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Gastrointestinal Helminthic Challenges in Sheep and Goats in Afro-Asian Region: A Review

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ABSTRACT

Sheep and goats, being hardy and prolific in their growth, play a crucial role in cultural and socioeconomic life of rural poor under privileged people in Afro-Asian countries by providing meat, milk, wool and hide to them. Gastrointestinal helminthic infections are worldwide problem in ruminants. They results considerable loss in them causing mortality and poor production. Various helminthes types like trematodes, cestodes and nematodes are prevalent in different climates and geographical regions depending on rearing systems, intermediate host's availability and management practices. Epidemiology of helminthic diseases, though variable at times, is determined by various factors like treatment, climate and poverty (socio-economic and traditional practices). The study oversees gastrointestinal helminthic challenges in goats and sheep faced in Afro-Asian region in last decade. Methodology involves exhaustive exercise of screening and massive literature hunt which included published research, both abstracts and full length papers on the subject in last 10 years in addition to authors own observations. The diseases like Fasciolosis, Dicrocoelosis, Amphistomosis in trematodes, Monieziosis, Avitellinosis in cestodes and Haemonchosis, Trichostronglylosis, Oesophagostomosis, Trichuriosis, Strongyloidosis in nematodes were still serious challenges in the region threatening the small ruminant production. Frequent reports on *Marshallgia, Ostertagia, Nematodirus, Stilesia, Thysaniezia* spp. from this region showed emerging threats. Infections like *Camelostrongylus, Graphidiops, Parabronema* and *Skrjabinema* spp. were scarcely distributed. The paper reviews scientific work and developments of last 10 years on occurrence, distribution and epidemiology of common gastrointestinal helminthic infections of sheep and goats in Afro-Asian region with future research prospective in light of newer scientific approaches.

Keywords: Helminthes, Sheep, Goats, Epidemiology, Research Gaps

Sheep and goats are important livestock species in Afro-Asian region of the world where three-forth of their world population of resides. Both the species play an important role in this region in providing food security to large population of small and marginal farmers and poor landless peoples. Through production of meat, milk, skin and wool they contribute significantly to their subsistence, employment generation and poverty alleviation. Production of sheep and goats, however, suffers severely from various infectious diseases of bacterial, viral and parasitic nature along with other management problems. Gastrointestinal helminthes infections (Trematodes, Cestodes and Nematodes) in small ruminants, both in intensive and extensive management, are considered serious constraints in their production as they lead to serious economic losses through lowering production of their produces along with morbidity and mortality. Further, substantial economic losses are encountered by the farmers in sheep and goat production in the form of expenditure incurred to control the helminthic infections. Local environment and climatic conditions along with traditional management practices and prevalence of intermediate host, if involved, determine the occurrence and pathogenesis of helminthic infections. Study of epidemiology of helminthic infections is important because they have wide geographical distribution in different regions world over. Epidemiological study

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provides us an important tool to prevent and control of these diseases. However, epidemiology is likely to change as an effect of natural and manmade adversaries of various natures. Global or local changes like variation in environmental temperature, total rain fall and humidity, water resources, level of different types of pollutions, use of chemicals in agriculture, depleting feed and fodder in pastures along with large scale shift in agricultural and animal husbandry procedures are likely to influence the occurrence and severity of these infections as both primary and secondary hosts along with different parasitic stages outside are continuously under stress. Climate changes bring adaptability changes in parasites which may involve strain variation in phenology, within genotype or host switching. Such changes work as strokes, be positive or negative, for parasites survival. In the light of present scenario, the paper reviews gastrointestinal helminthic challenges of sheep and goats of last decade and suggests future research perspectives.

TREMATODES INFECTIONS

Fasciola spp.

Infection of *Fasciola* spp. remained quite common in sheep and goats during last decade. It has been reported from different parts of Afro-Asian region like India (Sutar *et al.,* 2010; Lone *et al.,* 2012; Khajuria *et al.,* 2013), Pakistan (Farooq *et al.,* 2012), China (Huang *et al.,* 2004), Bangladesh (Rahman *et al.,* 2014; Hossain *et al.,* 2015), Iran (Ali *et al*., 2011; Khanjari *et al.,* 2014), Thailand (Worasing *et al.,* 2011), Ethiopia (Sissay *et al.,* 2007; Dagnachew *et al.,* 2011; Ibrahim *et al.,* 2014; Gizachew *et al.,* 2014), Tanzania (Mhoma *et al.,* 2011), Zimbabwe (Zvinorova *et al.,* 2016), Kenya (Musotsi *et al.,* 2017). Fasciolosis is responsible for 3.28-4.8 percent of total liver condemnation in ruminants (Ali *et al.,* 2011; Mhoma *et al.,* 2011; Khoramiam *et al.,* 2014). *Fasciola hepatica* and *F. gigantica* are the two common species affecting the small ruminants. It carries public health importance also and as per WHO (2006) estimates 2.4 million people were infected with *Fasciola hepatica* and a further 180 million were at risk of infection. Arbabi *et al.* (2018), from Iran, reported that *Fasciola* spp. infection caused financial losses of 7160 and 6098.4 USD magnitudes during 2013-2016 in sheep and goat respectively.

The incidences reported in various studies from different places were different. From Pakistan the reported incidence in Sheep was as high as 2.8 to 40 percent (Farooq *et al.,* 2012) against 15.6-29.35 percent in India (Lone *et al.,* 2012; Nagesh and Das, 2013; Nagesh and Das, 2015) and 14.29-46.67 percent in Bangladesh (Rahman *et al.,* 2014; Hossain *et al.,* 2015). The overall prevalence of fasciolosis in sheep and goats in Iran was described to 0.35-22.8 and 0.50-11.4 percent respectively (Ali *et al.,* 2011; Khanjari *et al.,* 2014). However, in sero -prevalence study from Turkey through in-house ELISA technique, Akca *et al.* (2014) described prevalence of *Fasciola* spp. infection as high as 93 percent in sheep.

Various reports from different parts of India on goats described fasciolosis 9.25 percent in Maharashtra (Sutar *et al.,* 2010), 3.88-14.8 percent in Jammu and Kashmir (Khajuria *et al.,* 2013). The prevalence of the disease was reported higher in sheep than goats (Dagnachew *et al.,*2011). In Africa fasciolosis incidence in Sheep and goats respectively ranged from 9-19.6 and 0.9-7.6 percent (Gizachew *et al.,* 2014; Ibrahim *et al.,* 2014) in Ethiopia and 37 and 36 percent in Kenya (Kenyari *et al.,* 2009), 4.2-8.2 percent in Tanzania (Mhoma *et al.,* 2011). Zvinorova *et al.* (2016) reported *Fasciola* spp. infection prevalence of 0.9-5.1 percent in goats from Zimbabwe.

Islam *et al.* (2016) from Bangladesh, described prevalence of Fasciolosis in goats as seasonal with highest prevalence recorded in rainy season. They found it more significantly occurring in female goats than males. Khanjari *et al.* (2014) reported that prevalence of *Fasciola* spp. was highest during spring (8.3%) followed by autumn (8.1%), winter (5.9%) and summer (4.3%). Bulbul *et al.* (2014) recorded highest *Fasciola* egg discharge (EPG) in winter followed by post- monsoon, pre-monsoon and monsoon season. Seasonality of *Fasciola* spp. infection has also been seen by other investigators also (Ali *et al.,* 2011). Regional and annual variations in *Fasciola* spp. prevalence were considered associated with prevailing weather conditions (Relf *et al.,* 2011). This is because the hatching of fluke eggs and multiplication of snail, the intermediate host, require proper high rainfall and temperature (>10°C) (Taylor, 2012).

Fasciolosis remained significantly more prevalent in sheep than goats (Khanjari *et al.,* 2014). Higher prevalence rate in sheep than goats was attributed to the grazing habits of sheep which graze plants from ground where metacercariae, the infective stages of *Fasciola*, were mostly found whereas goats nibbled from top branches and leaves away from ground (Theodoropaoulos, 2011; Khanjari *et al.,* 2014). Talukder *et al.* (2010) described age and sex of the animals as important determinant factors in pathology of fasciolosis in goats. However, both sheep and goats were described as very susceptible to *Fasciola hepatica* and with no resistance to reinfection.

In general, pathology of the disease is similar in sheep and goats. In sheep common lesions of livers were variable degree of cholangitis, biliary obstruction, fibrosis, hyperplasia, hemorrhages, enlargement, fibrinous exudation and oedema (Khan *et al.,* 2015). In goats, affected livers were enlarged with hemorrhagic spots, hepatic bile duct protruding and engorged (Islam *et al.,* 2016). They described microscopic hepatic lesions as hemorrhagic migratory tracks marked with infiltration of numerous eosinophils and lymphocytes, fatty changes, atrophy, thickened bile duct with hyperplasia of epithelial lining (Talukder *et al.,* 2010). Calcification of bile duct in chronic infection of *Fasciola* spp., as seen in cattle, was not featured in sheep and goats (Talukder *et al.,* 2010; Islam *et al.,* 2016).

The gravity of problem and economic losses due to fasciolosis in sheep and goats in Afro-Asian region can be realized by extrapolation of study conducted by Khoramian *et al.* (2016) who reported an economic loss of 23360 USD and 30240 USD in sheep and goats respectively in Iran.

Dicrocoelium spp.

Dicrocoelium spp. hepatic infection is responsible for direct losses in sheep and goats' production due to discard of parasitized livers and indirect losses through costs associated with anthelmintics treatments. It has been reported from Iran (Khanjari *et al.,* 2014), India (Lone *et al.,*2012; Khajuria *et al.,* 2013; Godara *et al.,* 2014), Nepal (Karki *et al.,* 2012), Malaysia (Tan *et al.,* 2017), Ethiopia (Sissay *et al.,* 2007) and Nigeria (Usman *et al.,*2016). However, being asymptomatic and masked by the presence of pathological effects of multiple parasitic infections in ruminants, dicrocoelosis remained little known and underestimated by researchers. Arbabi *et al.* (2018) reported losses of USD 10880 and 9079.2 respectively in sheep and goats resulted from dicrocoelosis during 2013-2016 in Iran, mainly due to condemnation of damaged liver.

The incidence of dicrocoeliosis in sheep and goats varied from 3.63-20.0 and 2.6-5.0 percent respectively (Khajuria *et al.,* 2013; Khanjari *et al.,* 2014; Godara *et al.,* 2014; Ezatpour *et al.,* 2015; Tan *et al.,* 2017). Nevertheless, there were reports of 32 percent prevalence in goats from India (Lone *et al.,* 2012). Sheep was described more susceptible to *D. dendriticum* infection (Khanjari *et al.,* 2014). However, higher infection infection rate was observed in older animals.

Ali *et al.* (2011) from Iran and Godara *et al.* (2014) from India described it to be seasonal and spring/winter season was found to have highest prevalence (Ezatpour *et al.,* 2015). However, Khanjari *et al.* (2014) reported that *D. dendriticum* infection did not follow any seasonal pattern. The dicrocoelosis was described more frequently in lowlands or mountains pasture lands at high altitudes and it was considered that chalk or alkaline soils favors the development of the vector snails and ants (Rojo-Vazqiez *et al.,* 2012; Arabi *et al.,* 2011).Unlike *Fasciola* spp., the intermediate hosts, in case of *Dicrocoelium* spp. infection were field snails and did not require much moisture for propagation and remained widely distributed in pastures surviving months together (Taylor, 2012). Further environment and ecological aspects were considered the main important factors for *Dicrocoelium* life cycle between intermediate and definitive hosts (Arabi *et al.,* 2011). Females showed a higher rate of dicrocoeliosis prevalence than males (Khanjari *et al.,* 2014) probably due to sex as a determinant factor influencing prevalence of parasite specially during pregnancy and peri-parturient period due to stress and low immune status(Khan *et al.,* 2010).

Jithendaran and Bhat (1996) reported livers in infected sheep and goats as swollen with thickened bile ducts, whitish spots on the surface, marked scarring and cirrhosis, with a large number of worms inside the bile ducts and gall bladder. Similarly, Arabi *et al.* (2011) from Iran reported liver distension along with severe fibrosis and obstruction of bile duct. They found a direct correlation between worm burden and lesion scores in infected animals. In general the disease has been reported far often from hilly pastures.

Though rarely, *D. dendriticum*, the lancet fluke, was reported carrying zoonotic importance. Samaila *et* *al.* (2009) described its infection in a 7 year old boy with clinical symptoms of jaundice and fever. Human infection could have been due to accidental ingestion of intermediate hosts, primary or secondary or through raw meat consumption. World health organization in 2007 included *D. dendriticum* on its list of organisms to target with its Food borne Diseases Epidemiology Reference Group (WHO, 2007).

Eurytrema spp.

In last decade the information about the subject lacked as literature on this parasite remained scanty except a few reports from Eastern Asia in sheep and goats (Sangvaranond *et al.*, 2010; Jittapalapong *et al.*, 2012; Xu *et al.,* 2013). Owhoeli *et al.* (2014) from Nigeria reported *Eurytrema* spp. infection in goats through a slaughter house study while Sangvaranond *et al.* (2010) and Jittalapong *et al.* (2012) described it from Thailand in meat goats raised in private farms through faecal examination (0.84-1.3%). Chang *et al.* (2016) characterized the complete mitochondrial genome from *E. pancreaticum* and established its close relation with *Dicrocoelium chinensis* and other members of Dicrocoelidae**.** Schwertz *et al.* (2015) has described Eurytrematosis, an emerging and neglected disease in recent time in Brazil and suspected human infection in the light of previous reports. There were two species main species, *E. pancreaticum* and *E. coelomaticum*, reported from sheep and goats, however, the first one was more frequently recorded throughout.

Amphistomes

Swarnkar and Singh (2012) have described the amphistomes infection one of the most economically important infections requiring particular attention in worm control programme. The condition is very common in small ruminants and has wide distribution. The disease has been reported from Ethiopia (Sissay *et al.,* 2007; Dagnachew *et al.,* 2011), Pakistan (Farooq *et al.,* 2012), India (Swarnkar and Singh 2012; Kandasamy *et al.,* 2013; Brahma *et al.,* 2015), Bangladesh (Hossain *et al.,* 2015), Thailand (Sangvaranond *et al.,* 2010), Turkey (Ozdal *et al.,* 2010), Malaysia (Tan *et al.,* 2017). Choudhary *et al.* (2010) described paramphistomosis as a neglected trematodes disease of ruminants and a significant cause of economic losses.

The incidence reported in different studies in India ranged from as low as 1.3 to 23.55 percent in sheep (Swarnkar and Singh, 2012; Lone *et al.,* 2012; Kandasamy *et al.,* 2013; Nagesh and Das, 2013; Maitra *et al.,* 2014) and as high as 18.26 to 91 percent in Goats (Lone *et al.,* 2012; Singh *et al.*, 2015). In African continent, the incidence in sheep was 3.1-19.6 percent in Ethiopia (Gizachew *et al.,* 2014; Ibrahim *et al.,* 2014), 9.38 percent in Egypt (Sultan *et al.,* 2016), 4.43 percent in Turkey (Ozdal *et al.,* 2010). In goats, Mhoma *et al.* (2011) from Tanzania and Zvinorova *et al.*(2016) from Zimbabwe reported prevalence as 7.3 and 0.6–24 percent respectively.

Swarnkar and Singh (2012) reported peak prevalence in June–August in Rajasthan, India and described it as summer enteritis syndrome. In goats, highest prevalence was reported in monsoon and lowest in winter (Choubisa *et al.,* 2010; Singh *et al.,* 2015) and associated it with probable availability of intermediate host, the snails. Maitra *et al.* (2014) reported highest mean EPG during monsoon and post monsoon in goats and sheep. On the other hand, Yadav *et al.*, (2010) described more cases in summer than rainy season. The highest incidence in sheep in Turkey was reported during autumn followed by summer (Ozdal *et al.*, 2010), however, it was reverse in Iran (Tehrani *et al.,* 2015). Maitra *et al.* (2014) described the difference in species/season/monthly prevalence due to the differences in the agro climatic conditions, availability or abundance of intermediate hosts, animal husbandry/ management practices, length of survey period, sample size and method of sampling. There was no evidence of auto expulsion of amphistomes from host body (Maitra *et al.*, 2014).

Kenyari *et al.* (2009) from Kenya and Ibrahim *et al.* (2014) from Ethiopia reported prevalence of *Paramiphistomum* spp. significantly low in animals with good body conditions. Ibrahim *et al.* (2014) also described significantly higher prevalence in young and female sheep and goats.

There were several species of amphistomes affecting sheep and goats in particular. The common prevalent amphistomes were described as *Paramphistomum, Cotylophoron, Calicophoron, Gastrothylax* species. Farooq *et al.* (2012) from Pakistan reported *Cotylophoron* spp. infection in sheep. Tehrani *et al.* (2015) described three species from sheep carcass as *P. cervi, Cotylophoron cotylophorum* and *G. crumenifer* in Iran. Tan *et al.*, (2017) from Malaysia described *Paramphistomum* spp. in goats.

Bulinus species of snails are found to play important role in amphistomes life cycle. Common snails described as intermediate hosts were *Bulinus syngenes*, *B. alluaudi* (Kenya), *B. truncates* (Iran, Egypt), *Planorbis planorbis* (Bulgaria), *Indoplanorbis exustus* (India).

Ozdal *et al.* (2010) observed that pathogenic effect of paramphistomosis was dependent on the number of parasites in animals and described the adult fluke infections as harmless except chronic ulcerative rumenitis along with ruminal papillary atrophy when flukes' number was large. Maitra *et al.* (2014) reported as high as 80-90 percent mortality rate due to immature paramphistomosis in domestic ruminants. Tehrani *et al.* (2015), among 2421 sheep tissue specimens in paramphistomosis, recorded major gross lesions as hyperemia, haemorrhage ulcers and nodular protrusions of different sizes and shapes in intestines along with dilatation and superficial destruction of intestinal glands and infiltration of erythrocytes and inflammatory cells and fibrinous membrane around them. Melaku and Addis, (2012) from Ethiopia quoted mature amphistomes infection with rumenitis, irregular rumination, un-thriftiness, lower feed conversion rate and loss of body conditions resulting in considerable economic loss. Clinical paramphistomosis in small ruminants is manifested by anorexia, profuse fetid diarrhea, drop in plasma protein concentration and anemia. Balakrishnan *et al.* (2014) described clinical signs of amphistomosis in native Indian goats as profuse fetid diarrhea, sub mandible oedema, anaemia, anorexia, weakness, dull and depression.

Diagnosis of amphistomosis conventionally depended on clinical signs, immature parasites in diarrheic fluid and amphistomes eggs in the faeces. However being marked seasonality in egg production and pathogenic effect being limited to immature stage of amphistomes, the diagnosis of based on conventional methods was found difficult in routine investigation (Saifullah *et al.* 2011). Attempts on immunodiagnostics have been made (Saifullah *et al.*, 2011) but still a reliable diagnostic test remained a far dream to achieve. Saifullah *et al.* (2011) detected a 33kDa protein excreted/secreted by *Gastrothylax crumenifer* as immunodominant to be used as antigen in its diagnosis**.**

Schistosomes

In last decade, *Schistosoma* spp. infection was reported from Bangladesh (Rabbi *et al.*, 2011; Sangma *et al.*, 2012); Nepal (Karki *et al.*, 2012); Nigeria (Amadi *et al.*, 2012; Owhoeli *et al.*, 2013; Usman *et al.*, 2016), Ghana (Futagbi *et al.*, 2015), Ethiopia (Kerie and Seyoum, 2016). The prevalence of infection ranged between 3.2–44.4 percent in goats (Rabbi *et al.*, 2011; Karki *et al.*, 2012; Futagbi *et al.*, 2015). Amadi *et al.* (2012) and Owhoeli *et al.* (2013) from Nigeria reported a prevalence of 6.4-21.1 percent in goats through faecal examination. Sangma *et al.*, (2012) and Kerie and Seyoum, (2016) reported prevalence of infection in sheep as 3.7 and 2.3 percent in Bangladesh and Ethiopia respectively. Swarankar *et al*. (2019) reported prevalence of schistosome as 0.19 percent in Rajasthan sheep. Prevalent species in sheep and goats were S. *ha*ematobium (Futagbi *et al.*, 2015), S. *bovis* (Kerie and Seyoum, 2016) and *S. indicum* (Sangma *et al.*, 2012, Swarnkar *et al.* (2019). Agrawal (2012) described *S. indicum*, *S. spindale* and *S. incognitum* in Indian goats occurring both as monospecies or sympatric infections. However, he reported absence of sympatric infection of *S. indicum* and *S. incognitum* suggesting a strong heterologous immunity between the two species. Agrawal, (2012) considered *S. indicum* responsible for outbreaks and considerable mortality in sheep in Indian states. He described *S. spindale* as species widely distributed in more countries than *S. indicum* and dominating species in goats. Kerie and Seyoum, (2016) reported no association of host age or gender to schistosome infection in sheep.

Gaps in Trematodes Research

Epidemiology of infections provides an important tool to control the diseases. However, there exists a big knowledge gap in relation to epidemiology of trematodes infection in snail, the intermediate host. Study of snail species spectrum, interaction between snail and parasites, snail habitats and behavior with respect to meteorological changes along with population dynamics is required to fill the knowledge gap and to control the disease. Further in developing countries, Amphistomosis could not get much attention for diagnosis compared to other trematode infections like Fasciolosis and Schistosomosis because the later were considered more important being more of pervasive and of zoonotic nature. There is a lot of scope to study the dynamics of the intermediate stages of these trematodes in the cold-blooded host like snail. The major area, which needs to be addressed, is to understand the immune-genomics of the snail with the recent technologies of gene-editing tools like CRISPR. This untouched domain could decipher the molecular pathogenesis and signatures that aids in the development of parasite in the definitive host. Soon these techniques could address the diagnostic and vaccine targeting issues for disease control.

Application of modern techniques like PCR, recombinant technique, transcriptomics in schistosomes study are to be used to unfold the epidemiology and immunity part. Further, the study of epidemiology of infections in snail, the intermediate host, along with the proteomics is necessary to impound the problem in livestock and human as well.

ANOPLOCEPHALID CESTODES

Moniezia spp.

Among cestodes infections of small ruminants, *Moniezia* spp. infection is most common and world widely distributed. It has been reported from Bangladesh (Nath *et al.*, 2011; Rahman *et al.*, 2014; Hossain *et al.*, 2015), India (Swarnkar and Singh, 2012; Lone *et al.*, 2012; Nagesh and Das, 2013; Brahma *et al.*, 2015; Verma *et al.*, 2017), Korea (Gebeyehu *et al.*, 2013), Sri Lanka (Kandasami *et al.*, 2013), Syria (Almalaik *et al.*, 2008), Nigeria (Owhoeli *et al.*, 2014), Thailand (Worasing *et al.*, 2011), Malaysia (Tan *et al.*, 2017), Ethiopia (Dagnachew *et al.*, 2011; Gizachew *et al.,* 2015).

The prevalence of moniezial infection in sheep as described by various workers ranged from 0.2 to 30.4 percent (Almalaik *et al.*, 2008; Kenyari *et al.*, 2009; Swarnkar and Singh 2012; Kandasami *et al.*, 2013; Gizachew et al 2015; Ibrahim *et al.*, 2014; Nagesh and Das 2013). In goats, prevalence range described was 0.1- 40.34 percent (Almalaik *et al.*, 2008; Kenyari *et al.*, 2009; Worasing *et al.*, 2011; Shaikh *et al.*, 2011; Nath *et al.*, 2011; Rahman *et al.*, 2014; Ibrahim *et al.*, 2014; Hossain *et al.*, 2015; Brahma *et al.*, 2015; Tan *et al.*, 2017; Verma *et al.*, 2017; Hassan *et al.,* 2019). Sissay *et al.* (2008) reported *Moniezia* prevalence as high as 61 and 53 percent in Sheep and Goats respectively from Ethiopia. Dagnachew *et al.* (2011) from Ethiopia, and Attindehou and Salifou, (2012) from Benin reported that prevalence of *Moniezia* infection in sheep was significantly higher than in goats. Kumsa *et al.* (2011) from Ethiopia also reported sheep being more vulnerable to infection. There were two species of *Moniezia* in small ruminants i.e. *Moniezia expansa* and *M. benedeni*, the first being more common (Kandasami *et al.*, 2013; Aragaw and Gebreeegziaber, 2014) but Sangavaranond *et al.*, (2010) found *M. benedeni* more prevalent species in goat in Thailand. Nguyen *et al.* (2012) based on PCR study in Vietnam described *M. expansa* as dominant spp. in sheep and goats whereas *M. benedeni* more common in cattle.

Nagesh and Das (2013) from India reported *Moniezia* spp. more prevalent in sheep in winter season. Kandasami *et al.* (2013) found higher prevalence rate after rainy season. Attindehou and Salifou, (2012) from Benin described the infection prevalent in all season nevertheless high rates in rainy seasons (beyond 50%). Nath *et al.* (2011) attributed the seasonal variation in incidence of *Moniezia* infection to active period of forage mites, the intermediate host for parasite. They reported the infection being more common in kids during one year of age than the older animals. Abdel-Megeed *et al.* (2014) from Egypt described the sero-diagnostic value of partially purified antigen of *Moniezia expansa* and reported infection prevalence of 69.7% and 74.4% in sheep and goats respectively. *Moniezia* spp. infection has also been associated with poor body conditions and age in goats.

Infection of *Moniezia* spp. in animals was reported to cause severe pathogenic effects viz. disturbance of gastrointestinal motility, secretion, diarrhea and anemia along with reduced slaughter yield, increased water content and reduction in protein and fat.

Stilesia spp.

Among anoplocephalids, *Stilesia* spp. infection is quite important and frequently observed in small ruminants. There had been several reports of this infection in small ruminants from Asia (Siddiqua, 2010; Mir *et al.*, 2013; Sankar *et al.*, 2016) and Africa (Sissay *et al.*, 2008; Ndom *et al.*, 2016). In India, a prevalence rate described in goats varied between 2.5-36.6 percent (Siddiqua, 2010; Mir *et al.*, 2013; Sankar *et al.,* 2016). Siddiqua, (2010) recorded a prevalence of 2.91 and 2.5 percent in sheep and goats respectively and described species as *S. vitatta*. In a 7 year slaughter house study, Sankar *et al.* (2016) described *Stilesia* as one of the neglected and economically important tropical parasites. Sissay *et al.*, (2008) and Ndom *et al.*

(2016) reported *Stilesia* spp. infection in small ruminants from Africa. The prevalence of infection was as high as 39 percent in sheep and 36 percent in goats (Sissay *et al.*, 2008). Sissay *et al.* (2008) described both *Stilesia globipunctata* and *S. hepatica* species affecting sheep and goats and *Stilesia hepatica* being more prevalent than *S. globipunctata*. Shankar *et al.* (2016) dsecribed sex and age as important factors affecting the incidence and reported male and age (6-12 M) being more susceptible and infection reaching its peak during rainy season. The infection is insect born and *Scheloribates indica* and *Erythreus* spp. were intermediate hosts for *S. globipunctata*.

***Avitellina* spp.**

Avitellina spp. infection was reported in Asia in last decade from India (Siddiqua 2010, Lone *et al.*, 2012), Iran (Naem and Gorgani, 2013,). Siddiqua, (2010) reported *Avitellina* spp. infection prevalence of 8.75 percent in sheep from Kanpur Dehat, India. Lone *et al.* (2012) reported prevalence of *Avitellina* spp. infection in slaughtered sheep and goats respectively as 17.75 and 24.25 percent from J & K state of India. Naem and Gorgani, (2013) from Iran reported *Avitellina* spp. prevalence in sheep as high as 20 percent. There had been several reports of Avitellina spp. infection in sheep and goats from Africa during last decade (Sissay *et al.*, 2008; Ndom *et al.*, 2016; Elkhatam and Khalafalla, 2016). Sissay *et al.*, 2008 from Ethiopia described *Avitellina* spp. in sheep and goats (20-39.5%). Ndom *et al.* (2016) from Senegal reported prevalence of *Avitellina* sp. as high as 38.7 percent in sheep. Elkhatam and Khalafalla, (2016) reported 4.0 percent prevalence of *Avitellina* infection in goat from Egypt in slaughter house study. They described the species as *A. centripunctata*. However, Taylor *et al.* (2016) described 3 more species of *Avitellina* as *A. goughi*, *A. chalmersi* and *A. tatia* sheep and goats.

***Thysaniezia* spp.**

The anoplocephalide cestode, *Thysaniezia* infection in sheep and goats was reported by Solsby *et al.* (1987) from UK, USSR, Africa and America. During last one decade, it has been reported from India, Senegal and Egypt (Lone *et al.*, 2012; Ndom *et al.,* 2016; Bashtar *et al.*, 2011). Lone *et al.* (2012) described *Thysaniezia* spp infection in sheep and goats (10.15 & 17.85 %) in J & K state of India. Ndom *et al.* (2016) from Senegal reported prevalence of *Thysaniezia* spp. sheep and goats as 0.4 and 2.1 percent respectively. Bashtar *et al.* (2011) reported this infection in sheep from Egypt with prevalence of 2.7 percent.

Gaps in Cestodes Research

The economic importance of infection of anoplocephalid cestodes in small ruminants is not well understood and it could not seek the required attention in past. However, their rampant and widely distributed occurrence in them along with pathogenic effects in severe cases emphasizes a well designed experimental study to explore the economic implications of these infections which cannot be ruled out and are likely to happen both directly or indirectly. A wholesome analysis of the pattern recognition receptor genes and their expression in response to anoplocephalids cutting across their hosts could unravel certain common factors supporting the development of these parasites. With the advent of the current developments in the molecular biology and next generation sequencing platforms, there is a possibility to delve in to every other important putative molecule that is involved in the development of the disease. Further, the proteomic study in area may be helpful to demonstrate the common candidate protein, if any, having vaccine potential.

NEMATODE INFECTIONS

***Haemonchus* spp.**

Haemonchosis in sheep and goat is a worldwide problem. *Haemonchus* spp. infection has been described as the most common and economically important strongyle nematode infection in sheep and goats (Almalaik *et al.*, 2008; Sharma *et al.*, 2009; Swarnkar and Singh; 2012; Asaolu *et al.*, 2012; Farooq *et al.*, 2012; Singh *et al.*, 2013; Okoye *et al.*, 2013; Kandasami *et al.*, 2013; Brahma *et al.*, 2015; Singh *et al.*, 2015). In last 10 years, *Haemonchus* spp. infection has been reported from Gambia (Asaolu *et al.*, 2012), Srilanka (Kandasami *et al.*, 2013), Sudan (Almalaik *et al.*, 2008), India (Sharma et al 2009; Sutar *et al.*, 2010; Mandal *et al.*, 2011; Swarankar and Singh 2012; Singh *et al.*, 2013; Singh *et al.*, 2015; Brahma e al., 2015; Bihaqi *et al.*, 2017), Nepal (Karki *et al.*, 2012), Iran (Naem and Gorgani, 2011), Bangladesh (Hossain *et al.*, 2015), Iraq (Mohammedameen, 2016), Nigeria (Okoye *et al.*, 2013; Owhoeli *et al.*, 2014; Soloman–Wisdom *et al.*, 2014; Odeniran, *et al.,* 2016), Ethiopia (Sissay *et al.*, 2007), Cameroon (Ntonifer *et al.*, 2013), Ghana (Blackie 2014; Futagbi 2015).

Prevalence of *Haemonchus* infection described time to time varied in different places and species. In goats, 26.0 percent from Sudan (Almalaik *et al.*, 2008), 24.25-70.0 percent from India (Sharma *et al.*, 2009; Sutar *et al.*, 2010; Singh *et al.*,2013), 61.5-69.5 percent from Nigeria (Okoe *et al.*, 2013), 67.5 percent from Ethiopia (Badaso and Addis, 2015), 10-14.5 percent in Nepal (Karki*et al.*, 2012), 62.8 percent in Ghana (Futagbi *et al.*, 2015). Interestingly, Bandhyopadhyaya *et al.* (2010) reported *Haemonchus contortus* prevalence in 76.8 percent cases from reticulum rather than in abomasums. Prevalence in sheep reported was 53.4 percent from Sudan (Almalaik *et al.*, 2008), 47.0 percent in India (Singh *et al.*, 2004), 75-81.3 percent in Sri Lanka (Kandasami *et al.*, 2013) and 56.6 percent from Ethiopia (Badaso and Addis, 2015). Prevalence rates in two species have been reported to be significantly different (Badaso and Addis, 2015). Futagbi *et al.* (2015) described higher prevalence of *Haemonchus* infection in imported than in local goats in Ghana.

Qamar *et al.*, (2009) from Pakistan reported the highest prevalence of *Haemonchus* infection during summer and more in younger animals (below 9 month) compared to older animals. The high humidity, in microclimate of faeces and the herbage, being essential for larval development and survival, was described to be the cause of frequent and severe outbreaks of GI nematode infection in rainfall season. Sissay *et al.* (2007) from a study in sheep in Ethiopia reported high levels of gastrointestinal nematode infections occurring during rainy seasons and *H. contortus* being most predominantly occurring GIN. Physiological states like pregnancy, age and lactation in animals were found to affect the faecal egg counts in *H. contortus* infected animals and thus the susceptibility their of (Agrawal *et al.*, 2010). Raza *et al.* (2014) attributed the higher prevalence of *Haemonchus* infection to short generation interval of this nematode along with high fecundity. Chiejina *et al.* (2015) described West African Dwarf goat as haemonchotolerant. There existed resistance within and between the breeds of sheep and goats against *Haemonchus* spp. (Babar *et al.*, 2015) which was regulated by immunological response against the infection. However, the mechanism remained still as an enigma.

Symptoms of acute haemonchosis were described as dark coloured faeces with blood and sudden death of affected animals (Kandasami *et al.*, 2013). Kandasami *et al.*, (2013) described the *Haemonchus* spp. infection leading immunosuppression which predisposes the animals towards secondary infections. Blackie (2014) described *H. contortus* blood sucking worms resulting anaemia and weight loss in areas permanently warm and humid or having prolonged warm rainy season.

***Trichostrongylus* spp.**

Trichostrongylosis is an important roundworm disease of small ruminants. It is widely distributed. *Trichostrongylus* spp. infection, in last one decade, was reported from Pakistan (Farooq *et al.*, 2012; Raza *et al.*, 2014), Sudan (Almanaik *et al.*, 2008), Ethiopia (Sissay *et al.*, 2007; Dagnachew *et al.*, 2011), India (Swarnkar and Singh, 2012; Singh *et al.*, 2013; Brahma *et al.*, 2015), Nigeria (Okoye *et al.*, 2013), Botswana (Sharma and Busang, 2013), Cameroon (Ntonifor *et al.*, 2013), Ghana (Blackie 2014).

The prevalence of *Trichostrongylus* spp. infection was varied. It ranged in goats from 5.68 to 28.33 percent in India (Lone *et al.*, 2012; Brahma *et al.*, 2015), 13.8-21.1 percent in Pakistan (Farooq *et al.*, 2012) 24.4 percent in Sudan (Almalaik *et al.*, 2008), 23.2-77.5 percent in Ethiopia (Aragaw and Gebreegziabher, 2014; Ibrahim *et al.*, 2014) 51.5 percent in Bangladesh. In sheep the prevalence varied 14.7 to 83.6 (Almalaik *et al.*, 2008; Aragaw and Gebreegziabher, 2014; Swarnkar and Singh, 2012; Ntonifer *et al.*, 2013; Lone *et al.*, 2012; Farooq *et al.*, 2012; Ibrahim *et al.*, 2014). *Trichostrongylus* genus has been reported among the commonest of the GIT nematode infections in Ethiopia and Bangladesh along with *Haemonchus, Nematodirus* and *Oesophagostomum* (Sissay *et al.*, 2007; Blackie, 2014). Farooq *et al.* (2012) described it as the 2nd most important parasites from Pakistan. Ntonifor *et al.* (2013) reported that tethered animals had highest infection rates than free range grazer both in sheep and goats. The infection was found more frequent in animals with poor body conditions (Kenyari *et al.*, 2009; Ibrahim *et al.*, 2014). Raza *et al.* (2014) from Pakistan reported three species prevalent in sheep and

Goats as *Trichostrongylus colubriformis, T. axei* and *T. ovis*. Blackie, (2014) reported the presence of two species as *T. colubriformis* and *T. axei* in Ghana.

Trichostrogylus spp. infection has been considered to thrive well in cool season and at times when mean monthly temperature ranged between 2.8 to 18.3 ^{o}C. However, there are reports which suggest non conducive effects of cool season on *Trichostrongylus* spp. (Farooq *et al.*, 2012).

Ostertagia spp. (*Teladorsagia*)

This is known as brown stomach worm of ruminant. The nematode has been reported from sheep in Egypt (Khalafalla *et al.*, 2011; 1.2 percent) Pakistan (Raza *et al.*, 2014, 4.2 percent) India (Khajuria *et al.*, 2013) Iran (Naem and Gorgani, 2013; 38 percent) Ghana (Blackie, 2014). Asrani *et al.*, (2011) reported *Teladorsagia* infection in migratory Gaddi sheep and goats from Himachal state in India and described lesions caused in abomasums as multiple tiny raised oedematous areas with petichae. Karki *et al.* (2012) from Nepal reported *Ostertagia* spp. infection in goats with a prevalence of 16.12 percent in summer. Raza *et al.* (2014) also reported its 2.4 percent prevalence in goats and described two spp. as *Ostertagia (Teladorsagia) circumcincta* and *O. ostertagi*. Blackie, (2014) described the species as *Ostertagia marshalli*.

Ostertagia (*Teladorsagia*) has been considered a major economic health hazard in sheep and goats in cool and moist climates and specially in Europe. Infection often referred more threatening, clinical and economic hazard when occurred concurrently with *Trichostrongylus* spp.

Nimatodirus

In last decade *Nimatodirus* spp. infection has been reported from Pakistan **(**Raza *et al.*, 2014), India (Lone *et al.*, 2012; Bihaqi *et al.*, 2017; Tramboo *et al.*, 2017), Iran (Naem and Gorgani, 2013), Iraq (Nasrullah *et al.*, 2014; Mohammedameen, 2016), Egypt (Sultan *et al.*, 2016), Ghana (Blackie, 2014).

Raza *et al.* (2014) reported the prevalence of *Nimatodirus* sp. in goats (1.4%) and sheep (0.8%) from Pakistan. Sultan *et al.* (2016) described prevalence of *Nimatodirus* as 0.45 percent from Egypt on the basis faecal egg examination. Lone *et al.* (2012) reported *Nimatodirus* infection in slaughtered goats and sheep from J & K state of India. They reported a prevalence of 32.60 and 27.40 percent in goats and sheep respectively. Bihaqi *et al.*, 2017 and Tramboo *et al.* (2017) reported relative prevalence in sheep and goats respectively as 68.3 and 55.75 percent. Naem and Gorgani, (2013) and Mohammedameen, (2016) reported *Nimatodirus* infection prevalence in sheep as 14 and 16 percent from Iran and Iraq respectively. Nasrullah *et al.* (2014), from Iraq, reported *Nimatodirus spathiger* infection as major problem in goats with relative prevalence of 38.7 percent, the highest among gastrointestinal parasitic infections. Blackie, (2014) reported *Nimatodirus filicollis* presence in Ghana in sheep.

Chabertia spp.

This worm is also known as large mouth bowel worm and its infection is more rampant in temperate climate. However, it has often been reported from tropical region also. The prevalence of *Chabertia* described by different worker in sheep and goats was varied. In sheep, the reported prevalence was 4.2-17.4 percent from Ethiopia (Ibrahim *et al.*, 2014), 0.6 percent from Egypt (Khalafalla *et al.*, 2011), 24.0 percent from India (Lone *et al.*, 2012), 2.0 percent from Iran (Naem and Gorgani, 2013), 1.25 percent from Iraq (Mohammedameen, 2016). However, the prevalence in goats ranged between 8.2 – 25 percent (Amadi *et al.*, 2012; Ibrahim *et al.*, 2014; Nasrullah *et al.*, 2014; Owhoeli *et al.*, 2014; Bihaqi *et al.*, 2017). In India, there were reports from Jammu and Kashmir regions describing the prevalence (Lone *et al.*, 2012; Mir *et al.*, 2013; Bihaqi *et al.*, 2017; Tramboo *et al.*, 2017). Lone *et al.* (2012) and Mir *et al.*, (2013) reported *Chabertia* infection from sheep and goats (4.57-28.0 percent). Karki *et al.* (2012) reported prevalence of *Chabertia* in goats from Nepal as high as 33.7 percent. Raja *et al.* (2014) from Pakistan reported prevalence in 0.4 percent in sheep and 0.6 percent in goats. Ibrahim *et al.* (2014) reported significantly higher prevalence of *Chabertia* infection more in young than adult small ruminants. Blackie, (2014) reported its presence in sheep and goats from Ghana and considered it a pathogen in these species in winter rainfall areas.

Oesophagostomum spp.

The infection of *Oesophagostomum* spp. in sheep and goats have been reported from Bangladesh (Nath *et al.*, 2011), Sudan (Almalaik *et al.*, 2008), India (Swarnkar and Singh, 2012; Singh *et al.*, 2013; Singh *et al.*, 2015; Brahma *et al.*, 2015), Ethiopia (Sissay *et al.*, 2007; Asaolu et al 2012; Ibrahim *et al.*, 2014), Ghana (Blackie, 2014), Nepal (Karki *et al.*, 2012), Pakistan (Raza *et al.*, 2014)

The prevalence of infection of *Oesophagostomum* from different parts ranged from as low as 2.2 percent to as high as 62.7 percent in sheep (Almalaik *et al.*, 2008; Lone *et al.*, 2012; Swarnkar and Singh, 2012) and 9.9 percent to 92 percent in goats (Almalaik *et al.*, 2008; Nath *et al.*, 2011; Karki *et al.*, 2012; Brahma *et al.*, 2015). Asaolu *et al.*, (2012) described *Oesophagostomum* spp. as commonest worm of large intestine. Brahma *et al.*, (2015) from West Bengal, India reported it the predominant infection in goats after *Haemonchus* sp. As concluded through coproculture examination. Bandhyopadhyay *et al.*, (2010) described its two spp. infecting goats in India as *O. columbianum* and *O. venulosum*. Raza *et al.*, (2014) described two spp. of this nematode in sheep and goats as *O. columbianum* and *O. radiatum* using keys given by MAFF, (1979).

Nath *et al.* (2011) reported highest occurrence of *Oesophagostomum* spp. in winter (100%) from Bangladesh on examination of viscera. Almalaik *et al.*, (2008) from Sudan reported least during dry season which increase gradually in rainy season. They observed positive correlation between worm burden and climatic factors like rainfall and humidity. Swarnkar and Singh, (2012), however, described highest *Oesophagostomum* spp. larvae occurrence in sheep faecal culture in February in stationary and in March in migratory flocks.

Nath *et al.* (2011) reported hard, raised, slightly yellowish to green colored nodules in large intestine of goats in *Oesophagostomum* spp. infection. Blackie (2014) from Ghana described that heavy burden of worms in small ruminants cause nodular colitis i.e. pimply gut which results in diarrhea and loss of condition. Jas *et al.*, (2010) through an experimental study in Black Bengal goats reported significant decrease in haemoglobin, packed cell volume, total erythrocytes and leukocytes counts in experimental *O. columbianum* infection. They also described hyperglobulin aemia and hypoprotein aemia in infected goats along with significant decrease in serum iron specially on 70 DPI.

Cooperia sp.

In last decade prevalence of *Cooperia* spp. infection in small ruminants has been reported from Pakistan (Raza *et al.*, 2014), Iran (Naem and Gorgani, 2013), Nigeria (Amadi, et. al., 2012), Ghana (Blackie, 2014), Botswana (Sharma and Busang, 2013). Amadi *et al.*, (2012) reported its prevalence in African dwarf goats from Nigeria as 1.8 percent. Raza *et al.*, (2014) described *Cooperia* infection in sheep from Pakistan and reported prevalence as high as 0.2 percent. Almalaik *et al.* (2008) from Sudan reported its prevalence as 3.1 and 0.1 percent respectively in sheep and goats post-mortem study. They described the species as *Cooperia pectinata.*

Marshallagia marshalli

In last decade the infection of *Marshallagia marshalli* was recorded from Algeria (Meradi *et al.*, 2011), Iran (Naem and Gorgani, 2011; Moradpour *et al.*, 2014) and Iraq (Al-Bayati and Arsalan, 2009; Nasrullah *et al.*, 2014; Mohammedameen, 2016).

Meradi *et al.* (2011) reported prevalence of this nematode parasite in small ruminants ranging 21 to 81 percent in Algeria and established significant linear regression between prevalence of *Marshallagia marshalli* and rainfall. They reported association of low rainfall to higher *M marshalli* prevalence. Naem and Gorgani, (2011) from Iran reported the parasite prevalence as high as 38 percent in sheep from slaughter house. There had been several reports from Iraq describing the infection in sheep and goats (Al-Bayati and Arsalan, 2009; Nasrullah *et al.*, 2014; Mohammedameen, 2016). Al-Bayati and Arsalan, (2009) reported *Marshallagia marshalli* highest among prevalent parasitic infection (62.9%) in Iraq (Mohammedameen, 2016). Nasrullah *et al.* (2014) reported the 33 percent relative prevalence of *M. marshalli*, the second largest after *Nimatodirus spathiger*, among gastrointestinal parasite infections in Sulaimani provice of Iraq. Moradpour *et al.*, (2013) described pathophysiological changes in experimental *M. marshalli* infection in lambs as reduced acidity of abomasal contents, increased abomasal pH and increased serum pepsinogen concentrations with histological change as mucosal cell hyperplasia, loss of parietal cells and inflammatory cells infiltration.

Hookworms

Bunostomum spp.

Bunostomum spp. infection in sheep and goats is common in Afro-asian region (Ibrahim *et al.*, 2014; Karki *et al.*, 2012; Amadi *et al.*, 2012; Raza *et al.*, 2014; Aragaw and Gebreegziabher, 2014; Brahma *et al.*, 2015; Sangma *et al.*, 2012; Naem and Gorgani, 2013). Prevalence of Bunostomum sp. (Hookworm) infection varied from 2.0-77.5 percent in sheep (Naem and Gorgani, 2013; Ibrahim *et al.*, 2014; Aragaw and Gebreegziabher, 2014; Mohammedameen, 2016) to 3.2-38 percent in goats (Karki *et al.*, 2012; Ibrahim *et al.*, 2014; Aragaw and Gebreegziabher, 2014; Nasrullah *et al.,* 2014). Amadi *et al.* (2012) from Nigeria reported *Bunostomum* spp. infection in African dwarf goats as high as 12.6 percent based on faecal examination. In India *Bunostomum* sp infection in sheep and goats has been reported from different places (Bandhyopadhyay *et al.*, 2010; Khajuria *et al.*, 2013) with varying prevalence. Raja *et al.*, (2014) from Pakistan reported prevalence in 1.4 percent in sheep and goats. Sangma *et al.* (2012) reported its prevalence as 19 percent in sheep from Bangladesh.

Another hookworm, *Gaigeria pachyscelis* has also been described in sheep and goat during last decade (Almalaik *et al*., 2008; Asrani *et al.*, 2011; Blackie, 2014). Almalaik *et al.* (2008) reported its prevalence (1percent) in Goats in Sudan. Asrani *et al.* (2011) reported *Gaigeria pachyscelis* infection in duodenum, jejunum and ileum in migratory sheep and goats' flock from Himachal state of India in mixed parasites outbreak. Bandhyopadhyay *et al.* (2010) reported its infection in goats from Shillong, Meghalaya.

Camelostrongylus spp.

It is nematode parasite of camel's abomasum. However, it has been reported from sheep (Naem and Gorgani, 2011) and goats also. Mayo *et al.* (2013) described goat and sheep infection of this nematode from Iberian Peninsula and Spain respectively. Mao *et al.* (2013) explained *Camelostrongylus* presence in sheep based on phylogenetic and specific relationship between parasite and its ancient host.

Gongylonema pulchrum

It is also known as tailor worm of oesophagus. *G. pulchrum* is parasite common in cattle. However, it has been reported in sheep as well as in goats from Iraq (Naem and Gorgani, 2011; Al- Bayati *et al.*, 2009), Algeria (Papini *et al.*, 2013). In Algeria 15% of goats and 5.5% of sheep examined were found positive for Gongylonemiasis (Papini *et al.*, 2013). Papini *et al.* (2013) also discussed the zoonotic aspect of *Gongylonema* infection.

Strongyloides spp.

The Strongyloidosis is common infection in small ruminants. It has been reported worldwide i.e. Korea (Gebeyehu *et al.*, 2013) Pakistan (Farooq *et al.*, 2012) Thailand (Sangvaranond *et al.*, 2010; Worasing *et al.*, 2011), Sudan (Almalaik *et al.*, 2008), India (Sutar *et al.*, 2010; Lone *et al.*, 2012; Singh *et al.*, 2013; Khajuria *et al.*, 2013; Varadharajan and Vijayalakshmi, 2015; Brahma *et al.*, 2015), Bangladesh (Rahman *et al.*, 2014; Hossain *et al.*, 2015), Malaysia(Tan *et al.*, 2017) Nigeria (Okoye *et al.*, 2013; Owhoeli *et al.*, 2014), Ethiopia (Ibrahim *et al.*, 2014), Ghana (Blackie 2014; Futagbi *et al.*, 2015), Zimbabwe (Zvinorova *et al.*, 2016)

The prevalence of *Strongyloides* spp. has been reported as high as 13.3 to 84.6 percent in goats in Nigeria (Okoye *et al.*, 2013; Owhoeli *et al.*, 2013), 23.5 percent in Korea (Gebeyehu *et al.*, 2013), 16.3-25.9 percent in Ethiopia (Ibrahim *et al.*, 2014), 3.55 percent in Egypt(Hassan *et al.*, 2019)up to 100 percent in Ghana (Futagbi *et al.*, 2015), 3.22-6.00 percent in Pakistan (Farooq *et al.*, 2012), 26.5 percent in Sudan (Almalaik *et al.,* 2008), 100 percent in Ghana (Futagbi 2015), 3.75-47 percent India (Sutar *et al.*, 2010; Lone *et al.*, 2012; Brahma *et al.*, 2015), 6-29 percent in Nepal (Karki *et al.*, 2012), 5.0-11.11 percent in Bangladesh (Rahman *et al.*, 2014; Hossain *et al.*, 2015), 7.26 percent in Thailand (Sangvaranond *et al.*, 2010).

Prevalence reported in sheep was 26.2 percent in Sudan (Almalaik *et al.*, 2008), 13.04-20.10 percent in Ethiopia (Ibrahim *et al.*, 2014). Almalaik *et al.* (2008) reported damage in intestinal mucosa in most of the infected sheep and goats by *Strongyloides* spp.

Trichuris spp.

The occurrence of *Trichuris* spp. in small ruminants has been reported from Bangladesh (Nath *et al.*, 2011; Hossain *et al.*, 2015), Sri Lanka (Kandasami *et al.* 2013), Pakistan (Farooq *et al.*, 2012; Raza *et al.*, 2014), Thailand (Worasing *et al.*, 2011), Sudan (Almalaik *et al.*, 2008), Korea (Gebeyehu *et al.*, 2013), India (Sutar *et al.*, 2010), Iran (Radfar *et al.*, 2011), Ghana (Blackie, 2014; Futagbi *et al.*, 2015), Zimbabwe (Zvinorova *et al.*, 2016), Ethiopia (Sissay *et al.*, 2007; Dagnachew *et al.*, 2011), Egypt (Khalafalla *et al.*, 2011),

Prevalence of *Trichuris* spp. infection described by various worker varied in range of 0.6- 68.6 in goats (Almalaik *et al.*, 2008; Kenyari *et al.*, 2009; Sutar *et al.*, 2010; Radfar *et al.*, 2011; Nath *et al.*, 2011; Gebeyehu, *et al.*, 2013; Hossain *et al.*, 2015; Futagbi *et al.*, 2015; Zvinorova *et al.*, 2016, Hassan *et al.,* 2019) and ranged 0.1- 47.8 percent in Sheep (Almalaik *et al.*, 2008; Dagnachew *et al.*, 2011; Kandasamy *et. al.*, 2013; Farooq *et al.*, 2012; Sultan *et al.*, 2016). Nath *et al.* (2011) from Bangladesh, however, reported higher prevalence rate in winter than in rainy season. Dagnachew *et al.* (2011) reported *Trichuris* prevalence significantly more in young animals compared to adults both in sheep and goats as well. Variations in prevalence due to sex and age as reported by Radfar *et al.* (2011) were non-significant but they suggested a definite seasonal sequence in the nematode burden and faecal egg counts in goats corresponding with the pattern of rain.

There were two species, *Trichuris globulosa* and *T. ovis* reported to infect goats and sheep (Sissay *et al.*, 2007; Almalaik *et al.*, 2008).

Nath *et al.* (2011) described the lesion caused by *Trichuris* spp. as catarrhal inflammation along with petechial haemorrhage on intestinal mucosa and proliferation of goblet cells.

Capillaria spp.

Infection of *Capillaria* spp. in goats was reported from Bangladesh (Rabbi *et al.*, 2011), Thailand (Jittapalapong *et al.*, 2012). However, the prevalence was scanty and as low as less than 2 percent.

Graphidiops spp.

Sultan *et al.* (2010) and Khalafalla *et al.* (2011) described *Graphidiops* spp. infection for the first time in sheep from Nile Delta, Egypt. Khalafalla *et al.* (2011) reported 2.9 percent abomasal prevalence of this nematode from slaughter sheep.

Parabronema skrjabini

The parasite is known to occur in abomasums of ruminants and characterized by the presence of large cuticular shields and cordons in cephalic region. Khalafalla *et al.* (2011) reported *P. skrjabini* infection in slaughtered sheep in Egypt and described that 2.9 percent of abomasums in slaughtered sheep in Egypt were infected with nematode.

Skrjabinema ovis

Almalaik *et al.* (2008) reported prevalence of *Skrjabinema ovis* prevalence in sheep and goats as 0.3 and 11.6 percent respectively. Naem and Gorgani, (2011) reported *Skrjabinema ovis* in sheep from Iran with a prevalence of 4 percent. Papini *et al.* (2013) reported the *Skrjabinema* sp. from South West Algeria in sheep and goats.

Gaps in Nematodes Research

Among nematodes, strongyle worms including hookworm infections were among most frequently reported nematode infections during review period. Stomach worms *Haemonchus* and *Trichostrongylus* spp. were most rampant and challenging pathogens in the region but *Ostertagia* (*Telodorsagia*), *Nimatodirus* spp. infection, specially in African continent, was not exception. *Marshallagia* spp. infection was observed distinctly distributed in some oriental and Middle East countries. Worms like *Trichuris, Chabertia* and *Oesophagostomum* spp. in caecum and colon and *Strongyloides* spp. in intestine were most reported and discussed. Besides these common and widely distributed nematodes some scarcely localized infections like *Camelostrongylus, Graphidiops, Parabronema* and *Skrjabinema* spp. have also been reported. However, their pathogenic potential or severity of infection remained un-discussed. Similarly, nematode like *Cooperia, Nimatodirus* also could not get their due attention. This can be attributed to their minimal economic value, scarce presence in specific geographical region and low intensity of infection. But as they are present as concurrent infection with other known pathogenic nematode parasites, the gravity of their infection could have been masked and overlooked in the shadow of serious pathogen. It is emphasized that pathogenic aspect of these lesser known nematodes should be explored with host-parasite interaction study. There is considerable scope to work and improve the forecasting and also the measurements of helminthes response to climate change. Modern molecular methods, both quantitative and qualitative, have not still been adapted for rapid estimation of level of parasitic challenges as they can be helpful to fight against worms. The work on female worm fecundity would help to overcome the frequent infection by improving the pasture conditions. Further there is need to study them for immunological reaction invoked by them if any, to find out a common candidate potential antigen. Molecular epidemiology of these nematodes may further help to establish their phylogenic relationship if any in the course of evolution.

The strongyle worms and other nematode parasites of small ruminants are indeed a huge economic problem affecting the livestock productivity. Despite the use of anthelmintics, there lies a dangerous anthelmintics resistance (AR) development (Kaushik *et al.*, 2016) that haywires the effectiveness of parasite control strategies. The need of the hour is to overcome the AR by identifying the markers in the parasites that differentiates the sensitive and resistance worm population. This can be an excellent domain to work on. Similarly interference in female worm fecundity could contribute to helminthic control. In hypobiosis, factors governing inhibition length and time of emergence of arrested larvae are still undisclosed or poorly understood specially biochemical intricacy involved. Over-the-top molecular techniques like NGS based transcriptomics or metagenomics can zero-in to the parasite-linked marker gene affecting the host susceptibility and (HS as well as contributing to AR. It can also be useful in unraveling the mechanism behind emergence of arrested larvae. If we can address the twin problems of HS and AR, then there is a huge possibility to contain the nematode menace.

CONCLUSION

Gastrointestinal helminthic infections in sheep and goats remained serious threats for their production as seen by various study conducted in last decade also. Though some infections like fasciolosis, amphisotomosis, haemonchosis, trichostrongylosis, oesophagostomosis were well known, quite discussed and studied in past, the other disease like cestodosis, schistosomosis and trichuriosis, gongylonemiasis could not get due attention either due to their low pathogenicity or more of zoonotic value. Further, infection like *Graphidiops, Skrjebinema, Camelostrongylus* and *Parabronema* in sheep and goats still remained almost as puzzle as nothing sort of their life cycle, economic importance and pathogenicity could get attention. Authors feels that these lesser known parasites need to be studied in the light of concurrent infection and their phylogenetic relationship with other similar parasites including the host-parasite relationship. Various molecular tools available these days can help to unravel the undisclosed part of epidemiology of these infections which may be helpful to control these infections.

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