemonchus* spp

Total no. of adult female linguiform type worms examined	**Linguiform subtypes of *Haemonchus* spp**	**No. of female *Haemonchus* spp (n=)**	**% of identified female *Haemonchus* spp**	**Chi-square value**	**Sig. level**
n=174	LA	6	3.4	37.287	.000 (***)
	LB	168	96.6		
	LC	-	-		
	LD	-	-		
	LI	-	-		

n=Number of observation, '-' = Not found; LA = with only one cuticular inflations; LB = with out cuticular inflation; LC =with two cuticular inflations; LI = the cuticular inflation arises from the linguiform processes and LD = sublinguiform vulvar flap with three cuticular inflations, ***Significant at 0.1% level (P<0.001).

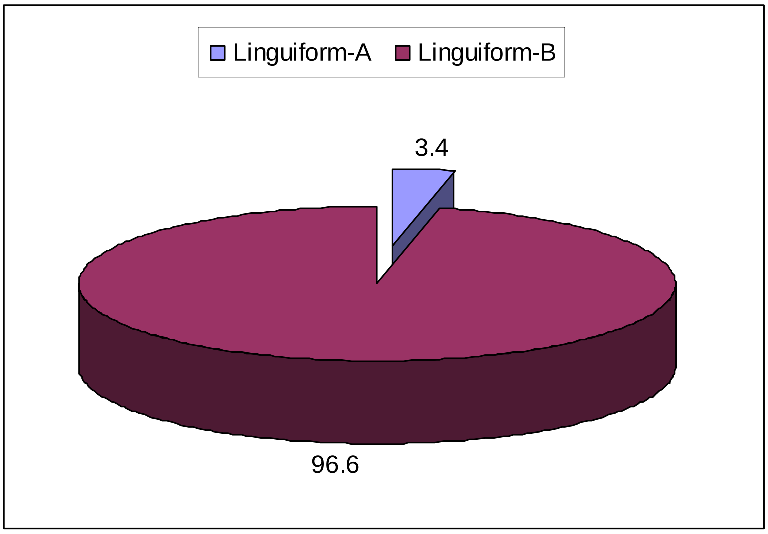


Figure 22: Pie-chart representation in the sub-linguiform types vulvar flap of female *Haemonchus* spp percentage in the abomasum of goats in both study area.

CHAPTER FIVE

DISCUSSION

Epidemiology of haemonchosis in goat

Haemonchosis caused by *Haemonchus contortus,* is one of the most economically deteriorating disease of goats (Maqsood *et al.,* 1996; Shahiduzzaman *et al*., 2003; Qamar, 2009; Nuruzzaman *et al*., 2012; Akkari *et al.,* 2013). Of these two species *Haemonchus contortus* is a predominant, economically important and highly pathogenic gastro-intestinal nematode of goats (Uhlinge *et al.,* 1992; Singh *et al*., 1997; Mortensen *et al.*, 2003). *Haemonchus* has become the most serious parasite affecting small ruminants throughout the world (Kaplan and Vidyashankar, 2012). Hence compared to other gastrointestinal nematodes *Haemonchus* is the most important parasite of domestic ruminants especially in sheep and goats (Perry *et al*., 1992; Le Jambre, 1995). The parasite inhabits in the abomasa goats, bores its walls and causes great economic losses including decreased weight gain (Ploeger *et al.,* 1990), decreased milk yield (Gross *et al.,* 1999). These parasites are common blood feeders that cause low productivity, blood loss, and decrease in haemoglobin that can lead to death in heavily infected animals (Githigia *et al.,* 2001; Vatta *et al.,* 2001). It has been estimated that each worm sucks about 0.05 ml of blood by seepage or ingestion from lesions per day (Urquhart *et al.,* 2000).

Madu, *et al.* (2005) reported that contaminated feed/ water and also contaminated utensils are favourable for the development and survival of pre-parasitic nematode. Waller *et al.* (2004) reported that *Haemonchus contortus* has some unique epidemiological developments i.e., complete inhibition of development of infective larvae occurs once during grazing they are acquired by goats. They further reported that the continuation of infection and early contamination of pastures can be initiated with only one parasite generation per year. The problem is however much more severe in tropical countries due to very favorable environmental conditions for helminth transmission (Mohanta *et al*., 2007 and Zeryehun, 2012) poor nutrition of the host animal (Mbuh *et al*., 2008) and poor sanitation in rural areas (Badran *et al*., 2012). As a result diseases caused by helminths remain a major impediment to small ruminant production in the tropics (Kumsa *et al*., 2011), and up to 95% of small ruminants are reported to show helminth infestation in these latitudes (Opara *et al*., 2005; Mbuh *et al*., 2008; Terefe *et al*., 2012). *Haemonchus* has become the most serious parasite affecting small ruminants throughout the world (Kaplan and Vidyashankar, 2012). Prevalence of haemonchosis in small ruminant being very high. They cause adverse effects on the host like haematological and biochemical disturbances (Rasool *et al.,* 1995; Hayat *et al.,* 1996; Iqbal *et al.,* 1998; Hayat *et al.,* 1999), loss of body weight (Khan *et al.,* 1988) and huge economic losses (Iqbal *et al.,* 1989; Iqbal *et al.,* 1993). Haemonchosis being the most prevalent disease in the tropics and subtropics, it has shown great economic losses and an increasing prevalence trend in sheep and goat flocks, (Lindqvist *et al.,* 2001). There are several factors that contribute the disease onset like warm, humid and wet grazing season, the more time animals spend on pasture, ineffeicient selection of de-wormers, poor husbandry practices and or the development of anthelmentic resistance against *Haemonchus contortus*. Nwosu *et al.* (2007) reported that abundance of the eggs and adult *Haemonchus* parasites in goats and revealed 55.8% of the samples were positive for haemonchosis.

5.1. Overall prevalence of haemonchosis

The current study was designed to record the prevalence of haemonchosis in goats under different managerial conditions. A total 720 goats were examined of these 416 were found positive for *Haemonchus* spp, so prevalence was 57.8%. This finding is almost similar with the earlier report of Nuruzzaman *et al*. (2012) who reported 58% *Haemonchus contortus* infection in slaughtered Black Bengal goats in Thakurgaon district of Bangladesh. These findings are also in line with those of Singh *et al*. (2013) from Mathura region (68.75%); Chagas *et al.* (2008) (65.58%) from Cameroon; Nwosu *et al.* (2007) 55.8%; Shahiduzzaman *et al*. (2003), 65.63% from Mymenshingh, Bangladesh; Maqsood *et al.* (1996) from Pakistan (47.1%). Talukdar (1996) and Swarnkar *et al*. (1996) reported more than 50% prevalence of *H. contortus* in Assam and Rajasthan, respectively. The results of present study are nearly similar to these workers. However, lower prevalence was reported by AL-Hasnawy (2014) from Hilla city, Iraq; (29.67%), Mir *et al*. (2013) from Kashnir (23.73%); Akkari *et al.* (2013) that recorded infection rate 33.6% in goat of Béja, Tunisia; Akanda *et al*.

(2012); 30% from Sylhet, Bangladesh; Nasreen *et al*. (2011) from Hyderabad 14.65%; Javed *et al.* (1992) from Pakistan (21.7%); Maqbool *et al.* (1997) from Pakistan (28.3%); Maqbool *et al.* (1997) from Pakistan (17.54%); Qamar (2009) from Lahore, 38.47%; Tariq, *et al.* (2003) from Pakistan (38%); Nwosu *et al*. (2007) from Nigeria (6.7%). A lower prevalence of *Haemonchus contortus* in goats (26%) was also reported by Almalaik *et al*. (2008).

The higher prevalence was reported by Garedaghi and Bahavarnia, (2013) from Tabriz town, Iran (73.1%; Demissie *et al. (*2013), 75.2%; Kakar *et al*. (2013), 71.37% from Pakistan; Fentahun and Luke (2012) from Ethiopia (73.5%); Mbuh *et al.* (2008) from Cameroon (94.23%); Pandit *et al.* (2003) from India (81.17%). Its higher prevalence could be attributed to the fact that this nematode has a relatively short generation interval and ability to take advantage of favorable environmental conditions (Grant, 1981). The mean monthly maximum temperature of 18ºC or above and total monthly rainfall of 50 mm are conducive for translation and transmission of *H. contortus* (Gordon, 1953). Therefore, climate of the study area is very conducive for the propagation of *H. contortus* larvae. Keeping in view the high pathogenicity of *H. contortus* compared with other nematode species, it is concluded that goat farmers of the study area are relatively at high risk of economic suffering due to lowered productivity of their animals.

This variation may be due to the difference in seasonal fluctuation of grazing pattern and practices of de-worming/medication, agro-ecological, breed, management and/or veterinary health care level differences (Radostits *et al*., 2007). Waller *et al.* (2004) reported that *Haemonchus contortus* has some unique epidemiological developments i.e., complete inhibition of development of infective larvae occurs once during grazing they are acquired by sheep and goats. There is almost no survival of infective larvae during winter season on pasture. They further reported that the continuation of infection and early contamination of pastures can be initiated with only one parasite generation per year. A variety of factors such as host, age, breeding status, grazing habits, level of education and economical capacity of the community, the standard of management and anthelmentics usage are crucial elements influencing the development, distribution and survival of parasites (Rahmeto *et al*., 2010).

5.2. Risk factors of haemonchosis in goats

5.2.a. Host related risk factors affecting *Haemonchus* spp infection rate

5.2.a.i. Effects of age of goat on the prevalence of haemonchosis

From the table-4, the occurence of haemonchosis was found to be highest in young (6 to 12 months of age), 88.5% compared to adult (>12 to <24 months of age), 69.6% followed by older (>24 months of age) goats. The lowest prevalence rate was observed in kids (>6 months of age). This is in agreement with the observation of AL-Hasnawy (2014) who found the highest infection rate in the ages of 6-12 months in goats at a rate of 48.57% in Iraq. Nabi *et al*. (2014) who studied high infection rate was recorded in young (1-6 months) and immature (6-12 months) i.e. 48 % while in adults (>1 year) was 26 % (P<0.05). It was also suggested that higher shedding of helminth egg around parturition can be a source of environment contamination that ultimately results in transfer of infection to young susceptible animals. Higher prevalence in young animals can be contributed due to contaminated environment, overstocking and lack of immunity (Biu *et al.,* 2009). With increase in age the prevalence of GIT nematodes decreases due to the development of immunity and it is well documented that small ruminants develop partial immunity against GIT nematodes. Age has significant influence on the prevalence of GIT nematodes (Tariq *et al.,* 2008) that agree our findings that young ones are more susceptible to nematode infections.

Maqsood *et al.* (1996) reported that the prevalence of haemonchosis was higher in goats less than two years of age (47.8%) compared with those of above two years (33.3%). Nuruzzaman *et al.*, (2012) was found that age can affect the occurrence of parasites. He also reported the prevalence of abomasal nematodes in goats were significantly (P<0.01) higher in young aged (84.61%) than adult aged (61.21%) goats. Youngs were 3.30 times more susceptible than adults. Higher prevalence in young animals can be contributed due to contaminated environment, overstocking and lack of immunity (Biu *et al.,* 2009). With increase in age the prevalence of GIT nematodes decreases due to the development of immunity and it is well documented that small ruminants develop partial immunity against GIT nematodes. Age has significant influence on the prevalence of GIT nematodes (Tariq *et al.,* 2008) that agree our findings that young ones are more susceptible to nematode infections. These results are also related to the findings of (Rizvi *et al*., 1999; Vlasoff *et al*., 2001; Magona and Musisi, 2002; Lateef *et al*., 2005; Yadav, *et al*., 2006), those researchers reported that, prevalence of haemonchosis was higher in young goats due to the fact that with the advancement of age, vigor of the goats become better and they develop resistance against the parasitic diseases. Mir *et al.* (2013) was found that young ones are having more infection (36.48%) than adults (18.57%). The lower prevalence of haemonchosis was observed in older (>2 yrs) goats because gradually as the exposure to parasitic infection increases, the immune system of host animals builds up specially against *Haemonchus* spp and age resistance develops. The hypothesis that older animals can acquire immunity against gastro-intestinal parasites has been supported experimentally by different studies (Gumble and Zajac, 1992; Knox, 2000). The present result related to many researches but variation may be due to sample size, age grouping, variation in geographical region, breed type, management factors and climatic changes etc.

5.2.a.ii. Effects of sex of goats on the prevalence of haemonchosis

Goats of female group had a significantly ($P<0.05$) higher *Haemonchus* spp infection rate (63.9%) as compared to male group (50.0%) of goats. Maqsood *et al.* (1996) reported that the rate of infection was higher (74.6%) in female ones than male (59.1%). However, most of the researchers have observed higher rate of *Haemonchus* infection in female goats compared with males, Pal and Qayyum (1992); Maqsood *et al*. (1996); Komoin *et al.* (1999); Valcarcel and Romero (1999); Gauly *et al.* (2006), Lateef *et al*. (2005); Al-Shaibani *et al*. (2008); Shimelis *et al*. (2011); Khan *et al.* (2010), Tehrani, *et al.* (2012), Demissie, *et al.* (2013), Al-Hasnawy, (2014). Demissie *et al.* (2013) also reported the sex related prevalence in goats was 81.6% in female and 71.9% in male for *Haemonchus* species. Kakar *et al.* (2013) was studied the prevalence of gastrointestinal nematodes was higher in female (56.87%) as compared to male (42.08%). Hassan *et al.* (2011) gave almost similar findings, 57.49 % in female and 42.51% in male goat in the Chittagong, Bangladesh. Maqsood *et al.* (1996) reported that the rate of haemonchosis was higher (74.6%) in females than males (59.1%). Shahiduzzaman, *et al*. (2003) reported that the infection rate of *Haemonchus* spp was significantly ($P<0.05$) higher in females than the male goats.

Raza *et al.* (2007) studied that incidence in female goat was 31.09% and male goat was 29.91%. Saiful *et al.* (2008), Qamar *et al.* (2007) and Zeryehun (2012) was observed higher rates of nematode infection in female hosts compared with the males. Higher prevalence of haemonchosis in females compared with males might be due to lowered resistance of female goats on the part of their reproductive events and unbalanced diet against higher needs and hench the females needs more nutrition for the nourishment of their kids they are voracious eaters by nature, which gives more chance of acquire of infective larvae than the males. Maqsood *et al.* (1996) and Gauly *et al.* (2006) studied that sex can influence the prevalence of helminthes. The influence of sex on the susceptibility of animals to infections could be attributed to genetic predisposition and differential susceptibility owing to hormonal control. The high infection in female species comparison with males possibly due to the numbers of females over males in the herd and the length of the period of their presence in the pasture **(**Al-Hasnawy, 2014). Maqsood *et al.* (1996); Valcarcel and Garcia (1999) assumed that sex is a determinant factor influencing prevalence of parasites. Dagnachew *et al.* (2011) showed female animals were affected higher infection rates than males despite similar husbandry practice. This finding support with the general understanding of helminth infection that females are more susceptible to helminthiasis.

The present value of prevalence of haemonchosis was different from findings of Nuruzzaman *et al.* (2012) who observed that male was higher prevalence (65.22%) than female (51.85%) goats. Nabi *et al.* (2014) observed prevalence and intensity of infection was high in males (46.66 %) as compared with females (34.66 %) which supported by (Kanyari *et al.,* 2009) that male were more susceptible to parasitic infections than females. Effect of sex on the resistance level against GI parasites was reviewed by (Barger, 1993) and reported that difference in resistance level were significant after puberty only. The difference in resistance level after puberty is due to estrogen stimulatory effect on immune response against GIT nematodes while androgen suppresses the immune response (Seli and Arici, 2002) and this is the reason that males are more susceptible to infectious diseases including nematode parasites than female. However, Gulland and Fox, (1992) reported that the intensity and prevalence of *Haemonchus* infection were higher in male goats than females, except during lambing season, and it decreased as age progresses in sexes of goats. Shahadat *et al.* (2003) also reported the prevalence is higher in males than female goat. This was might be due to the study area, management effects, sample size, experimental design and de-worming status of the goats. In contrast to present study Mushtaq and Tasawar (2011) observed the prevalence of gastrointestinal nematode parasites was higher in male (81.4%) as compared to female animal (73.1%). Bilbo and Nelson (2001) reported that such differential prevalence of gastrointestinal nematodes in sheep may be due to stimulatory effects of estrogens and inhibitory effect of androgens on immune responses. While Qamar (2009) was of view, that the animals of either sex were equally affected by the helminths. Similarly, Urquhart *et al.*, (1996) correlated the hormonal difference in either sex with parasitic susceptibility and found that males are more susceptible than female due to androgen hormones. The females are more resistant to infection might be due to the stimulatory effects of estrogen on immune response, whereas the androgen have an opposite effect in males. In contrast, Raza *et al.* (2009) clarified that the higher prevalence in females might be due to lower resistance on the part of their reproductive events and insufficient/ unbalanced feed against higher need. The female animals generally harbored a significantly higher worm burden than male animals due to the enhanced grazing of females during lactation and their low resistance during pregnancy and parturition. Silva *et al.* (2011) also supported the rearing systems and observed that the goats in the organic system had higher fecal egg counts ($P<0.05$) than the goats in the conventional system.

Among the female goats in this study, infection was higher in pregnant 76.0% compared to non pregnant 62.2% goats. This is in line with Nabi *et al.* (2014) who reported infection was found relatively high (42%) in pregnant animals as compared with non pregnant animals (33.92 %). It is evident that pregnancy greatly influenced the prevalence rate due to temporary relaxation in immunity (Mandonnet *et al.* 2005). High infection rate and intensity has been observed in pregnant animals especially around parturition in small ruminants (Chartie *et al.* 1998). High intensity of nematode infection around parturition plays significant role in pasture contamination and disease transmission to susceptible animals especially kids. Urquhart *et al.* (1996) reported females are more prone to parasitism during pregnancy and peri-perturient period due to stress and decreased immune status. The present result was related to many findings of the other researcher of the world but variation may be due to the reasons that small sample size, variation in geographical location of the study area, properly uses of anthelmintics and other management practices etc.

5.2.a.iii. Effects of breed on the prevalence of haemonchosis in goats

There was no statistically significant (P>0.05) association between breed and prevalence of haemonchosis in goats. The results showed that the prevalence of haemonchosis is higher in crossbred, 60.2% goats compared to Black Bengal (Local) bred, 55.6% of goat. Nuruzzaman *et al.* (2012) observed that Black Bengal goats were comparatively higher (57.14%) prevalence than cross-bred (55.81%) goats in Thakurgaon district of Bangladesh. Those findings are almost similar to the present findings. This is due to the resistance of the Black Bengal goats against the *Haemonchus* infection. Goats which are browsers in their natural environment, the genetic pressure to develop resistance to *Haemonchus contortus* in the local breeds might be precluded. Genetic resistance operated mainly against worm establishment and that this was controlled by the immune response (Shahiduzzaman *et al.,* 2003). Indigenous goat breeds can tolerate gastrointestinal parasite infestation (Baker *et al*., 1998). The breed wise investigation of helminths revealed that local (indigenous) breeds, 19.04% of study area were found to be resistant to helminths parasites as witnessed due to low prevalence of infection in small ruminant (Mir *et al*., 2013). The reason for high prevalence of helminths in exotic breeds of animals may be that the exotic animals which are grazed here before slaughtering pick up the infection at a higher rate because of less immunity and less exposure to these parasites they are easily infected (Maraqa *et al.,* 2005). Chaudhary *et al*. (2007) stated that genetic variations and natural resistance could be responsible for the differential prevalence of *H. contortus* among different breed of animals.

5.2.a.iv. Effects of body condition on the prevalence of haemonchosis in goats

Goats of poor body condition group had a highest prevalence 82.8%, followed by medium, 61.3% and lowest prevalence of *Haemonchus* infection rate, 39.3% was observed in good body conditioned goats. The result also revealed that haemonchosis was significantly (P<0.001) influenced by the body condition of goats. Mesele *et al.,* (2014) was noticed that high prevalence was recorded in animals with poor body condition (33.6%), followed by medium body condition (21.7%) and the lowest was recorded in animals with good body condition (19.7%). Results of the present study in the epidemiology of haemonchosis revealed that body condition of the host seems to have influence on the prevalence of infection. In the present study, an animal with poor body condition seems to have higher prevalence than other groups could be related to their higher susceptibility to infection than other groups of goats. This agrees with Nigatu (2008), Keyyu *et al.* (2006), Kanyari *et al.* (2009). Gonfa *et al.* (2013) was found the overall prevalence of abomasal nematodes was 94.44%, 77.21% and 84.47% in poor, moderate and good body condition score, respectively. There was a statistical significant difference ($P<0.05$) in prevalence among body condition scored goats. Concerning the prevalence of haemonchosis in different body conditioned animals, higher prevalence was observed in medium body conditioned animals (81.6%) than good body conditioned ones (75%). There was no significant difference ($P<0.05$) was observed in prevalence of the disease between both groups (Fentahun and Luke, 2012). Muluneh *et al.* (2014) also found that the slightly higher prevalence of nematode infection in poor body condition animals (48.1%) followed by good (43.0%) and medium (37.1%) body conditioned animals in Ethiopia. The highest infection rate recorded in poor body condition may be due to the effect of heavy infection rate of *Haemonchus* spp and other factors, which lead to significant weight loss. Small ruminant with poor body conditions were the most affected compared to the medium and good body conditions. When animals suffer from shortage or scarcity of nutrition, and infected with gastrointestinal internal parasites their immunity compromised. Hence, possibly this can be accounted for the higher prevalence of the *Haemonchus* spp in poor body condition animals. Well-nourished animals are known to withstand the effects of worm infection much better than those given a lower plane of nutrition. Meanwhile, the resistance of animals to establishment of worm larvae can be enhanced by improved protein nutrition (Sykes and Coop, 2001). Well-fed animals have better resistance to parasites and most pathogens (Kumba *et al.,* 2003). Muluneh *et al.* (2014) also reported this poor body condition might be due to malnutrition or other concurrent disease and parasitic infection which lead to poor immunological response to infective stage of the parasites. This result present result was related to the many researcher’s works in the other parts of the world but variation may be occurs due to the sample size, examination procedure, composition of feed, hygienic and de-worming management of the animals, geography and climatic condition of the study area.

5.2.b. Management factors affecting prevalence of haemonchosis in goats

5.2.b. i. Effects on husbandry system in prevalence of haemonchosis in goat

The present study indicated that haemonchosis was highly significantly (P<0.001) influenced by the different practiced husbandry system of goats. Goats managed under intensive husbandry system had a significantly low *Haemonchus* infection rate (15.3%) as compared to goats under extensive husbandry system (71.6%). This is in agreement of Rabbi *et al.* (2011) who observed helminth and protozoan infections were recorded as the highest in extensive system (86.1%) followed by semi-intensive (76.3%) and intensive (57.5%) systems of Black Bengal goats in Bangladesh. Findings of this study suggest that goats reared in extensive system are more susceptible to helminth parasitic infection. The goats under extensive system and semi-intensive system were about 2 times and 1.5 times, respectively more likely to be infected by strongyles than the goats of intensive system. Badran *et al.* (2012) studied the epidemiology of *Haemonchus* spp (40.8% ± 14.2 and 0.0% ± 0.0) for extensive and intensive rearing system, respectively. Under the extensive system, animals are grazed and herded together in the same area during dry and wet seasons. This increases the possibility of pasture contamination and consequently higher prevalence rate of parasitic infections (Magona and Musisi, 2002). In addition to that, in extensive system, the grazing areas are located lowland and mid altitude areas, which are thought to be suitable for survival of the larval stage of the parasite. Moreover, the low levels of infection were detected in animals reared in an intensive system and were kept in wooden barn with raised floor that were cleaned regularly while those in extensive rearing system were kept in places which were not regularly cleaned. The access to the extensive and the change in housing conditions result in breaking existing bio-security barriers both between and within farms. Furthermore, the extensive rearing environment is considered more conducive of parasitic infections than the intensive rearing environment. In both cases, the closer contact between faeces, parasites and hosts may increase the incidence of existing infections, and potentially result in emergence (or re-emergence) of new parasitic diseases

(Waller 2004; Ng'ang'a *et al*., 2004). Results of this research are consistent with the findings of other researchers (Keyyu *et al*., 2006; Raza *et al*., 2007) who found a direct influence of grazing characteristics on the prevalence of most of GIP and who reported that under traditional free-range grazing systems (extensive) there is continuous infection and re-infection from heavily contaminated pastures compared to their intensive-grazed counter parts. Evaluation of genera diversity in the two rearing systems revealed that poor diversity is found in the intensive rearing system. The prevalence of haemonchosis higher in extensive system possibly there was closer contact between faeces, infective stage of parasites and hosts may increase the incidence of existing infections and potentially result in emergence and re-emergence of new parasitic diseases.

5.2.b. ii. Effects of floor of housing on the prevalence of haemonchosis in goat

Goat maintained on muddy floor was infected more, 71.3% with more *Haemonchus* infection than slatted floor, 44.1% housing during the study period. In the present study it was found that haemonchosis was highly significantly ($P<0.001$) influenced by the floor of housing of goats Hasan *et al*. (2011) from Bangladesh and Jugessur *et al*. (1998) from India gave similar report on village goats. This variation of haemonchosis among the housing system of goats due to the low level of hygiene which favours re-infestation (Hasan *et al*., 2011). Poor and unhygiening housing is one of the causes of losses as it is in the dung of animals that parasites survive and affect young animals (Ficarreli, 1995). The low levels of infection were detected in animals reared in an intensive system and were kept in wooden barn with raised floor that were cleaned regularly. In muddy housing, there were close contact of faeces with animals as well as infective stage of parasites contaminate with the grasses or feeds of animals resulting parasitic infection. The variation of the present result compared to other researches may be due to the climatic change of the region, type of floor, feeding system, hygienic management and other management practices of animal.

5.2.b. iii. Effects of de-worming status on the prevalence of haemonchosis of goats

Goats without anthelmintic treatment (none) had a higher, 71.47% prevalence followed by those given anthelmintics as irregular basis, 56.45% and least 25% prevalence in those given anthelmintic regularly. The result also revealed that haemonchosis was significantly (P<0.001) influenced by the management practice like deworming status of the goats before sample collection. Anthelmintics are drugs used to treat against helminthic diseases. Anthelmintics such as mebendazole, albendazole, fenbendazole and oxyclozanide had been continuously and extensively used for deworming ruminants in our country for several years. Methods to control *H.* contortus must attempt the break the life cycle of the worm, whether through anthelmintics, animal management, or pasture management (Hepworth *et al.,* 2006). Anthelmintics, drugs that remove the parasite from the intestines, are the most common method for managing *H. contortus.* Chemical anthelmintics are often used to combat haemonchosis, because they are cheap, simple and cost effective; but parasite resistance to them is growing, (Stear *et al.,* 2007).

In this study, goat without anthelmintic treatment was higher prevalence of haemonchosis because *Haemonchus* worms were not under controled, easily survive within the abomasums of goat. Parasitic disease control failures were temporarily alleviated by higher drug doses and more frequent treatment as resistance developed, the beneficial effect of this strategy was short lived. The exclusive use of anthelmintics to control nematodes has selected worm populations that simultaneously exhibit increasing levels of resistance to several classes of anthelmintics (Van Wyk *et al*., 1997; Fontenot *et al*., 2003) and in some cases to all major anthelmintic activity groups (Van Wyk *et al*., 1997a, b). Goats with regular anthelmintic treatment was the lowest prevalence rate due to continued use of anthelmintics has had the effect of increasing the frequency of resistant alleles in parasite populations due to the selective effect of the drugs, and anthelmintic resistance has become sufficiently widespread and serious as to threaten the viability of sustainable small ruminant production in many countries (Waller, 1999). Assoku (1981) evident that routine prophylactic drenching at regular intervals with different anthelmintics has a significant lowering effect on the total worm burden. The misuse and or widespread intensive use of sometimes poor quality synthetic or semi-synthetic anthelmintics, inappropriate route of administration and massive re-exposure has lead to development of high level multiple anthelmintic resistance against the three main families of anthelmintic drugs, namely, Benzimidazoles, Macrocyclic lactones and Imidazothiazoles (Lioyd *et al.,* 2000; Hertzberg *et al.,* 2000; Chandrawathani *et al.,* 2003; Melo *et al.,* 2003). Ivermectin as well as albendazole and fenbendezol (both benzimidazoles) have produced the highest levels of resistance, and resistance with levamisole and moxidectin is increasing (Burke, 2005; Schoenian, 2013). However, the failure of anthelmintics to control GIT nematodes may also be due to reasons other than resistance, such as poor maintenance of drenching equipment, and under-dosing due to errors in assessing body mass (Taylor *et al.,* 2002). Resistance to these drugs is high because each one uses a specific mechanistic pathway to kill *H. contortus.* For example, ivermectin binds to glutamate-gated channels in the worm's nervous system, opening them, paralyzing the worm and killing them through starvation (Nolan, 2004). Alternatively, albendazole binds to the parasite’s tubulin subunits and interferes with microtubule formation impairing their ability to uptake glucose and therefore maintain energy production, resulting in death (Theodorides *et al.*, 1976). When farmers treat all animals in a herd with a chemical anthelmintic only the worms that are resistant to its specific mechanism will survive to reproduce. As a result, parasite resistance to the drug grows over time (Burke, 2005). Actions that cause increased resistance include frequent dosing, under-dosing to save money, inappropriate administration, wrong anthelmintic choices, and massive re -exposure to the parasites (Machen *et al.*, 1998).

5.2.b.iv. Effects of feeding system of goat on the prevalence of haemonchosis in goat

Goats managed under feeding system, grazing feeding was the highest prevalence, 67.23% than stall-feeding, 15.3%. The present study indicated that haemonchosis was significantly ($P<0.001$) influenced by the feeding system of goats. This is in agreement with the author Bilal *et al.* (2009) who reported that the higher incidence of worm infestation in grazed animals as compared to stall fed animals might be due to picking of worm eggs shed by the infected animals during grazing through faeces. The infection was lower in stall-feeding goats possibly due to the less faecal contamination with *Haemonchus* eggs because usually concentrate feeds and vegetable wastes were fed by the household and intensively reared goats.

Among the grazing period, the morning grazing practice had significantly increased the worm burden (77.14%) in goats compared to the afternoon grazing (52.7%). This was due to the presence of infective larvae on the dew-laden pasture in the mornings. Infective larvae are sensitive to weather conditions in the morning, as humidity and low degree of sunshine allow the larvae to become abundant on pasture compared to during the evening when the absence of dew prevents the larvae from being present on herbage (Nor-Azlina *et al.,* 2011). Kusumamihardja (1982) studied the effect of season and the time of day on the presence of nematode larvae on grass. The numbers of larvae were higher in the wet season than in the dry season, whereas, the number of larvae on the leaf blades was found to be highest in the morning. Kusumamihardja (1988) reported that in the dry season, worm burden was significantly higher in the group which was grazing in the morning than in the group which was grazing in the afternoon. However, there was no significant difference in the worm burden between morning and afternoon grazing during the wet season. Many other researchers (Raza *et al.,* 2007; Keyyu *et al.,* 2006) who found a direct influence of grazing characteristics on the prevalence of most of GIP and who reported that under traditional free-range grazing system (extensive) there is continuous infection and re-infection from heavily contaminated pastures compared to their intensive-grazed counter parts. Evaluation of species diversity in the two rearing systems revealed that poor diversity is found in stall-feeding system. High stocking density on pasture increases pasture larval burden. On lowering the stocking density there occur reduction in amount of manure in given area and higher height of residual grazing forage (Morley and Donald, 1980). Assoku (1981) showed that sheep kept under rotational or restricted grazing (semi-intensive) system of management had fewer worm egg counts ($P<0.01$) than those kept under the free-range grazing or extensive system. 80% of parasite larvae live in first 5cm of vegetation. In older pasture, animals should be grazed on longer (10 cm) grasses. New pasture should be grazed closely so that sun rays can dry the faeces and diminishes the chances of larval survival (Jones, 1993). Larvae move to the top of herbage when intensity of light is low. Limit grazing time to when the sun is strong diminishes the risk of infection

(Bukhari and Sanyal, 2011). In grazing feeding, the occurance of haemonchosis was higher possibly due to more infective stage of *Haemonchus* spp were present pasture during grazing of affected goats that shedding of infective larvae with their faeces. When different animal species were grazing same pasture land there may be ingestion of contaminated grass occurs rapidly but in stall-feeding animals no such contamination occurs. In afternoon grazing, there was no available infective stage of any helminth present possibly due to the direct sunlight at that period of grazing. The variation of the present result with that of other researcher's works may be due to the nutritional condition of the grazing animals, study methodology, type of sample examined, geographical region of the area, time of grazing and sample size of the study etc.

5.2.b. v. Effects of herd-size on the prevalence of haemonchosis in goats

In the present study, large herd size was found higher (72.4%) prevalence of haemonchosis compared to those of small herd size (38.2%) followed by medium sized (64.2%) herds of goats. The present study indicated that haemonchosis was significantly ($P<0.001$) influenced by the herd size of goats. Hasan *et al.* (2011) gave similar report on Bangladesh. Large flock was more infected to parasitic infestation (both by ecto and endo parasites) than the smaller ones and this is due to direct contact, overcrowding and unhygienic condition of goat housing. In this study, large herd group was more susceptible of *Haemonchus* spp infection possibly due to over-crowding, un-hygienic condition of the floor of house, more closer contact of healthy and un-healthy animals which facilitates the favourable environment for larval development due to moisture by urine with faeces of infected animals resulting easily swallowing of the infective stage of the *Haemonchus* spp stage as well as more infection occurs.

5.2.c. Environmental factors affecting *Haemonchus* infection in goats

5.2.c.i. Effects of month of the study on the prevalence of haemonchosis in goat

The prevalence of haemonchosis is highest in the month of July (82.1%) followed by August (79.7%) and lowest in January (28.3%) followed by December (40.0%). The average maximum temperature reaches 33.9°Ċ in May, 2011 and minimum 11.7° C in January, 2012. The relative humidity is highest (88%) in the month of August and lowest (65%) in the month of March. In the month of June and September the infection rates were 61.9% and 71.9% respectively. Shahiduzzaman *et al*. (2003) reported peak infection rate was in the month of July (84.42%) followed by June (72.58%) and October (72.41%). Whereas, the lowest infection rate was found 46.15% in the month of January. The prevalence of infection relate to the humidity during the study period which also occur in the increasing pattern from April to August (72% to 88%) and then gradually decrease from September to March (87% to 65%) depending upon the rainfall of the particular area. The findings of the study also in closely related to the findings of Enyenihi *et al*. (1975) who reported that optimal conditions (hot and humid climate) are really helpful in the development of parasites. For these reasons, the infection rate was started to decline from November (55.0% to April (49.1%) then increased gradually from May (61.3%) to August (82.1%) whereas in September, 71.9%. The effect of climatic factors on worm burden revealed a significant positive correlation with rainfall and relative humidity which favourably support the larvae survival and development. This finding consisted in Amenu, (2005) who reported that the higher prevalence and worm burden occur during months of rainy season. During the study period, monthly prevalence of *H. contortus* was corresponds with wet, humid and warm with season. It was observed that highest prevalence of haemonohosis was recorded during the month of July (82.1%) and the lowest (28.3%) prevalence was recorded during the month of January. The highest EPG count in % ages of *Haemonchus contortus* larvae were found in faecal cultures during rainy season. This is in agreement with studies conducted in different parts of the world i.e., Maingi *et al.* (1993); Vlasoff *et al.* (2001); Waruiru *et al,* (2001); Nginyi *et al*. (2001) in Kenya; Katoch (2000) and Laha *et al*. (2001); Khajuria and Kapoor; (2003) in India; Shahadat *et al.* (2003) in Bangladesh; Lateef *et al.* (2005) in Pakistan Keyyu *et al.* (2005) in Tanzania. These findings are consistent with those of (Lateef *et al*., 2005) and (Maryah, 2005) reported that the high biotic potential of *H. contortus* result in rapidly assuming dominance at times when environmental conditions on pasture are favorable for the development and survival of free living stages. The prevalence rate of haemonchosis started to decrease steadily from November to January and increase steadily from January to March. Nwosu *et al.,* (2007) reported that *Haemonchus* was the most common nematode recorded during their study. They also reported that *Haemonchus* eggs and adults were high in prevalence and seasonal fluctuation was common in the study area. They further reported the high prevalence during hot humid season. The results of the study are in close agreement with the findings of the above mentioned workers of Nigeria. Hansen and Perry (1994) and Urquhart *et al.* (1996) reported the higher parasitic load in the wet season is significantly higher than the dry season owing to the general understanding that moisture is one of the bionomic factor that support the development of the infective stage of most parasites. The incidence of higher incidence of GIN in rainfall area followed by *Haemonchus contortus* was maximum during July to Cauvery delta and North-eastern zone, Sanyal and October and minimum during March to June. Therefore, climate of the study area is very conducive for the propagation of *H. contortus* larvae. The migration of infective larvae on grass in faecal egg counts (Gupta *et al.* 1986). The migration of infective larvae on grass blades was more in autumn, while all the pre-parasitic activities were low in winter due to scanty rainfall. The lowest pasture contamination was observed in the month of December and attributed it to harsh climate as a result of low temperature and sparse rainfall. The survivability of infective larvae was more than 11 weeks in rainy season. In face of sufficient rainfall, larvae were found to migrate vertically up to 15 cm and laterally up to 50 cm compared to only 5 cm and 20 cm, respectively during non rainy season (Sanyal, 1989b).

Self-cure phenomenon is the important for the epidemiology of haemonchosis in this phenomenon, expulsion of adult parasite from the host takes place simultaeneously although not invariably, eliminate incoming larvae. This may be associated with changes in the pastures, when a large uptake of infective larvae is superimposed on an established worm burden in a sensitized animal. Predisposing factor for haemonchosis include overcrowding, lush pasture, hot and humid weather and a low plane of nutrition. Self cure phenomenon is induced by the acquisition of large number of infective larvae developed in the pasture after heavy rainfall (Soulsby, 1982, Urquhart *et al.,* 1996). It was observed that, during the study period when the rain starts from the month, in that month goats were grazed and fed more amount of infective larvae and then infection was occurred. In this context, the highest rate of haemonchosis in the month of July followed by August and June. Re-establishment of infection after self-cure phenomenon is indicated by the gradual increase of infection rate.

In the month of January, the lowest prevalence indicates to the less survival of eggs and pre-infective larvae (L_1, L_2) on pasture due to minimum temperature (11.7 °C) less moisture (relative humidity, 79%) and dry condition. In the winter month, due to the adverse environmental conditions arrested or inhibited (L_4) larval development occurs in the *Haemonchus* spp, this condition is known as hypobiosis. In this period, infective larvae was not developed and eggs of *Haemonchus contortus* was not available in the faeces of goats due to low temperature (17.5°C), humidity (79%) and rainfall (5.5 mm). Arrested larval development plays important role in the prevalence of the *Haemonchus contortus* infection. The infection rate started to decline from November to January and then increased gradually from February to May this is similar to the findings of previous report given by (Al-Dulaimi *et al*., 1985). The mean monthly maximum temperature of 18ºC or above and total monthly rainfall of 50 mm are conducive for translation and transmission of *H. contortus* (Gordon, 1953). The overall mean temperature, mean relative humidity and mean rainfall was 25.6°C, 79.8% and 148.1 mm respectively present in the study year which was favourable for the development of *Haemonchus* larvae as a result haemonchosis was present in throughout the year round. The high temperature, relative humidity and total rainfall in Bangladesh favourable for the establishment of *Haemonchus* spp in this area. So, month of the study is the determinant factor influencing haemonchosis of goat.

5.2.c. ii. Effects of season of the study on prevalence of haemonchosis in goat

Among the season of study, the highest prevalence was recorded during Rainy (76.6%) followed by Summer (56.0%), whereas the lowest prevalence (40.5%) was recorded during winter. The chi-square test and ANOVA analysis was revealed that the season of the study had significantly ($P<0.001$) prevalence of haemonchosis in goats. Qadir, (1967) was reported that the peak infection of haemonchosis in goats from June to September. Yadav *et al*. (2006) also reported maximum prevalence of nematodes in rainy season in goats of Kashmir. Laha *et al.* (2001) from Bengal goats recorded the highest percentage of infection with *Haemonchus contortus* during the rainy season. Heavy rainfall and high relative humidity predispose to heavy parasitic infections (Hawkins, 1945). The rainy season which started in the spring and earlier in summer made the environmental conditions more favorable for the development and survival of pre-parasitic stages and led to increased availability of infective larvae in the rainy and post rainy season. It is well documented that gastrointestinal parasitism in grazing animals is directly related to the availability of larvae on pasture and seasonal pasture contamination (Smeal *et al*. 1980). Lima (1998) and Githigi (2005) reported the animals are expected to acquire high number infective larvae during rainy season and harbor higher prevalence of gastrointestinal nematodes.

These findings are consistent with those of Shahadat *et al.* (2003); Lateef *et al.* (2005); Nwosu *et al.* (2007). They reported that the high biotic potential of *H. contortus* results in rapidly assuming dominance at times when environmental conditions on pasture are favourable for the development and survival of the free living stages. They also reported that high prevalence and seasonal abundance of eggs and adult stages of *Haemochus* parasites of sheep and goats during hot humid season. Nwosu *et al.* (2007) reported the prevalence and seasonal abundance of the egg and adult stages of *Haemonchus* parasites of sheep and goats and counts of *Haemonchus* egg increased with the rains and peak levels were attained during rainy season. Adult worm burdens were generally low and showed seasonal variation that corresponded with the rainfall pattern in the study area during the period. Pathak and Pal (2008) was reported *Haemonchus* spp was highest in monsoon (94.6%) might be either due to favorable environment in monsoon which were conducting the development of exogenous stages of parasites or due to reduced prepatent period and also increased larval population. Saha *et al*. (1996) and Katoch *et al*. (2000) also made similar observations in goat recorded highest incidence of *Haemonchus* spp during rainy season. In the month of June to October, there was a fluctuating rate of infection. Statistical analysis revealed a significant correlation ($P<0.01$) between disease prevalence and humidity, rainfall and high temperature (Qamar *et al*., 2007).

Haemonchosis, being the most prevalent disease in the tropics and subtropics, it has shown great economic losses and an increasing prevalence trend in sheep and goat flocks, (Lindqvis *et al.,* 2001). There are several factors that contribute the disease onset like warm, humid and wet grazing season, the more time animals spend on pasture, ineffeicient selection of de-wormers, poor husbandry practices and or the development of anthelmentic resistance against *Haemonchus contortus*. Nwosu *et al.* (2007) reported that in the study there were abundance of the eggs and adult

Haemonchus parasites in goats and revealed that 55.8% of the samples were positive for haemonchosis. The prevalence showed a definite correspondence with weather conditions and rainfall pattern in the study area. In goats, counts of *Haemonchus* eggs increased with the rainfall and peak levels were noted during rainy season. However, adult worms were low and they also showed definite seasonal variation that correlate with the rainfall pattern in the study area.

From the results it was indicated that environmental conditions during Rainy season were quite favorable for the development and completion of *Haemonchus contortus* life cycle that corresponded with the rainfall pattern in the study area. Smith, *et al.*, (1984) stated that the inhibition of *Haemonchus* larvae could be initiated by the host immune response, as it was noted only in those animals which were exposed to haemonchosis previously. In another study, the levels of arrested *Hamonchus* larvae in animals were similar with or without earlier contact with *Haemonchus* parasites from October onwards. This suggested that inhibition of larvae was probably linked to winter season, Zajac *et al.* (1988). However, the grazing and reproduction management of sheep and goats had some contribution to such variations. As there was no rise in eggs excretion during February and March was because of the fact that in winter these animals were grazing on non-contaminated pasturelands. Similarly, under different management conditions high intensity of infection was observed during summer season, this phenomenon was attributed to the high PPR that took place during June and July.

Role of meteorological data on the prevalence of the disease was also studied in the present study. It was noted that temperature, humidity and rainfall play very important role in the causation and spread of disease. In the present study the highest prevalence was noted during Rainy season, where the temperature, humidity and rainfall were quite favorable for the development and hatching of larvae of *Haemonchus contortus*. It was also noticed that there was maximum grazing in that season. Similar results were also reported by Wallera and Chandrawathani (2005) reported that approximately 50 mm rainfall and mean monthly temperature of 18ºC was most favourable for haemonchosis to occur in small ruminants. Thus it has been generally recognized that *Haemonchus contortus* is a problem parasite restricted to the warm, wet countries where sheep and goats are raised. Rainfall play very important role in the spread of disease i.e., spread of *Haemonchus contortus* larvae from one place to another. High mean relative humidity (86%) and high mean rainfall (209.4) mm during rainy season in this study period was very helpful in the causation of disease. Environmental conditions are favorable for propagation and development of larvae as it was reported by Besier and Dunsmore (1993). The results showed that infected animals harboured *Haemonchus contortus* infection with varied incidence in all areas throughout the year. It demonstrated that there were substantial worm burdens of *Haemonchus contortus* in goats of the study areas. Gupta *et al.* (1988) also reported that higher infection rate was probably due to warm and humid environmental temperatures ranging between 19°C and 37°C in the study area. Van Dijk *et al.* (2008) studied the effect of moisture and temperature on the free-living stages of gastrointestinal nematodes and explained the effect of climate change on parasite epidemiology. Haemonchosis increased with increase in temperature and very few larvae survive during winter and spring season at pasture. The data presented in our study serve as a baseline against haemonchosis, where future changes can be measured with the change of climatic conditions. Lathoud and Estudos (2001) reported that in tropical areas the climatic conditions have a large influence on the development of the *Haemonchus*. During this research work the mean temperature (25.6°C) and rainfall (monthly mean above 123 mm) was within the limits required for development of *Haemonchus contortus*. It is obvious that the peak of parasitic infection by *Haemonchus contortus* was observed between 135 ± 8 and 159 ± 8 days after weaning. From our studies it was concluded that seasonal change might alter the *Haemonchus* epidemiology so the effectiveness of control strategies must be taken into consideration. Many earlier researchers, Kao *et al.* (2000); O'Connor *et al.* (2006), had extensively studied the influence of climatic conditions on the development and mortality of the free-living stages of *Haemonchus*. The observations regarding season, region and between month changes could be explained by understanding the effects of temperature on *Haemonchus* transmission. Barger (1997) reported that the accumulation of *Haemonchus* infective stages (L_3) from generations of adult parasites is accelerated at higher temperatures, leading to higher parasite burden during summer and thus increased risk of haemonchosis from summer to onwards. Increase in temperature favour the development of *Haemonchus* larvae (Beveridge *et al.* 1989). The evolution of monthly FECs followed the well-known pattern influenced primarily by temperature and moisture (Radostits *et al.* 1994; Urquhart, *et al.,* 1996; Arosemena *et al.,* 1999) as they were highest in the wet season (which is warm), moderate in the hot-dry season and lowest in the cold-dry season. The enhanced larval survival during winter leads to increased larval availability during spring and summer season. The decrease in haemonchosis during summer could be attributed to decreased larval survival during winter and spring at higher temperatures. Higher summer temperatures increase the proportion of ingested larvae that develop into adults and cause haemonchosis in the following months, rather than they enter into hypobiosis (Waller *et al.*, 2004). It was not surprising that climate conditions could produce changes in epidemiology for those diseases that are caused by parasites whose development and propagation outside the definitive host is sensitive to temperature and humidity (Poulin, 2006). Now it is well established that the effects of climate change does affect the disease dynamics. However, in the epidemiology of *Trichostrongyloid* evidence of systematic changes of grazing livestock can be ascribed to increased regional mean temperatures that have not previously been published, even though there were many discussions on such changes in the veterinary profession. This was explained by the fact that there were no long term studies or databases in which haemonchosis incidence is recorded using constant criteria. Akanda *et al.* (2012) was reported seasonal variations of gastro-intestinal nematodes should be considered due to their distribution and frequency of larval stages.

5.3. Effects of study area on prevalence of haemonchosis in goat

Prevalence of haemonchosis did not vary significantly (P>0.05) between the study sites. The prevalence was found 55.6% in Rajshahi district and it was 60.0% in Noagon district. The environmental and managerial conditions of farms situated at different districts of greater Rajshahi were different from each other. It was noted that the prevalence of haemonchosis was reported throughout the year. The results of present study are in agreement with the findings of Pal and Qayyum (1993); Tembely *et al.* (1998); Mandonnet *et al.* (2005); Mbuh *et al.* (2008). Such a regional variation in the prevalence of haemonchosis has been widely reported. This variation may be attributed to different geographical distribution, host factors and climatic conditions required for the development of free-living stages of different nematodes. A variety of factors like age, sex and breed of the host, grazing habits, level of education and economic capacity of the farmers, standard of management and anthelmintic used may affect as discussed by Asanji and Williams (1987); Pal and Qayyum (1992); Gulland and Fox (1992); Maqsood *et al.* (1996); Jorgensen *et al.* (1998); Komoin *et al.* (1999); Valcarcel and Romero (1999) and Ouattara and Dorchies (2001).

The differences in the prevalence of various gastrointestinal parasitic infections in goats are thought to be due to sex variation, time of studies, risk factors and determinants, environmental condition (Mcculloch *et al.*, 1986) and frequency of examination of the animal, management of helminthes status of a group of goats and concurrent topography (Tariq *et al.*, 2010). The rate of *H. contortus* infection in goat varies from one part of the world to the other could be accounted on the basis of differential management practices, such as regular de-worming, intensification, housing and feeding management practice (Barger, 1999; Lindqvist *et al.*, 2001). So, it is obviously a basic need to analyze the GIT in goats in this farm through cross-sectional studies to construct a valuable epidemiological figure so that effective management and treatment can be introduced.

5.4. Effects of examination procedure on the prevalence of haemonchosis in goat

Postmortem examinations were conducted in some butcher houses to appreciate the adult parasites and to relate the coprological findings with the postmortem findings. The total number of goats examined was 357. From these 234 goats harbored adult and immature stages of parasites of *Haemonchus* spp. The overall prevalence of *Haemonchus* spp during postmortem examination was 65.5%. In necropsy, prevalence of haemonchosis was observed the higher, 65.5% (234 out of 357, abomasal sample) compared to coproscopy, 50.1% (182 out of 363 faecal sample) findings. In necropsy findings, adult and immature worms were easily seen during the examination and numerous haemorrhagic lesions were observed on abomasal mucosa. Post-mortem examination may revealed an extremely high proportion of adult worms (2000 adult worms in some cases). This is in line with the findings of Shahiduzzaman *et al.* (2003), 65.63% from Mymenshingh, Bangladesh; Nuruzzaman *et al.* (2012), was 58% from Thakurgaon, Bangladesh and Tefera *et al.* (2011) from in and around Bedelle, South-western Ethiopia who reported the prevalence of *Heamonchus* spp was 65% in slaughtered goats. This was agreed with Hailelul (2002) who reported 54.76% in goats in and around Wollaita Soddo. The prevalence of haemonchosis, 65.5% in the present study area was lower than the previous studies conducted by different workers in different study areas of Ethiopia. Fentahun and Luke (2012), 80.21% in randomly selected restaurants and hotels of Gondar Town, Ethiopia. Abebe and Esayas (2001), 100% in goats in the arid and semi arid zone of eastern confronted by amazingly very high prevalence rate of Ethiopia and Kumsa and Wossene (2006) haemonchosis; 82.9% in goats of Ogaden region slaughtered at Debrezeit Elfora abattoir and Ahmed (1988), 88.23% prevalence of *Haemonchus* spp in goats East wollega zone at Mechara settlement area. This variation in prevalence of haemonchosis in goats may be due to the difference in the age, sex, differences in agro-ecology, season, sample size and management practices.

Whereas, in faecal sample examination (coproscopy), most cases *Haemonchus* eggs were not found because eggs are found in faeces when the damage has already been done. Confirmed diagnosis is based on the detection of characteristic eggs in the faeces. A faecal egg count to assess for presence of *Haemonchus* eggs should be performed. Nabi *et al.* (2014) was recorded overall prevalence of gastrointestinal nematodes in goats was 40.67% during coproscopy. Khajuria *et al.* (2013) was studied coproculture examination and revealed that *Haemonchus contortus,* (61.18 %) predominated during all the seasons in middle agro-climatic zone of Jammu province. Gadahi *et al.* (2009) was observed incidence of *Haemonchus* spp. 64.19% in goats at faecal sample examination. The prevalence of haemonchosis during coproscopy varies among the other researcher of the world and may be due to the sample size, host's age, sex, breed, nutritional status, husbandry practices and climatic condition of the area.

In coproscopy, specially faecal egg count is the best method by assessing the gastro-intestinal parasitic load for the prevention, control and treatment of the diseased goats but necropsy is done only after slaughtering and already death of the goats merely for the evaluation of the parasitic disease status for future control plan in the study area. The result also revealed that prevalence of haemonchosis was significantly ($P<0.01$) influenced by the methods of examination of the sample. Prevalence of haemonchosis in the present study by coprological examination was found comparatively less than postmortem examination possibly due to presence of immature and hypobiotic larvae within the abmasal contents, amount faeces, consistency of faeces, regularly anthelmintics used, time of examination and differences in examination procedure and geographic condition of the study area. The prevalence of *Haemonchus* spp was reported earlier by Demissie *et al. (*2013); Garedaghi and Bahavarnia (2013**)**; Gupta *et al.* (2013) and Fentahun and Luke (2012) and found 75.2%, 73.1%, 77.83% and 73.5% respectively from slaughtered goats in different parts of the world. Those findings were relatively higher. The rate of *H. contortus* infection during the methods of examination in goat varies from one part of the world to the other could be accounted on the basis of differential management practices, such as regular de-worming, intensification, housing and feeding management practice (Barger, 1999; Lindqvist *et al.* 2001). In the present study, the prevalence of the haemonchosis among the examination procedures varies possibly due to type of sample, sample size, type of instrument and appliances used, types of chemical, expertness of the researcher or technichian, management practices of experimental animals and other factors that influence the occurrence of disease.

5.4.a. Effects of degree of infection on prevalence of haemonchosis in goat on coprological examination

In the present study, 10.4% (19 out of 182) goats were heavy infection compared to light infection 48.4% followed by moderate, 41.2% degree of infection depending on Egg Per Gram (EPG) of faeces counted by the Mc Master slide during faecal sample examination of goats. The result revealed that there was highly significant ($P<0.001$) difference among the degree of infection. This is in line with Nasreen *et al.* (2011) who observed 51.4% light, 38.3% moderate and 10.2% heavy infection; while Tefera *et al.* (2009) was recorded 40.53% were lightly, 48.52% moderately and 10.95% heavily affected goats with gastro-intestinal parasites. Majority of infected animals had faecal egg count in the range of 50-800 EPG and only few proportions of animals had fecal egg count over 1200. Zeryehun (2012) reviewed that faecal samples positive for GIT helminthes were subjected to McMaster egg counting chamber for EPG count to determine the degree of severity of parasitic infection. Amenu (2005) and Hailelul (2002) reported higher prevalence of 86.67% with a mean EPG of 1016 in goats. The maintenance of high infection rates of GIT helminthes in goats in the study areas was associated with the presence of favorable environmental conditions for the existence and development of the parasitic GIT helminthes larvae. The variation of faecal egg counts (infection category) may be due to the presence of adult female *Haemonchus* spp within the abomasum, favourable environmental condition of the study area, management practices, body conditioned of the examined animals, immunity and de-worming status of the animals, sample size and examination procedure etc.

5.4.b. Effects of degree of infection on prevalence of haemonchosis in goat on abomasum examination (Necropsy)

In this study, among the 65.5% prevalence, moderate degree of infection was higher 54.2% than light 28.6% infection followed by heavy, 17.0% degree of infection. There was statistically highly significant ($P<0.001$) difference was found among the degree of infection of the affected goats. This is dissimilar to the findings of Teshale and Aragaw (2014) in Northwest Ethiopia who found 100% light infection by *Haemonchus* spp whereas moderate and heavy degree of infection was not recorded. Kumsa and Wossene (2006) was recorded majority of goats harboring adult abomasal nematodes with light to moderate degree of infection whereas only small proportions were with heavy degree of infection. This was in a general agreement with reports from Ethiopia (Gonfa *et al.,* 2013) and elsewhere in Africa (Almalaik *et al.,* 2008) where majority of the goats were affected with light to moderate degree of infection. Moderate infection with *Haemonchus* was reported to cause chronic anaemia, severe loss of body condition and death in animals grazing on poor quality pasture (Allonby and Urquhart, 1975). The present result showed that moderate infection was higher proportion may be due to chronic infection was present all the year round, without anthelmintic treatment or resistance of anthelmintics occurred against *Haemonchus* spp of affected goats. The variation of number of *Haemonchus* spp (degree of infection) possibly due to anthelmintics used by the animals, husbandry system, floor of housing, feeding system, grazing period and geography of the region etc.

5.5. Morphology of adult female *Haemonchus* spp

5.5.a. Total worm (*Haemonchus* spp) burden in the abomasum of goat

In this study, total 17250 adult female *Haemonchus* spp were collected from 14 positively infected abomasa of goats in the study area. The result also revealed that sex ratio of adult *Haemonchus* spp were found 1:0.59.

5.5.b. Overall Sex (Male: Female) ratio of collected adult *Haemonchus* spp

From the collected worms, female *Haemonchus* spp was found in 62.95% (10860 out of 17250) whereas 37.05% (6390 out of 17250) in male worms. The percentage of adult female *Haemonchus* spp were 63.0% significantly ($P<0.01$) higher than adult male *Haemonchus* spp, 37.0%. The sex ratio of male and female *Haemonchus* spp was found in 1:0.59. In case of goat, male and female ratio of *Haemonchus* spp did not vary significantly ($P>0.05$) between the study sites.

The sex ratio of *Haemonchus* spp was found 1:0.61 in Rajshahi district and that was 1:0.57 in Noagon district. There was no significant difference in worm burden was detected between the isolates, in either of the experiments. When worm burden was compared between districts of the study area, no difference was observed. This in line with the previous workers (Kelkele *et al*., 2012). Shahiduzzaman *et al*. (2003) was recorded 1:0.65 male and female ratio of *Haemonchus* spp in Mymenshingh, Bangladesh which is in line with the present study. This variation may be due to differences in ecology of the parasite and the study area. The female *Haemonchus* spp was higher proportion than male worms in abomasum of goats probably due to the eggs produced by the adult female *Haemonchus* spp resulted more worms. The adult female worms laying several thousands of eggs per day in the abomasum of the animal host (Coyne *et al*., 1991). Adults also have high fecundity, with reports of 10,000 eggs per female worm per day or even more (Abbott, 2012). Female *H. contortus* worms produce enormous numbers of ova which facilitates the building up of a heavy degree of pasture contamination in a short time. Each female is capable of producing 5-10 000 eggs per 24 hours so that a lightly infected goat harbouring say 300 female worm may disseminate 1.5-3 million eggs on pasture every 24 hours. High levels of pasture contamination with infective larvae can result in early summer, and lambs can acquire heavy worm burdens very rapidly on such pastures. For these reason we should know about the biology of female *Haemonchus* worms. Kelkele *et al*. (2012) was reported worm burden, their sex ratio, establishment of infection and correlation with FEC were similar to findings obtained from previous experimental trials on abomasal nematode, *H. contortus* (Stear *et al.,* 1995; Terefe *et al.,* 2005).

5.6.a. Overall prevalence of major vulvar flap morph type of *Haemonchus* spp

The study revealed that out of total 520 adult female *Haemonchus* spp worms from goats 25.4% linguiform, 24.2% smooth and 50.4% knobbed vulvar morphs were identified. Statistically significant ($P<0.001$) fluctuation was observed among three major vulvar flap morph types in the study area. The finding of the predominance of knobed vulvar flap types in goats in the current study is in line with the previous works of Javquiet *et al.* (1995 and 1998); Rahman and Hamid (2007); Gharamah *et al.* (2012); Akkeri *et al.* (2013) who reported the predominance of knobbed vulvar morph types in small ruminants. It was differentiated female worms into 27.7%, linguiform, 65.8% knobbed and 6.4% smooth vulvar morph types where the knobbed type predominatnt However, this observation is in contrast to the previous reports by Gharamah *et al.* (2011); Thomas *et al.* (2007); Gelaye and Wossene (2003); Tod (1965); Roberts *et al.* (1954) and they reported the linguiform type of vulvar morph was predominant. Gharamah *et al.* (2011) was observed 50% linguiform predominant in Governorates in Yemen; Thomas *et al.* (2007) as 43.8% linguiform in Ethiopia and Kumsa *et al.* (2008) were identified 53.8% linguiform, 18.5% knobbed and 27.6% smooth vulvar morph types in goats of Ethiopia. The observation of the predominance of the linguiform vulvar flap types in *Haemonchus* spp from goats coincides with the investigations by the aforementioned authors. No statistically significant ($P>0.05$) difference was noticed in the proportions of the three major vulvar flap types (linguiform, knobbed and smooth) collected from domestic ruminants between the different months of the study period. This observation collaborates the earlier findings reported by Roberts *et al.* (1954); Tod (1965); Le Jambre and Whitlock (1968); Thomas *et al.* (2007). The vulvar process of *Haemonchus* spp. worms varies both in shape and size (Roberts *et al.,* 1954; Rose, 1966; Le Jambre and Whitlock, 1968). The study showed widespread and common polymorphism of vulvar morphology of female *Haemonchus* spp in goats of the Northern region of Bangladesh. Many investigators indicated that vulvar polymorphism has advantages such as increasing the ability to use a wider range of available habitats and it is marker of ecological adaptation, has great taxonomic significance and is important to understand the biology of these parasites (Roberts *et al*., 1954; Das and Whitlock 1960; Tod, 1965; Rose, 1966; Jacquiet *et al*., 1995). This difference of major vulvar morph types of female *Haemonchus* spp is most probably attributed to the variation in the sample size, examination procedure, agro-ecology, animal management and genetics of parasites among the various studies.

5.6.b. Prevalence of major vulvar flap morphology of goat in Rajshahi and Noagon district

The study revealed that out of total 520 adult female *Haemonchus* spp worms from goats 33.5% linguiform, 20.4% smooth and 46.1% knobbed major vulvar morph types were identified. Statistically significant ($P<0.001$) fluctuation was observed among three major vulvar flap morph types in the study area. The study revealed that out of total 260 adult female *Haemonchus* spp worms from goats 43.0% linguiform, 21.1% smooth and 35.8% knobbed vulvar morphs were identified in Rajshahi district. Whereas in Noagon district, among 260 adult female *Haemonchus* spp from goats 23.8% linguiform, 19.6% smooth and 56.5% knobbed vulvar morphs were found. In Rajshahi, linguiform type vulvar morphs were predominant but knobbed type in Noagon district. The present work showed the widespread occurrence of polymorphism in vulvar morphology of female *Haemonchus* spp of goats in Bangladesh. Several investigators have pointed out that vulvar polymorphism has taxonomic significance, great biological advantages in increasing the ability of parasites to use a wider range of available habitats and hosts, and is also considered as a marker of ecological adaptation and helps to understand the biology of parasites (Roberts *et al.,* 1954; Das and Whitlock 1960; Tod, 1965; Rose, 1966; Jacquiet *et al.,* 1995). The present study suggests that variation of major vulvar morph types of adult female *Haemonchus contortus* in two study district within the same country most probably due to the smaller sample size, differences in management practices, examination procedure and geographical condition of the area.

5.6.c. Overall percentage of sub-types of vulvar flap morphology of female *Haemonchus* spp

Further classification of 174 linguiform vulvar flap female *Haemonchus* spp from goats revealed overall proportions was LA type, 3.4% and LB type, 96.6% linguiform subtypes. The result also revealed that female *Haemonchus* spp was highly significantly (P<0.001) influenced between the linguiform subtypes of female worms in the study area. In the current study, within the linguiform vulvar flap type *Haemonchus* spp collected from goats, the linguiform B type was encountered as the most predominant sub-linguiform. This finding is in contrast with the previous work of Jacquiet *et al.* (1995) and Kumsa *et al*. (2008), Akkeri *et al*. (2013) who reported the predominance of the LA sub-linguiform type in small ruminants. Le Jambre and Whitlock (1968) was observed within the linguiform vulvar flap morph types a clearly defined monthly variation was observed, where the A subtype linguiform showed significant (P<0.05) fluctuations in different months of the study period, while all the other linguiform subtypes showed no significant (P>0.05) fluctuation during months of the study period. This is most probably suggestive of the lower ability of the B subtype linguiform in coping with the dry months of the study period as compared to the A subtype linguiform. However, on the other hand, this finding contrast with the previous report by Thomas *et al*. (2007) reported the predominance of the LC sub-linguiform type in small ruminants in Hawassa in Ethiopia. This may probably be attributed to variations in agro-ecological conditions, environmental factors and the seasons of the surveys between the various study sites.

Akkeri *et al*. (2013) reported a new type of sub-linguiform vulvar flap, designated as LD for the first time in their study in North Tunishia. The A sub type linguiform appeared as the dominant linguiform sub type in goat followed by B, C and I sub types of linguform vulvar morphs in Eastern Ethiopia (Kumsa *et al*., 2008). As no previous studies on the vulvar morphology of *Haemonchus* worms from any species of ruminants are available in Bangladesh. In the present study, this is most probably suggestive of the lower ability of the A subtype linguiform in coping with this climatic condition of Bangladesh of the study period as compared to the A subtype linguiform. Whereas, there was no found in LC, LD and LI subtypes linguiform vulvar flap morph types of female *Haemonchus* spp in this study area. This variation is most probably attributed to the differences in the climates of the two study sites and the smaller size per abomasums, lower adaptive capability of *Haemonchus* spp within the abomasums of goat in the study area, variances due to examination procedure and lacking of other sophisticated laboratory equipment and appliances in the study region. They believe that it is most probably an indication of adaptation to this environment by *Haemonchus* spp population, occurring in the tropical climate prevailing in northern area of Bangladesh.

CHAPTER SIX

SUMMARY AND CONCLUSIONS

SUMMARY

The objective of the present study was to determine the prevalence of haemonchosis, to determine the stomach worm responsible for haemonchosis, with their morphology, to identify the role of some factors on the prevalence of haemonchosis of goats and to determine the vulvar morphology of female *Haemonchus* spp in the study area. Haemonchosis in sheep and goats is caused by *Haemonchus* spp. The disease causes great economic losses in terms of weight loss, poor quality meat. The overall prevalence of haemonchosis was 57.8% in goats. The prevalence rate of haemonchosis was found to be highest in young (6 to 12 months), 88.5% compared to adult (>12 to <24 months), 69.6% followed by older (>24 months) goats. The lowest prevalence rate was observed in kids (>6 months). It was observed that in relation to sex the prevalence of haemonchosis was higher in female, 63.9% compared to male, 50.0% goats. Among the female goats in this study, infection was higher 76.0% compared to non pregnant 67.0% goats. Among the breed, the crossbred goats were the maximum, 60.2% infection rate of haemonchosis than that of Black Bengal, 55.6% goats. Goats of good body condition group had a significantly low *Haemonchus* spp infection rate (39.3%) as compared to poor body condition group (69.2%).

It was noted that under management practices, goats housed in muddy floor was significantly higher (71.3%) infection rate than slatted floor (44.1%). In the husbandry practice, the high prevalence of haemonchosis was found in extensive system (71.6%) of goat rearing followed by semi-intensive (61.1%) and lowest in intensive (15.3%) system of rearing. Grazing feeding was the highest prevalence, 67.2% than stall-feeding, 15.3%. The morning grazing practice had significantly increased the worm burden (77.1%) in goats compared to the afternoon grazing (52.7%). Goats with lack of anthelmintic treatment (none) had a significant (71.5%) prevalence followed by those given anthelmintics as irregular basis (56.5%) and least (25%) prevalence in those given anthelmintic regularly. Goats with small (1-5) herd group had a significantly low *Haemonchus* spp infection rate (38.2%) as compared to medium (6-10) herd group (64.2%) of goats whereas the large (above 10) herd group had the highest prevalence of *Haemonchus* spp infection.

The highest prevalence was observed in the month of June (82.1 %) by August (79.7 %) and lowest in the January (28.3 %) followed by February (38.7 %). Among the season, the peak level of *Haemonchus* spp infection was recorded in the Rainy, 76.6% followed by lowest in Winter 40.5% season. It was also observed that temperature (29.4°Ċ), relative humidity (85%) and rainfall (341.1 mm) was recorded in the month of June which was favourable for the egg laying, hatching and survival of infective larvae of *Haemonchus* spp on the pasture. On the other hand, in the January, all the factors like temperature, humidity and rainfall was recorded lowest as 17.5°C, 79%, 5.5 mm respectively which was unfavourable for the reproduction and survival of infective larvae. For these reason, lowest percentage of haemonchosis was recorded in the winter season (January) of the study year.

The prevalence of haemonchosis was higher 60.0% in Noagon district than Rajshahi district, 55.6%. In the present study, light infection, 48.4% were higher followed by moderate, 41.2% compared to 10.4% heavy infection depending on Egg Per Gram (EPG) of faeces counted by the Mc Master slide during faecal sample examination of goats. In necropsy, moderate infection was higher 54.2% than light 28.6% infection followed by heavy, 17.0% degree of infection was identified by counting of adult *Haemonchus* spp.

In this present study, a total 17,250 *Haemonchus* spp were collected from fourteen positively infected abomasa of goats in the study area. From the collected worms, female *Haemonchus* spp was found in 63.0% whereas 37.0% in male worms. It was also revealed that sex ratio of adult *Haemonchus* spp were found 1:0.59. The study revealed that out of total 520 adult female *Haemonchus* spp from goats and linguiform (33.5%), smooth (20.4%) and knobbed (46.1%) type of vulvar morphs were identified. Among the study area, total 260 female *Haemonchus* spp from goats 43.0% linguiform, 21.1% smooth and 35.8% knobbed vulvar morphs were identified in Rajshahi district. Whereas in Noagon district, among 260 female *Haemonchus* spp from goats 23.8% linguiform, 19.6% smooth and 56.5% knobbed vulvar morphs were found. In the Rajshahi linguiform type vulvar morphs of *Haemonchus* spp were predominant but knobbed type in Noagon district. In the chi-square test, statistically significant (P<0.001) fluctuation was observed among three major vulvar flap morph types in both of the study area. Further classification of 174 linguiform vulvar flap female *Haemonchus* spp worms from goats and was revealed overall proportions of LA type, 3.4% and LB type, 96.6% of linguiform subtypes. The present work showed the widespread occurrence of polymorphism in vulvar morphology of female *Haemonchus* spp worms of goat in Bangladesh. This study concludes that haemonchosis is a very important helminthic disease in goats in Northern area of Bangladesh.

The young (6 to 12 months age) group, female and pregnant goats, poor body conditioned group were more prone to haemonchosis in goats during the study period. Management practices such as husbandry system, floor of housing, grazing system, de-worming status and herd size of goats were significantly influenced the occurrence of haemonchosis in the study area.The role of meteorological data i.e., temperature, humidity and rainfall was influenced with the occurrence of the haemonchosis. It was noted that high humidity and high rainfall during rainy season played an important role in the spread of disease. Maximum numbers of eggs per gram of faeces were found to be infective during rainy season and are responsible for the occurrence of disease. Rainfall is considered the main climatic factor determining the availability of infective Strongylid larvae and the transmission of infection in grazing animals. However, management systems, and host factors such as age, sex, breed and body condition of the host also influence the incidence rate and severity of infection. Epidemiological knowledge is crucial to the development of a comprehensive and sustainable strategy for controlling *Haemonchus* spp infections in goats in the different agro-ecological zones and management systems in Bangladesh. Improvements in the management systems and husbandry practices coupled with strategic de-worming when conditions are most favourable for larval development on pasture could be a more sustainable way of improving small ruminant production in Bangladesh. Knobbed vulvar morph types were the predominant characteristics in the female *Haemonchus* spp in the study goats. Different vulvar morphs are modified in the abomasum of goats for the adaption and survival in different agro-ecological region. Vulvar polymorphism has advantages such as increasing the ability to use a wider range of available habitats and it is marker of ecological adaptation, has great taxonomic significance and is important to understand the biology of *Haemonchus* spp. The prevalence, epidemiology, morphological, molecular and genetic characterization of *Haemonchus* spp with biology and significance of major vulvar flap morphs, sub-linguiform vulvar flap morphs and species identification in all species in different agro-ecologies, animal species, breed and management system in other districts of Bangladesh and other countries will need to be pursued.

CONCLUSIONS

The results of this study lead to the following conclusion:

- The young (6 to 12 months of age), (88.5%) goats were more prone to *Haemonchus* spp infection. Statistically a significant ($P<0.001$) difference was noted.
- Prevalence was more in female (63.9%) goats than male (50%). Pregnant (76%) goats were more readily affected with *Haemonchus* spp.
- Cross-bred (60%) and poor body conditioned (82.8%) goats were more likely to be infected with *Haemonchus* spp.
- Extensive husbandry system (71.6%), muddy floor housing (62%), none of anthelmintic treatment (71.5%), grazing (67.2%) goats, morning (77.1%) grazing and large herd size (72.4%) of goats were detrimental factors those responsible for the occurrence of haemonchosis.
- The highest prevalence of haemonchosis was recorded in the month of July (82.1%) while the lowest durinpog January (28.3%) of the study year.
- The abomasums of goat remain loaded with high *Haemonchus* spp burden throughout the year; however, prevalence keeps changing with change in season. Its highest prevalence was noticed during rainy season (76.6%) followed by summer (56%) whereas the lowest during winter (40.5%) season of the study year.
- Prevalence of haemonchosis was higher in Noagon (60%) district compared to Rajshahi (55.6%) district of Bangladesh.
- Necropsy (65.5%) of abomasum finding was the more prevalence of haemonchosis compared to coproscopy .
- The female *Haemonchus* spp was higher proportion (63%) than male worms (37%) in abomasum of goats probably due to the eggs produced by the adult female worm results more worm population within abomasums of the goat.
- The knobbed (46.1%) vulvar flap was encountered as the most predominant form of vulvar flap morph type of *Haemonchus* spp in goat.
- Among the linguiform subtypes, linguiform-B (96.6%) sub-type of *Haemonchus* spp was the most prevalent subtype in abomasums of goat in the study area.

CHAPTER SEVEN

RECOMMENDATIONS AND SUGGESTIONS

The present study indicated that goats are victim of haemonchosis in the study areas. *Haemonchus* spp is of the major cause helminthic infection of goats which causes production losses and anaemia. Majority of the goats suffer from chronic haemonchosis which lead to anaemia, anasarca, poor weight gain, emaciation that lead to mortality. Light infection is prevalent in faecal sample examination by Mc Master technique and moderate infection is more during the examination of abomasums by slaughtering of goats among the degree of infection of the affected goats in abattoir. In these studies there was no clear pattern of *Haemonchus* spp infection in goats; however, summer and rainy season are more crucial to be considered for the strategic control.

RECOMMENDATIONS

The following measures are recommended for the prevention of haemonchosis in goat:

1. Good pasture management – Proper pasture and animal management is a key component to managing gastrointestinal helminthes in small ruminants. Non-chemical parasite control measures will become even more important as resistance to de-wormers grows. Here are some key practices that can help producers reduce the need for chemical de-worming:

- The animals are prevented from contaminating the pasture by turning out clean animals on clean pasture.
- Cultivation of new pasture
- Moving of animals from pasture to pasture after de-worming
- Grazing of animals during rainy season should be avoided.
- Do not feed animals directly on the ground, rotate pastures and allow as much rest time as possible between re-grazing at least three weeks; six months is much more effective in ensuring larval death.

- Rotation grazing is used in interval and avoids communal grazing with other animals to avoid parasite contamination and separation of animals according to their age group should be practice.
- If possible, practice multi-species grazing. Only a few parasites are transmissible between species, so following sheep or goats with horses, for example, will help reduce the number of small ruminant parasites on pastures
- Protect feed troughs, water sources and trace-mineral salt feeders from manure contamination.
- Provide as much browse as possible for goats.
- Strip grazing areas must be large enough to avoid severe buildup.
- Small strips must be changed more frequently.
- Overcrowding at farms should be avoided and good sanitary conditions should be provided.
- Predisposing factors such as poor management and concurrent chronic diseases should be avoided
- Limit the grazing in highly contaminated pasture during summer months.
- Put the animals on new pasture during monsoon.
- Implementation of pasture control to reduce larval contamination and decrease animal density in pasture and at watering points particularly during dry season

2. Strategic use of de-worming on susceptible, infected animals

- Goat should be treated at the start of the dry season (winter) preferably before the start of prolonged rain (rainy season) for better control of this stomach worm
- Late gestation or during early lactation to treat peri-parturient rise and to decrease parasite load being introduced on to pasture.

- Place goats onto a clean pasture after de-worming
- Treat and move to safe pastures which have not been grazed before or for at least three months. Treating before moving does select for parasite resistance.
- De-worm when fecal examinations are positive
- De-worm all animals at the same time
- De-worm regularly
- Rotate de-wormers

- Pre-breeding (fall) to decrease over wintering of arrested larvae and to improve body condition, reproduction, and kid birth weights.
- Monitor faecal shedding during the summer and treat and move as needed.
- Strategic treatment of small ruminants with anthlmentics should be practiced in the study area to minimize the impact of gastrointestinal nematodes on the health of animals.

3. Increasing efficacy of the de-worming program

- Identify which wormers are effective on farm. This is done by pre- and post-treatment faecal egg counts
- Hold animals to be wormed off feed for 12-24 hours before treating with Benzimidazoles (Fenbendazole and Albendazole) or Ivermectin, Doramectrin, and Moxidectin. This slows the digestive processes, allowing the de-wormer to remain in the animal's body longer for increased effectiveness. Do not hold pregnant does off feed in late gestation.
- The problems of haemonchosis and anthelmintic resistance should receive special attention at all levels
- To assess animals with clinical anemia due to *Haemonchus* spp
- Weigh representative animals to determine proper dose.
- Hold off feed overnight to increase efficacy (not in late pregnancy, because of risk of pregnancy toxemia). Ideally, treat two days in a row.
- Effective and broad spectrum anthelmintic should be practice at the beginning and after the end of rainy season.
- Avoid frequent rotation of de-wormers - ideally, stay with one drug for an entire year.
- Do use an adaptor that allows delivery of the de-wormer over the base of the tongue.
- During the grazing season, monitor for clinical signs (anemia, diarrhea, bottle jaw) and treat the affected animals but leave goats that are in balance with their parasite load untreated. This slows the development of resistant parasites by leaving unselected worms in the population. Record the identity of animals requiring frequent treatment and cull them and their offspring to increase genetic resistance of the goats to parasites.

- Animals should be provided with balanced feed containing more than 3 % protein.
- The best strategy would be to use a combination of all available broad spectrum anthelmintics on goats on a farm during winter housing period.
- To ensure that any goats entering the farm are quarantine dosed with anthelmintics to safeguard against the importation of *Haemonchus* spp back on to farm.

4. Improve awareness to the farmer

- Regular screening of animals for the presence of *Haemonchus* spp should be carried out to understand the disease potential.
- Awareness of animal owner's about the disease, treatment and the control strategy.
- The initiative should be taken at government level to develop and update quality and quantity of pastureland for animals grazing along with supplementary food.
- Education and awareness creation of farmers with regards of haemonchosis epidemiology and choosing of the best parasite control strategy and possible management systems should be given through strong extension. Continuous extension about the disease treatment and control strategy.
- The local government should organize meeting/seminars by involving local farming community. Training program addressing the importance of parasitism especially *Haemonchus* spp infection and their possible eradication strategies. Furthermore, scientific knowledge gained through epidemiological studies should be disseminated to farmers on these platforms.
- The field veterinarians and stockowners should be aware of the importance and burden of GIT helminthosis in goats.
- New parasite control strategies should be developed in the future that combine grazing management techniques with the use of bioactive forages and the biological control of parasites.
- Knowledge of the disease epidemiology in the county; which vary from place to another according to the agricultural and ecological variation.
- The control of haemonchosis must be done by the integration of several methods; because each method has it is own advantages and disadvantages.

SUGGESTIONS

- Epidemiology of haemonchosis in other areas of Bangladesh will be carried out.
- To study the prevalence of other parasitic diseases in relation to meteorological data in other areas of Bangladesh. This will help in understanding the epidemiology of diseases. In this way control of disease is possible.
- For early detection of parasitic infections such serodiagnostic techniques should be developed which should be cheaper than others and convenient in field application.
- Grazing of animals during rainy season should be avoided.
- It would be wise to include in the control *Haemonchus* spp targeted therapies using management of grazing and husbandry practices with emphasis on the seasons that interferes the life cycle of *Haemonchus* spp.
- Economic losses due to parasitic diseases will be calculated as scientific manner. This will help to adopt measures for reducing the losses due to parasitic diseases.
- The occurrence of polymorphism in vulvar morphology which will be need further study.
- Epidemiological, morphological, molecular and genetic characterization of *Haemonchus* spp with biology and significance of different vulvar flap types and species identification in all species in different agro-ecologies, animal species and breeds on management systems in Bangladesh and other countries will need to be pursued.

CHAPTER EIGHT

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Appendix-I

Investigation of goat haemonchosis in Rajshahi, Bangladesh

Date______________Locality: _______________

Address ________________

Table I: The following risk factors have been studied:

Sl. No.	Parameters	Description	
1	Area of the study	………Rajshahi	……………..Noagon
2	Type of sample	Faeces/Abomsum	
3	Age of the animal	Kid (<6 months)/ Young (6 to 12 months)/ Adult (>12 to <24 months)/Older (> 24 months)	
4	Sex of the animal	Male/Female (pregnant/Non-pregnant)	
5	Breed of the animal	Black Bengal (local)/cross-bred	
6	Body condition of the animal	Poor/Medium/Good	
7	Floor of housing of goat	Muddy/slatted (Woody)	
8	Feeding system of goat	Stall-feeding/Grazing (Morning/Afternoon)	
9	Husbandry system	Intensive/Semi-intensive/Extensive	
10	De-worming status	Regular/Irregular/None	
11	Herd size of goats	Small(1-5)/Medium(6-10)/Large(Above10)	
12	Month of the sample collection		
13	Season of the collection of sample	Summer (Mar-June)/Rainy (July-Aug)/Winter (Nov-Feb)	

……………………………………………. …….
Signature of the sample collector

Appendix II

Univariate analysis for the association of haemonchosis in 720 goats examined by coproscopy and necropsy examination with potential risk factors using Chi square ($\chi 2$) test.

Table II.1: Age of goat

Parameter	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	28.813[a]	1	.000
Continuity Correction[b]	27.593	1	.000
Likelihood Ratio	28.234	1	.000
Linear-by-Linear Association	28.831	1	.000
N of Valid Cases	720		

Table II. 2: Sex of goat

Parameter	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8..202[a]	1	.010
Continuity Correction[b]	7.220	1	.009
Likelihood Ratio	8.220	1	.011
Linear-by-Linear Association	12.202	1	.000
N of Valid Cases	720		

Table II. 3: Type of female goat

Parameter	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.569	1	.009
Likelihood Ratio	6.659	1	.017
Linear-by-Linear Association	7.954	1	.011
N of Valid Cases	404		

Table II. 3: Type of female goat

Parameter	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.569	1	.009
Likelihood Ratio	6.659	1	.017
Linear-by-Linear Association	7.954	1	.011
N of Valid Cases	404		

Table II. 4: Breed of goat

Parameter	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.610[a]	1	.123
Likelihood Ratio	.601	1	.105
Linear-by-Linear Association	1.610	1	.205
N of Valid Cases	720		

Table II. 5: Body condition of goat

Parameter	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	35.647	2	.000
Likelihood Ratio	24.601	2	.000
Linear-by-Linear Association	16.323	1	.000
N of Valid Cases	720		

Table II. 6: Husbandry system of goat

Parameter	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	11.014[a]	2	.001
Likelihood Ratio	10.131	2	.000
Linear-by-Linear Association	11.014	1	.001
N of Valid Cases	720		

Table II. 7: Floor of housing

Parameter	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	58.583[a]	2	.000
Likelihood Ratio	57.940	2	.000
Linear-by-Linear Association	58.778	1	.000
N of Valid Cases	720		

Table II. 8: De-worming status of goat

Parameter	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	62.023[a]	2	.000
Likelihood Ratio	61.517	2	.000
Linear-by-Linear Association	62.023	1	.000
N of Valid Cases	720		

Table II. 9: Feeding system of goat

Parameter	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	34.112[a]	1	.000
Likelihood Ratio	33.121	1	.000
Linear-by-Linear Association	34.112	1	.000
N of Valid Cases	720		

Table II. 10: Period of grazing of goat

Parameter	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	12.277[a]	1	.000
Likelihood Ratio	10.828	1	.001
Linear-by-Linear Association	11.704	1	.001
N of Valid Cases	720		

Table II. 11: Herd size of goat

Parameter	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	55.086[a]	2	.000
Likelihood Ratio	54.517	2	.000
Linear-by-Linear Association	55.084	1	.000
N of Valid Cases	720		

Table II. 12: Month of sample collection

Parameter	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	79.707[a]	11	.000
Likelihood Ratio	82.636	11	.000
Linear-by-Linear Association	17.158	1	.000
N of Valid Cases	720		

Table II. 13: Season of sample collection

Parameter	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	65.520[a]	2	.000
Likelihood Ratio	67.643	2	.000
Linear-by-Linear Association	32.70	1	.000
N of Valid Cases	720		

Table II. 14: Study area

Parameter	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.611[a]	1	.123
Likelihood Ratio	.601	1	.105
Linear-by-Linear Association	1.611	1	.205
N of Valid Cases	720		

Table II.15: Method of examination

Parameter	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	17.512[a]	1	.000
Continuity Correction[b]	15.216	1	.000
Likelihood Ratio	15.883	1	.000
Linear-by-Linear Association	17.512	1	.000
N of Valid Cases	720		

Table 16: Degree of infection (Coproscopy)

Parameter	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	27.521	2	.000
Likelihood Ratio	25.601	2	.000
Linear-by-Linear Association	27.521	1	.000
N of Valid Cases	363		

Table II. 17: Degree of infection (Necropsy)

Parameter	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	23.368	2	.000
Likelihood Ratio	21.601	2	.000
Linear-by-Linear Association	23.368	1	.000
N of Valid Cases	357		

Table II.18 : Sex ratio of adult female *Haemonchus* spp

Parameter	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	25.624	1	.000
Likelihood Ratio	23.642	1	.000
Linear-by-Linear Association	25.624	1	.000
N of Valid Cases	17250		

Table II. 19: Major vulvar flap morph types of female *Haemonchus* spp

Parameter	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	22.288[a]	2	.000
Likelihood Ratio	20.288	2	.000
Linear-by-Linear Association	11.144	1	.001
N of Valid Cases	520		

Table II. 20: Subtypes of linguiform vulvar flap morph types of female *Haemonchus* spp

Parameter	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	37.287[a]	1	.000
Likelihood Ratio	37.218	1	.000
Linear-by-Linear Association	37.281	1	.000
N of Valid Cases	174		