A Review of the Epidemiology of Gastrointestinal Nematode Infections in Sheep and Goats in Ghana

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Abstract

In this paper, 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. Seasonal changes in the level of infective strongylate nematode larvae on pasture in the different agro-ecological zones of Ghana are reviewed. The number of infective larvae on pasture is reported to be directly related to the pattern of rainfall. Consequently, rainfall could be relied on to predict the rate of transmission of infection in grazing animals. Finally, the relevance of epidemiological knowledge in the development of efficient measures for controlling gastrointestinal nematode infections in sheep and goats in Ghana is discussed.

Keywords: gastrointestinal nematodes, small ruminants, epidemiology, agro-ecological zone, host factors, Ghana

1. Introduction

Helminth infections remain one of the most important diseases limiting small ruminant production in tropical Africa (FAO, 1992). About 95% of sheep and goats are reported to be infected with helminths with *Haemonchus* and *Trichostrongylus* being the key species involved (Rey, 1991). Production losses through mortality and reduced weight gain have been reported by several authors (Oduro, 1972; Schillhorn van Veen, 1973; Allonby & Urquhart 1975; Fabiyi, 1987; Bekele et al., 1992; Nwafor, 2004). Strongyle nematodes are the main cause of parasitic gastroenteritis (PGE) in sheep and goats in Ghana (Agyei & Amponsah, 2001). The epidemiology and pathogenesis of many strongyle infections of grazing animals are very similar. Sheep and goats are infected by ingesting infective larvae (L3), which develops to L4 and adult stages in the gastric or intestinal mucosa (Demeler, 2005; Roeber et al., 2013). Disease is caused by the L4 and/or adult stages and depends on factors including: species of nematode infecting the host; intensity of the infection; species, age and immunological/ health status of the host; host response against the parasite; environment and management aspects (Assoku, 1981; Kassai, 1999; Taylor et al., 2007; Roeber et al., 2013). The prepatent period is normally 2-3 weeks, although it may be more than 6 months for certain species or if development is "arrested" (Michel, 1974; Eysker, 1993). Rainfall is considered to be the main climatic factor determining the availability of infective strongylid larvae and the transmission of infection in grazing animals (Chiejina et al., 1989; Fakae, 1990; Agyei & Amponsah, 2001; Agyei, 2003; Agyei et al., 2005). This paper reviews the epidemiological knowledge of gastrointestinal (GI) nematode infections in sheep and goats in the different agro-ecological zones of Ghana with the view to providing adequate information for developing strategic control measures against GI nematode infections in small ruminant in Ghana.

2. Species of Nematodes Found in the Gastrointestinal Tract of Sheep and Goat in Ghana

GI nematode infections in Ghana have been reported by several authors (Beal, 1929; Edwards & Wilson, 1958; Jackson, 1965; Dolu, 1972; Naate, 1973; Oppong, 1973; Assoku, 1981; Agyei, 1997, 2003; Agyei & Amponsah, 2001). PGE in sheep and goats is caused by mixed infections of several nematode species. Twelve GI nematodes species belonging to six families have been reported to infect sheep and goats in Ghana (Table 1). The most prevalent genera of GI nematodes reported in order of prevalence are: *Haemonchus, Trichostronglyus. Oesophagostomum and Cooperia* (Agyei & Amponsah, 2001). The life cycles of these nematodes follow a similar pattern, with some exceptions (e.g., *Nematodirus* spp., for which larval development occurs within the egg)

(Figure 1) (Levine, 1968). Adult worms in the digestive tract produce eggs that are passed in the faeces on to pasture. The reproductive potential of different gastrointestinal nematode species varies quite significantly. Females of *Haemonchus contortus* may lay over 10,000 eggs a day whilst *Oesophagostomum* and *Charbetia* produce between 5000-1000 eggs/female/day. Females of *Teladorsagia* and *Trichostrongylus* spp. are less fecund with an average egg production of 100-200 eggs per female per day (Hanson & Perry, 1994). Under favourable conditions, the eggs will hatch into first and second stage larvae and feed on bacteria in the faeces until finally the infective stage L3 is reached. First, second and third-stage larvae (L1, L2 and L3, respectively) are free-living in the environment. The fourth larval (L4) and adult stages (dioecious) are parasitic in the gastrointestinal tract of the host (Demeler, 2005). The development to L3 is temperature dependent and may be as rapidly as 3 days under tropical conditions (Sani et al., 1995).
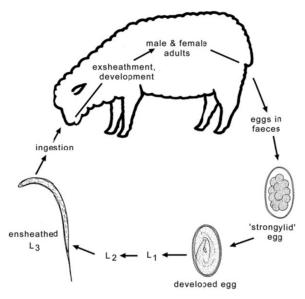

Figure 1. Life cycle representing gastrointestinal nematodes of small ruminants-Adapted from (Demeler, 2005)

Table 1. Gastrointestinal nematode species reported in sheep and goats in Ghana

Family*	Species**	Host species** affected	Location in the host*
Trichostrongylidae	*Haemonchus contortus*	Sheep and Goats	Abomasum
	Ostertagia circumcincta	Sheep and Goats	Abomasum
	Trichostrongylus axei	Sheep and Goats	Abomasum
	Trichostrongylus colubriformis	Sheep and Goats	Small intestine
	Cooperia curticei	Sheep and Goats	Small intestine
	*Ostertagia mashali*****	Sheep	Large intestine
Chabertiidae	*Chabertia ovina*	Sheep and Goats	Large intestine
	Oesophagostomum columbianum	Sheep and Goats	Large intestine
Strongyloididae	*Strongyloides papillosus*	Sheep and Goats	Small intestine
Ancylostomatidae	*Gaigeria pachyscelis*	Sheep and Goats	Small intestine
Molineidae	*Nematodirus filicolis*	Sheep	Small intestine
Trichuridae	*Trichuris ovis*	Sheep and Goats	Large intestine

Adapted from *Rahmann & Seip (2006); Roeber et al. (2013); **Assoku (1981). **** Lichtenfels and Pilitt (1989) identified this *Mashallagia marshalli*.

Susceptible animals are infected by ingestion of the infective third stage larvae L3. Depending on species development to the adult stage occurs either in the abomasum or in the small intestine after two moults. For most species development to the adult stage takes between 2-3 weeks. Development may also be 'arrested' or 'inhibited' at a specific parasitic stage, usually the early fourth stage (EL4). In a number of species, but particularly in *Haemonchus* and *Teladorsagia*, it represents a seasonal phenomenon, enabling the parasite to survive unfavourable conditions such as winter or a dry season. However, inhibited development may also be associated with host resistance (Eysker, 1993).

3. Development and Survival of Free-Living Stages in the Environment

The development and survival of free-living stages of GI nematodes of small ruminants are influenced mainly by environmental temperature and humidity with the effects of pasture conditions playing a significant role (O'Connor et al., 2006). These researchers reported that early in the free-living phase, the developmental success of *Haemonchus contortus*, *Teladorsagia circumcincta* and *Trichostrongylus colubriformis* is limited by susceptibility to cold temperatures with *H. contortus* being most susceptible, followed by *T. colubriformis* and then *T. circumcincta*. They observed that the length of the development cycle is dependent largely on temperature, with development rate increasing at warmer temperatures. However, addition of moisture is generally required for development to proceed to the infective larval stage. *H. contortus* was found to be most susceptible to desiccation during the pre-infective stages. Once the infective stage is reached, the influences of temperature and moisture on survival are less important, resulting in considerable survival times under conditions lethal to pre-infective stages. However, hot, dry conditions can be lethal for infective larvae of all three species, while extreme cold is also lethal with significant species variation (O'Connor et al., 2006). On the contrary, Ostertagia, and Nematodirus have been reported to show a strong adaptation to low temperatures. Nematodirus larvae are able to survive to winter inside the egg shell (Manfredi, 2006). Larvae may be protected from desiccation for a time by the crust of the faecal pat in which they lie or by migrating into the soil. Many biological factors contribute to disperse the larvae on the pasture. Dung burying beetles, coprophagous beetles and earthworms can greatly reduce the larvae of some trichostrongylids on pasture as they contribute to the spread of the faecal material on the pasture and allow the larval death as a consequence of drying (Manfredi, 2006).

4. Factors Influencing Gastrointestinal Nematode Infection in Sheep and Goats

4.1 Climate

In the permanently humid and savanna zones of the tropics, rainfall is the major factor determining the availability and transmission of strongylid nematodes in sheep and goats on natural pastures (Okon & Enyenihi, 1975, 1977; Ogunsusi, 1979). Ghana is divided into six major agro-ecological zones (Table 2). The forest, transitional and coastal savanna zones, which lie in the southern parts of the country, are characterized by two rainy seasons falling from March-July and September - October, except for the forest zone where the minor rainy season extends to November, with a short dry season whilst the Guinea and Sudan savanna zones in the northern parts have one rainy season (May – Sept.) with a prolonged dry season. The mean monthly temperature over most parts of the country never falls below 25°C (Dickson & Benneh, 1988; Benneh et al., 1990).

The seasonal influence on GI nematode egg counts and on the availability of infective strongylate larvae (L3) on pastures has been reported in the various agro-ecological zones of Ghana. In the forest zone with annual rainfall above 2000 mm (Table 2), L3 are found on pasture throughout the year however the number varies month by month. The level of L3 starts to pick up at the beginning of the rains in March and reaches a peak in June (the peak of the rainy season), but declines in July until November. It rises again in December only to fall in January and fluctuates between February and April (Agyei & Amponsah, 2001). The presence of L3 on pasture throughout the year in the forest zones of Ghana reported by Agyei and Amponsah (2001) agrees with the observations by Hammond and Sewell (1991), who found that in the humid tropics where the annual rainfall is between 1000-2000mm with a short dry season the microclimate is always suitable for the development and survival of the infective larvae. The level of infective larvae on pasture in this zone therefore remains relatively constant throughout the year. The stocking rate in the forest zone is therefore an important factor in determining the level of challenge. Adult sheep and goats are capable of building up some resistance but young stock are very susceptible to gastrointestinal helminths (Assoku, 1981; Chiejina, 1986).

Similarly, in the coastal and the transitional savanna regions, the population of infective larvae on pastures increases to a maximum during the rainy season, which coincides with the peak in feacal egg counts (FECs). However, in the coastal savanna regions no infective larvae are found on pasture during parts of the dry season (January and February) (Agyei, 1997); and in the transitional savanna regions infective larvae are absent on pasture from November to February during the dry season (Agyei et al., 2005). The mean annual rainfall in the

coastal and transitional savanna zones is comparatively lower than that of the forest zone (Table 2) and it is obvious that in the former zones, lack of adequate moisture on pasture during some periods of the dry season prevents the development and translation of worm eggs into infective larvae (Sprent, 1946; Lee et al., 1960; Durie, 1962).

In the Guinea savanna regions with only one rainy season, fluctuating low levels of worm egg output in lambs and kids have been reported during the prolonged dry season from January to April and October to December. It has been found that worm eggs deposited during the prolonged dry season, in this climatic zone, do not develop to infective stage and development of new infections does not occur after the cessation of the rains early in October. However, transmission of infection continues until late in November due to the persistence of infective larvae on pastures. Pastures are free of infection from December to the start of the rains in May and hypobiosis (inhibited development of early fourth stage-EL4) is a means by which *Haemonchus* survives the dry season and re-infest pasture at the onset of the rains. Then as the rain progresses the climate become increasingly favourable for the free living stages (Ogunsusi, 1979; Agyei et al., 2005). Worm egg count starts to rise at the onset of the rains in May and reaches a peak in June but declines in July until September. It rises again in October and thereafter declines to low levels during the dry season (Agyei et al., 2005). It has been found that lambs and kids born during the dry season remain uninfected until the onset of the rains when the young animals become susceptible. However, if the nutrition of the young animals is good, they may withstand initial infection and develop some resistance (Hammond & Sewell, 1991).

The reports by Agyei (1997), Agyei and Amponsah (2001) and Agyei et al. (2005) indicate that significant positive relationship exists between the level of herbage infective larvae and rainfall. This relationship supports the view that rainfall could be used to predict the level of infective larvae on pasture. Grazing animals would therefore be more susceptible to worm infections during the rainy season. This knowledge is important in the development of strategic interventions for the control of nematode infection in sheep and goats in Ghana.

Table 2. Climates of the agro-ecological zones

Agro-ecological zone	Mean annual rainfall (mm)	Range (mm)	Major rainy season	Minor rainy season
Rain forest	2200	800-2800	March- July	Sept.-Nov.
Deciduous forest	1500	1200-1600	March- July	Sept.-Oct.
Transitional zone	1300	1100-1400	March- July	Sept -Oct.
Coastal savanna	800	600-1200	March- July	Sept.-Oct.
Guinea savanna	1000	800-1200	May - Sept	
Sudan savanna	1000		May - Sept	

Source: Adapted from data from the Meteorological Department, Legon, Accra, Ghana.

4.2 Management and Husbandry Practices

The prevalence of GI nematode infections in small ruminants are also influenced by management systems and husbandry practices (Assoku, 1981). The system of sheep and goat production in Ghana is mainly traditional except for a few modern systems mostly associated with government and research institutions. The traditional system is common in the rural areas with intense agricultural activity. Three feeding systems are found within the traditional system: Free range grazing; Stall feeding or zero grazing; and tethering. A common characteristic of these feeding systems is that the animals are kept under unhygienic conditions and depend mainly on forage from poor natural pastures with very little input of feed supplement with virtually no anthelmintic treatment (Ockling, 1987). Malnutrition, poor growth rate and heavy worm burden have been reported in sheep and goats kept under the traditional system of production in sub Saharan Africa (Kusiluka & Kambarag, 1996). Studies by Notifor et al. (2013) on the prevalence of gastrointestinal tract parasites in animals kept under different traditional management systems showed that prevalence were higher in tethered animals (88.7%) followed by free range grazing animals (60.9%). Animals confined in paddocks had the least prevalence (45.5%). It is recommended that control measures should make use of the variation in helminth prevalence and intensity among management systems and age groups to achieve a rational use of anthelmintics. In addition, grazing spot should be rotated to reduce the chances of ruminants being re-infected with contaminated pastures (Notifor et al., 2013).

In the modern system of small ruminant production, the animals are either stall fed or grazed on improved pastures often in combination with beef cattle and receive regular feed supplementation such as concentrates. In addition they receive regular anthelmintic treatment at the onset of the dry season or at the beginning of the rainy season (Ockling, 1987). Such strategic anthelmintic treatment has been shown to reduce worm burden and increase productivity in the modern system of production (Thomas & Bell, 1988; Agyei, 1991; Nwafor, 2004). It is also known that alternating sheep and cattle every sixth month has proved successful in controlling helminth infections in both species as worm burdens in the hosts and the level of pasture contamination were both reduced (Barger & Southcott, 1975).

Differences in the prevalence and intensity of GI nematode infections between the traditional and modern system of small ruminant production in Ghana has been demonstrated by Assoku (1981). His study showed that sheep 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 (Table 3). It is evident that routine prophylactic drenching at regular intervals with different anthelmintics has a significant lowering effect on the total worm burden.

Table 3. The Effect of the type of management/ husbandry practices on the mean worm-egg load in sheep

Animals	Mean Worm-Egg Load (EPG)	
	Extensive System (free range grazing) with irregular drenching schedules	Semi-Intensive System (Paddock grazing) with regular but routine drenching schedules
Lambs	9813* (96)	1612* (83)
Adults	763** (102)	335** (78)

Assoku (1981) Figures in brackets are the total number of animals examined in each group.

*- Differences are significant, **- at significant 1% (P<0.01).

4.3 Host Factors

Host factors such as age, breed, nutrition, physiological state and presence or absence of inter-current infections also influence the incidence rate and severity of infection with GI nematodes in sheep and goats (Assoku, 1981; Kusiluka & Kambarage, 1996). Kids and lambs are known to be more vulnerable compared to adults and worm burdens decrease with increasing age (Goldberg, 1952; Paver et al., 1955; Edwards & Wilson, 1958; Brunsdon, 1962; Assoku, 1981; Kusiluka & Kambarage, 1996). Clinical parasitic gastroenteritis has been reported in young animals whilst infections in mature animals are generally subclinical in nature (Chiejina, 1986). The lower prevalence in adults has been attributed to immunological maturity as the animals grow and the increase in acquired resistance due to repeated exposure (Chiejina, 1986). Some breeds of sheep and goats are known to be genetically resistant to gastrointestinal nematodes infections than others. For instance, in Ghana, the local breeds, the West African dwarf sheep and the West African Long-legged sheep have both been shown to be more resistant to *Haemonchus* than the non indigenous Nungua Black-head (NBH) sheep (Assoku, 1981). It has also been demonstrated that within breeds, some lambs are naturally more resistant to *T. colubriformis*, for instance, and have lower worm burdens and reduced production losses than those of normal susceptibility (Windson, 1990). This information is important in breeding programmes to reduce the use of anthelmintics.

Another host factor known to influence nematode infections in small ruminants is the periparturient egg rise- a temporary loss of naturally acquired immunity to gastrointestinal parasites that begins approximately two weeks before parturition and continues for up to eight weeks after (Schoenian, 2012). During the period the females are readily infected and existing worm burdens become more active resulting in a sudden increase in worm eggs passed in the faeces and an increase in infectious L3 larvae on the pasture during late pregnancy and lactation. Lambs and kids are very susceptible to worms and thus particularly at risk (Hunter, 1996; Schoenian, 2012). It has been documented that increasing the protein level of the diet near kidding or lambing could significantly contribute to alleviate the increase in faecal egg excretion usually observed in ewes and does around the end of gestation and start of lactation (Etter et al., 1999; Hoste et al., 2005). The periparturient egg rise is believed to be the result of

various nutritional and hormonal factors and its intensity and distribution varies by breed, individual and season (Schoenian, 2012)

Generally poor nutrition decreases the resistance of sheep and goats thus improving the establishment of worm burdens and increasing the pathogenicity of the parasites. Therefore, worm burdens tend to be higher in poorly- fed animals than in well-fed animals. Malnutrition during the dry season has been found to lower the resistance of goats and sheep to *H. contortus* infections resulting in heavy mortalities while restricted feeding due to tethering during the rainy season has been associated with higher nematode burdens and mortality of goats in some parts of sub-Saharan Africa. Health status of the host and other stress factors also enhance the establishment of higher worm burdens (Kassai, 1999; Taylor et al., 2007).

5. Impact on Production

The pathological features of gastrointestinal nematode infections vary. Most of the nematodes however are capable of producing diarrhoea and loss of condition when present in sufficient numbers (Anderson et al., 1965; Blood et al., 1979) and some species such as *Haemonchus contortus*, are blood suckers and cause anaemia (Urquhart et al., 1996). The clinical signs of the most important gastrointestinal nematodes of ruminants are shown in Table 4. Clinical signs depend on a number of factors such as nutritional status of the animal, the level of infection and the species of helminths (Hunter, 1996).

The most noticeable effect of helminth infections in small ruminants in tropical Africa is death of the host (Wanyangu et al., 1994). Mortality rates may exceed 40% whilst weight loss of 0.6-1.2/year/animal may occur (IEMVT, 1980). Subclinical and chronic conditions resulting from reduced feed intake and decreased feed utilization efficiency are believed to be the major economic losses caused by helminth infections (Holmes, 1993).

Table 4. Gastrointestinal nematodes of ruminants

Stomach worms	
Haemonchus spp.	Blood sucking worms that can cause anaemia and weight loss; very important in areas that are permanently warm and humid or have prolonged warm rainy season.
Ostertagia spp.	Causes gastritis, diarrhoea and weight loss; important in sub-tropical climates with winter rainfall.
Trichostronglyus axei	Similar but lesser effect to *Ostertagia* spp
Worms of the small intestines *Trichostronglyus spp* *Cooperia spp* *Nematodirus spp*	Heavy burdens cause enteritis, loss of condition, diarrhoea, and loss of appetite; Trichostronglyus and Cooperia spp. can be important in tropical and sub-tropical areas; Nematodirus only a problem in temperate climates, e.g. tropical highlands
Hookworms *Bunostomum spp.* *Gaigeriapachyscelis* *Agriotomumvryburgi*	Blood sucking hookworms which can cause anaemia, diarrhoea and loss of condition; G. pachyscelis found only in sheep and goats in the tropics and sub-tropics; A. vryburgioccurs in cattle and buffaloes in Asia and South America
Worms of the large intestines *Chabertia ovina*	Heavy burdens cause haemorrhagic colitis (inflammation of the large intestines) resulting *in* diarrhoea and anaemia; primarily a pathogen of sheep and goats in winter rainfall areas.
Oesophagostomum columbianum	Heavy worm burden cause nodular colitis (pimply gut) resulting in diarrhoea and loss of condition; found worldwide, especially in warm moist climates.

Adapted from Hunter, 1996.

Anthelmintic treatment is the most common way of controlling nematode infections in small ruminant particularly in institutional and commercial farms in Ghana. However, several countries have reported anthelmintic resistance, representing a limitation for sustainable small ruminant production (Domke et al., 2011). Improvements in the management systems and husbandry practices coupled with strategic deworming when conditions are most

favourable for larval development on pasture could be a more sustainable way of improving small ruminant production in Ghana.

6. Conclusion

Twelve nematode species belonging to six families have been reported to infect sheep and goats in Ghana. *Haemonchus, Trichostronglyus, Oesophagostomum* and *Cooperia* are the principal genera (Agyei & Amponsah, 2001). 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, breed, nutrition and health 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 gastrointestinal nematode infections in sheep and goats in the different agro-ecological zones and management systems in Ghana.

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