



## **Oesophagostomum and Other Strongylid Nematode Infections in Ruminants and Pigs in the Upper East Region of Ghana**

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### **Authors' contributions**

*This work was carried out in collaboration between all authors. Authors BWL and AMP conceived and designed the study, advised on its implementation and reviewed the manuscript. Author CAA carried out the field survey, laboratory processing and examination of samples and wrote the first draft and performed preliminary data analysis and literature searches. Author AMP also assisted in procuring partial funding from WOTRO. All authors read and approved the final manuscript.*

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### **ABSTRACT**

*Oesophagostomum* species are strongylid nematode parasites of monkeys, sheep, goats, pigs, cattle, camels and antelopes. Human infections were considered zoonotic. Studies in the north-eastern parts of Ghana suggested that the human infections might be common but focally distributed. Factors determining the focal distribution are not known. The relationship between the human and animal infections is also not known. It is also not known whether the animal infections are focal in distribution. In the present study, two communities known to be endemic to the human infection (Kulbia and Kologo) and two other communities known to be non-endemic to the human infection (Kalbiong and Gbeogo) in the Upper East Region (UER) of Ghana were selected. Prevalences and intensities of *Oesophagostomum* infection and other related strongylid nematode infections in ruminants and pigs were determined and compared. Faecal samples from cattle, sheep, goats and pigs were collected, processed by coproculture and examined under the microscope for larvae of the different strongylid nematodes. The results show no significant

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differences in prevalence of infection between the human endemic and human non endemic communities ( $P = 1.00$ ) during the rainy season and ( $P = .134$ ) in the dry season. However, there were significant differences in the intensity of infection between the two types of communities only during the dry season ( $P = .032$ ). Other strongylid nematodes observed were *Necator* sp., *Strongyloides* sp. and *Trichostongylus* sp.

**Keywords:** Communities; endemic; nematode; *Oesophagostomum* species; zoonoses.

## 1. INTRODUCTION

Evidence from earlier studies suggested that humans may be predisposed to heavy or light infection with a variety of helminthes [1]. Persons at greatest risk, according to Rosenfield et al. [2] are those who live in rural areas without toilets, and urban squatter settlements, where safe potable water supply is lacking, coupled with unsatisfactory waste disposal systems and inadequate housing. Studies in Latin America [3] indicate that intestinal parasites are prevalent in both rural and urban populations. Intestinal parasitic infections are encountered as occupational hazards by farmers and other workers whose job brings them into contact with soil, soil contaminated materials or contaminated water.

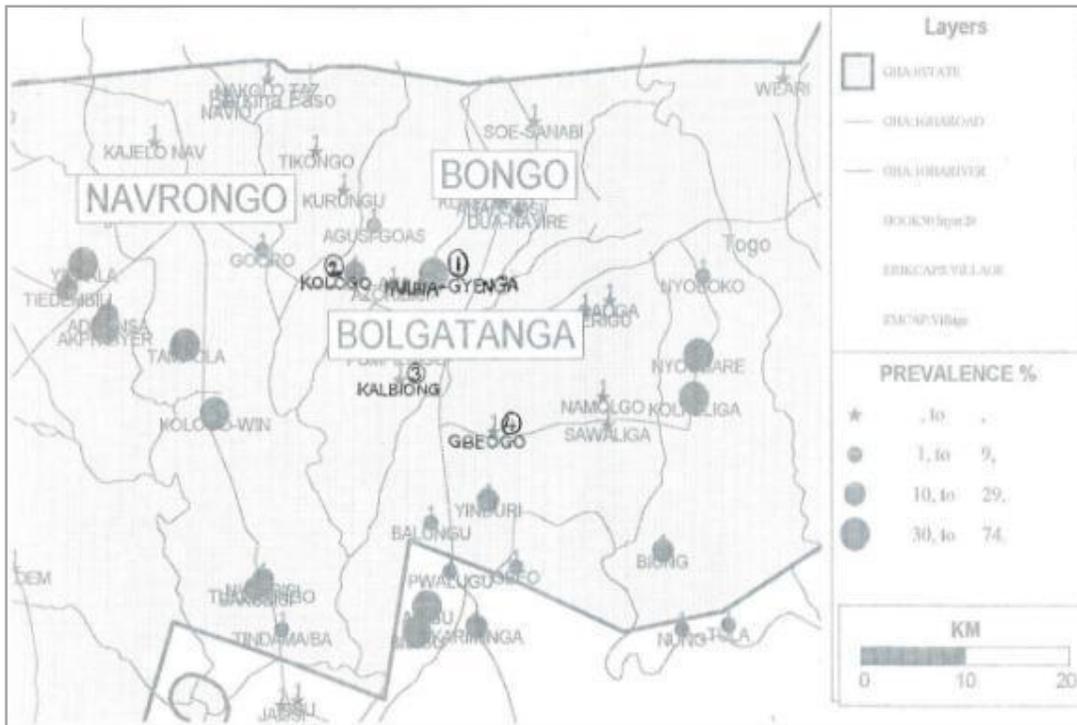
Wild animals do not suffer epizootics because of normal dispersal and territorialism of most species. Domesticated animals however, are usually confined to pastures or pens year after year thereby, infective stages of parasites become extremely dense in the soil of the pens. Some of these parasites are infective to man [4].

*Oesophagostomum* species are a type of strongylid nematodes usually parasitizing monkeys, pigs, sheep, goats, cattle, camels and antelopes. Human infections were, until recently, rare. According to Krepel et al. [5], the few reports in the literature include those from Brazil (1910); Nigeria (1911 & 1913); Guinea (1920); Indonesia (1949, 1989 & 1992); Ivory Coast (1958 & 1975); Uganda (1972) and Malaysia (1992). Later, however, there were increasing reports of human *Oesophagostomum* infection, focally distributed in the northeastern border area of Ghana with Togo [5-9]. Three species of *Oesophagostomum* have been recognised as causing occasional infections in humans. These are *O. aculeatum*, *O. bifurcum* and *O. stephanostomum*. Of these three, *O. bifurcum* is

the most commonly encountered species. Polderman et al. [8] demonstrated that man is a definitive host to *O. bifurcum* in these regions. Further studies of the human infection in parts of the northern region of Ghana [10,11] revealed prevalences ranging up to 87%.

*O. columbianum* is a serious pathogen of sheep, whilst *O. radiatum* and *O. dentatum* occur in the colon of cattle and pigs respectively [12]. Transmission is believed to occur by ingestion of infective third stage larvae ( $L_3$ ). Thus, poor hygienic conditions of communities could facilitate the transmission. It is, however, not yet clear which ecological and behavioural factors are key to the focality of the distribution and the high local prevalence of the infection. Nevertheless, the role of pigs as carriers of *O. bifurcum* and *Necator americanus* have been documented [13]. The relationship between human and animal infections is not well understood as different species are reported to infect man, ruminants and pigs. The extent of the infection in ruminants and pigs in communities endemic for the human infection is also not known.

Kulbia-gyenga (Kulbia) and Kologo (Fig. 1) are communities endemic for human oesophagostomiasis with prevalences of 74% and 29% respectively [14]. The people in these communities live in compounds separated by stretches of land that are used for farming in the rainy season. Most compounds keep livestock consisting of cattle, goats, sheep, and pigs. Some compounds keep in addition, donkeys, dogs and cats. The cattle, donkeys, goats and sheep are kept in kraals normally built near the entrance to the compounds. These animals are usually confined during the rainy season to prevent them from destroying crops but released to roam freely during the dry seasons. Guinea fowls, ducks and chicks are reared as poultry. The sources of drinking water are open wells and boreholes.



**Fig. 1. Geographical distribution of *Oesophagostomum* spp in northern Ghana**  
(Source: By courtesy of Yelifari L. 1999)

Kalbiong and Gbeogo (Fig. 1) are communities not endemic for human oesophagostomiasis. The people also live in compounds, which are separated by farmlands. The designs of the houses follow the same pattern as in Kulbia and Kologo and the same groups of animals are reared. The chiefs in these communities are however, educated whereas those in Kulbia and Kologo are not at the time of study. There are also community schools. The sources of drinking water are open wells and boreholes.

The present study therefore investigated prevalence and intensity of *Oesophagostomum* infection in ruminants and pigs in Kulbia and Kologo (two communities known to be endemic to human oesophagostomiasis) and Kalbiong and Gbeogo (two communities known to be non-endemic to human oesophagostomiasis) and the extent of related strongylid nematode infections in pigs and ruminants.

The specific objectives were to:

Determine the types of strongylid nematode parasites infecting pigs and ruminants, their

prevalence and intensity in the selected communities.

Determine the seasonality (rainy versus dry season) of the infections in the animals in the selected communities.

## 2. MATERIALS AND METHODS

### 2.1 Study Areas

The study was undertaken in four communities in the Upper East Region, ie Kulbia-gyenga (Kulbia), Kologo, Gbeogo, and Kalbiong. A compound in these communities consists of small circular, square or rectangular houses made of mud (Figs. 2 and 5). The houses are connected by walls enclosing a courtyard with kraals built near the entrance to the compounds (Figs. 3 and 6). Between two compounds are stretches of land that are used for farming. Cattle and donkeys are kept in separate enclosures within the kraal while sheep and goats are usually put together. The pigs, however, are kept in separate pigsties built near the compounds (Fig. 4). Photographs were taken with permission from the chiefs during visits to their compounds.



**Fig. 2. Kulbia-gyenga (chief's compound) showing stretch of land used for farming**



**Fig. 3. Kraal, built near entrance to chief's compound (Kulbia-gyenga)**

## **2.2 Collection and Culture of Stool Samples**

In the communities fresh stool samples were taken from the animals by inserting a finger into the vent of the animals. Approximately 3 grams of stool were collected into clean plastic containers with fitting lids and taken to the laboratory for culture. Each stool sample was cultured on the day of collection and two cultures were made from

each sample with approximately 2 grams of each stool using the coproculture method for the infective third stage larvae (L<sub>3</sub>). A total of 858 stool samples were collected, 73 samples from cattle, 374 samples from sheep, 334 samples from goats and 177 samples from pigs.

A plastic disc (40 mm x 4mm) was placed in the center of a petri-dish of 9 cm diameter with nipped lids (Fig. 7). A filter paper of 8 cm

diameter was placed on the plastic disc and approximately 2 ml distilled water was poured into the petri-dish to the level just below the top of the plastic disc. Two (2) grams of stool was mixed with an equal quantity of vermiculite. The mixture was divided into two equal parts and each part placed on the moist filter paper in a petri-dish. The stool-vermiculite mixture was left in culture for seven (7) days at room temperature and stirred every other day to prevent the growth of fungi.

Any maggots present in the stool cultures were removed. However, cultures heavily infested with maggots were discarded. Eggs present in the stool hatched into larvae, which leave the stool-vermiculate mixture for the clean water in the petri dish. On the eighth (8<sup>th</sup>) day, the fluid containing L<sub>3</sub> larvae from each culture was harvested into conical tubes. The petri-dishes were rinsed once with distilled water and added to the conical tubes.



**Fig. 4. Pigsty built near a compound**



**Fig. 5. Kalbiong (chief's compound) showing stretch of land used for farming**



Fig. 6. Kraal, built near entrance to chief's compound (Kalbiong)

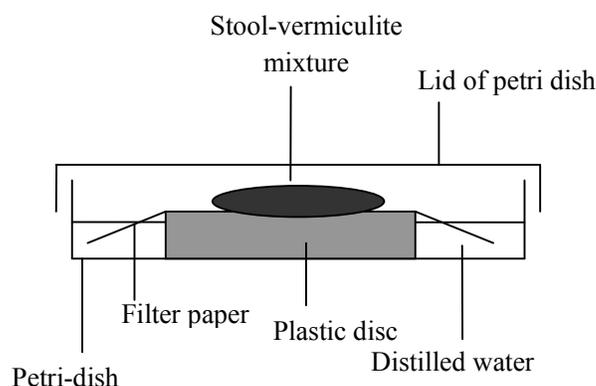


Fig. 7. Setup for coproculture

### 2.3 Examination and Identification of Larvae

A sedimentation time of at least two (2) hours was allowed for the larvae to settle and 100  $\mu$ l of sediment was pipetted unto a microscope slide. A drop of diluted Lugol's iodine was added to kill and stain the larvae. The sample was then covered with a cover slip and observed using the x10 and then x40 objectives of the light microscope. Two readings were made for each sample and the mean larval counts calculated. Photographs of larvae were taken at x100 and x400 and presented Plates 1-7.

Identification of larvae was based on the characteristic features as indicated by Little [15].

A typical larva of *Oesophagostomum* has a relatively thick sheath and shows pronounced transverse striations. It has a length of about 700-950  $\mu$ m and a long hair-like tail sheath tapering to a fine point. The intestinal cells appear triangular (Plate 1 and 2).

The larva of *Trichostrongylus* shows a relatively thick sheath which is thicker than the cuticle of the larva. The tip of the larva's tail is rounded or blunt with a short tail sheath (Plate 3).

The larva of *Strongyloides* lacks a cuticular sheath. It has a slender body with length of about 14-17  $\mu$ m. The tip of the tail appears notched and the oesophagus is about half the length of the body (Plates 4 and 5).

A hookworm larva has a thin sheath. The body is thicker than 20  $\mu\text{m}$  and the oesophagus is about  $\frac{1}{4}$  the length of the body (Plates 6 and 7).

### 3. STATISTICAL ANALYSIS

The data collected were entered into SPSS (windows) and the prevalence and intensity of infections computed. Prevalences of infection are given as the percentage of individuals infected with a parasite and the intensity of infection computed from mean larval counts in 100 $\mu\text{l}$  of

sediment of the culture fluid. Significant differences were determined at 5% level, using one-way ANOVA (LSD) after outliers were removed using the Pearson and Hartley, Biometric Tables for Statisticians [16].

### 4. RESULTS

A total of 858 stool samples were collected, 73 samples from cattle, 374 samples from sheep, 334 samples from goats and 177 samples from pigs.

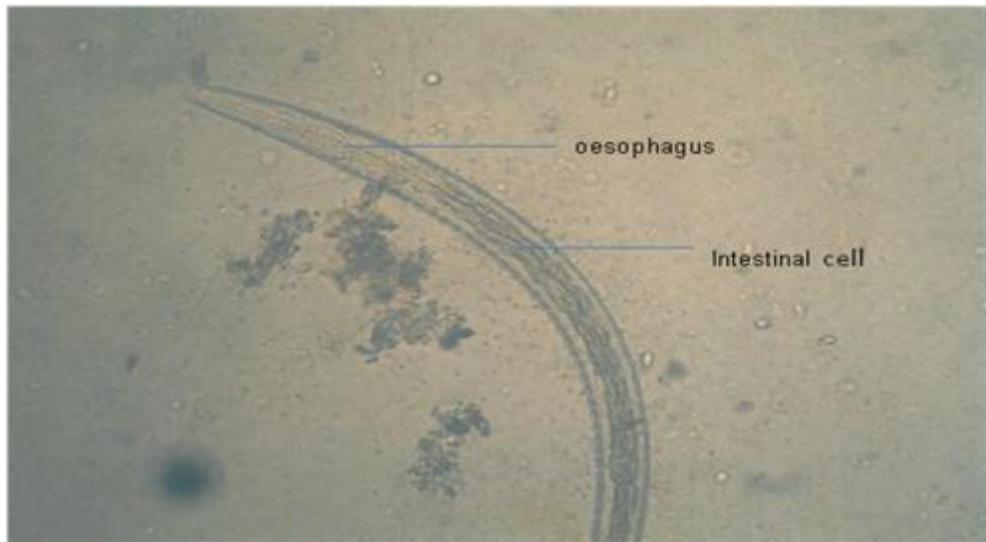


Plate 1. Anterior portion of *Oesophagostomum* larva (x100)



Plate 2. Posterior portion of *Oesophagostomum* larva showing whip-like tail sheath (x 400)



**Plate 3. Larva of *Trichostrongylus* showing relatively short tail sheath (x100)**



**Plate 4. Larva of *Strongyloides* (whole mount, x100)**

Four nematode species were identified in the animal samples collected. These were *Oesophagostomum* sp, *Necator* (hookworm), *Strongyloides* sp and *Trichostrongylus* sp. A comparison showed no significant differences in prevalences of infections between the endemic and non endemic communities both during the rainy ( $P = 1.$ ) and dry ( $P = .134$ ) seasons. Significant differences however, were observed in intensities of infection between the endemic and non endemic communities only in the dry season ( $P = .032$ ).

#### **4.1 Prevalence of *Oesophagostomum* Infections in Cattle, Sheep, Goats and Pigs in the Study Communities**

Fig. 8 represents prevalence of *Oesophagostomum* infection in cattle in the different study communities. Generally, prevalences were higher during the rainy/wet season with the endemic communities recording the highest.

*Oesophagostomum* infection in sheep (Fig. 9) were also generally higher during the rainy

season in the study communities except Kulbia (endemic) community where higher prevalences were observed during the dry season.

In Fig. 10, goats showed very high prevalences for *Oesophagostomum* infection in Kulbia and Kologo (63.3% and 60.0%) respectively in the rainy season. Prevalences were also higher in Gbeogo and Kalbiong during the rainy season. The highest prevalence in the dry season was

also in Kulbia (48.4%) followed by Kalbiong (36.4%).

The highest prevalence value for *Oesophagostomum* infection, observed during the study was recorded for pigs (74.1%) in Kalbiong (Fig. 11). During the dry season however, higher prevalence of *Oesophagostomum* infection was observed in Kologo.

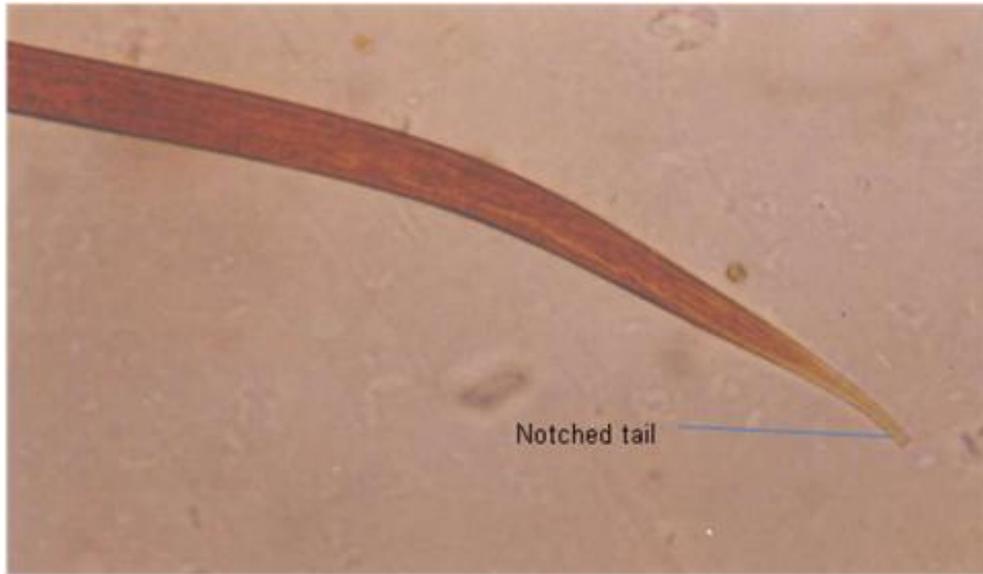


Plate 5. Posterior portion of *Strongyloides* larva showing notched-tail (x 400)

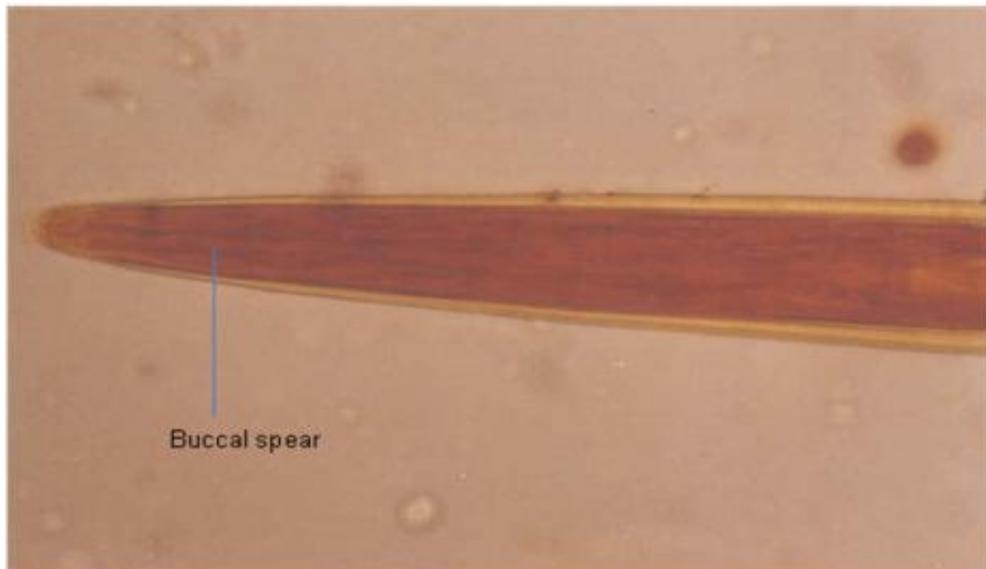


Plate 6. Anterior portion of hookworm larva showing buccal spear (x 400)



Plate 7. Posterior portion of hookworm larva (x 400)

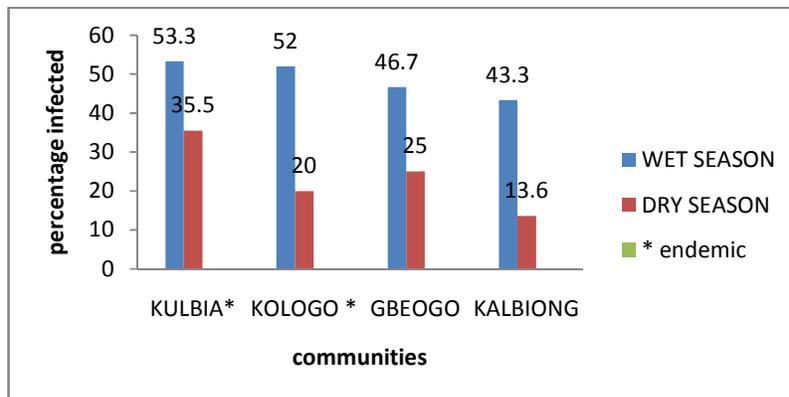


Fig. 8. Prevalence of *Oesophagostomum* infection in cattle

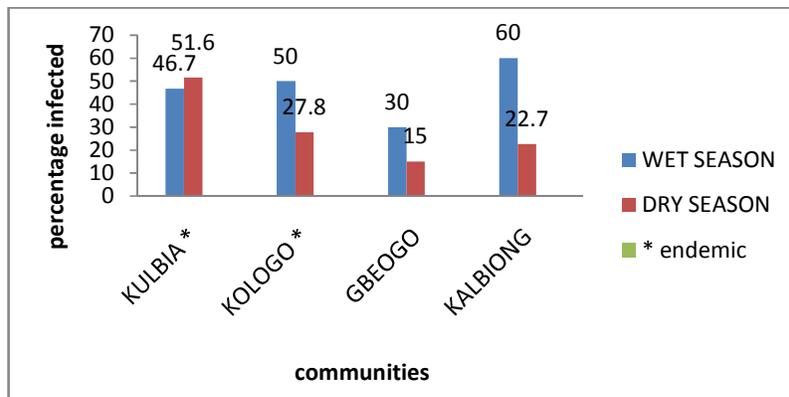


Fig. 9. Prevalence of *Oesophagostomum* infection in sheep

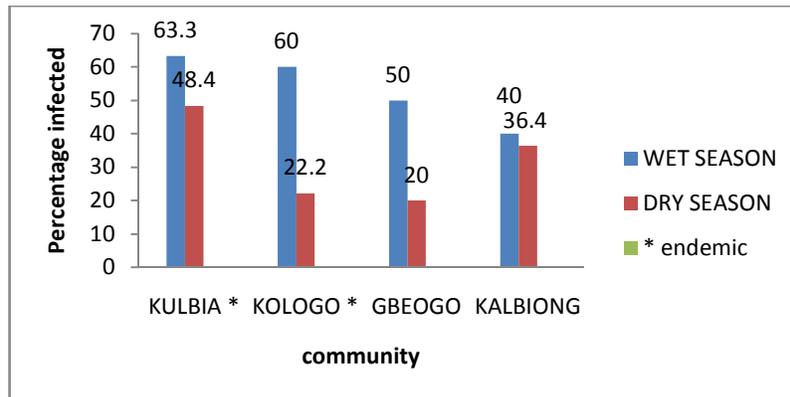


Fig. 10. Prevalence of *Oesophagostomum* infection in goats

#### 4.2 Prevalence of Hookworm Infection in Cattle, Sheep, Goats and Pigs in the Study Communities

Hookworm infections were recorded in all the animal hosts examined, but to different extents in the different study communities.

Cattle hookworm infections were recorded only during the rainy season in Kulbia (Table 1), whereas sheep hookworm infections were recorded during the rainy season in Kologo and Kalbiong. Goat hookworm infections were observed in Kulbia and Kologo and pig hookworm infections were observed in all the study communities.

#### 4.3 Prevalence of *Strongyloides* Infection in Ruminants and Pigs in the Study Communities

The prevalence data for *Strongyloides* spp. infection is presented in Figs. 12, 13, 14 and 15. Prevalences for *Strongyloides* infections in cattle (Fig. 12) were generally higher during the rainy season. Comparatively, higher prevalences were observed in Gbeogo during the rainy and dry seasons. No infection was observed during the dry season in Kalbiong.

In Kulbia, higher prevalences were observed during the dry season for *Strongyloides* infection in sheep. The rest of the communities showed lower prevalences during the dry season. The highest prevalence of *Strongyloides* in sheep was recorded in Kalbiong (Fig. 13).

Generally, low prevalences of *Strongyloides* infection were recorded for goats in the study communities. Prevalences were higher in the

rainy season except in Kologo (Fig.14) where prevalences observed were higher in the dry season.

*Strongyloides* infections in pigs showed higher prevalences in the rainy season (Fig. 15). Kologo and Gbeogo recording the lowest both during the rainy and dry seasons.

#### 4.4 Prevalence of *Trichostrongylus* Infection in Ruminants and Pigs in the Study Communities

In some instances prevalences were higher during the rainy season while in other cases the dry season recorded high prevalences. Details are given in Figs. 16, 17, 18 and 19.

*Trichostrongylus* infection in cattle was high during the dry season in Kulbia and during the rainy season in Kologo. Lower prevalences were recorded in the other communities both during the dry and rainy seasons (Fig.16).

*Trichostrongylus* infections in sheep were mostly higher in the dry season in the study communities. In Kalbiong very low prevalence (3.7%) were observed in the wet season (Fig. 17). Only in Gbeogo were higher prevalences recorded in the rainy season.

*Trichostrongylus* infections in goats were also higher in the rainy season with Gbeogo recording the highest (Fig. 18).

In the human *Oesophagostomum* endemic communities, prevalences of *Trichostrongylus* infections in pig were higher in the dry season. On the other hand, higher prevalences were recorded during the rainy season in the human non endemic communities (Fig. 19).

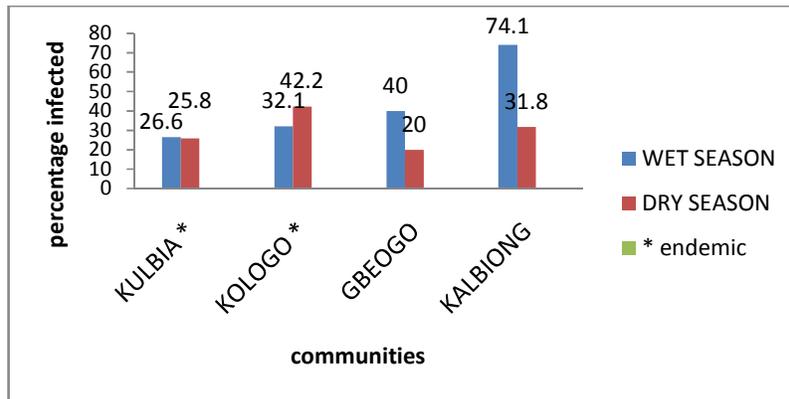


Fig. 11. Prevalence of *Oesophagostomum* infection in pigs

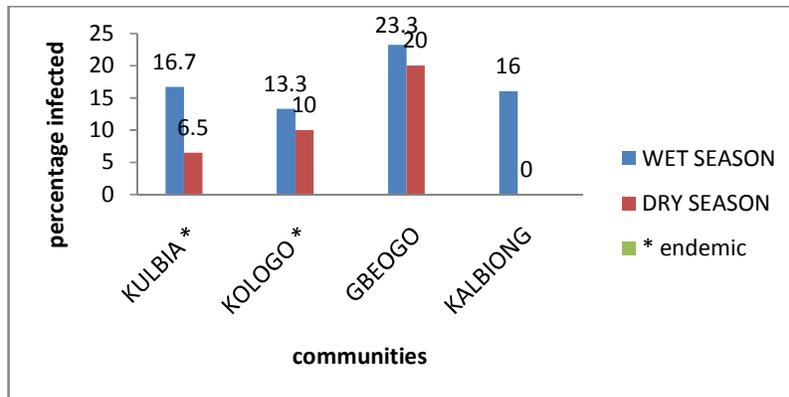


Fig. 12. Prevalence of *Strongyloides* in cattle

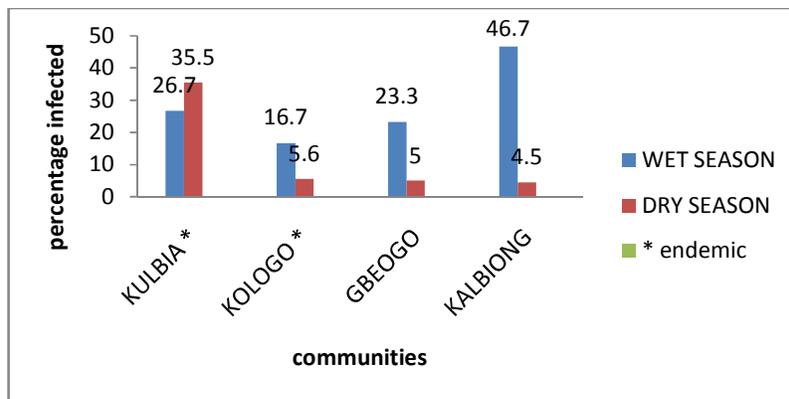


Fig. 13. Prevalence of *Strongyloides* in sheep

#### 4.5 Intensity of *Oesophagostomum* Infections in Ruminants and Pigs in the Study Communities

Intensities of infections are presented as the mean number of larvae in 100 µl culture fluid

sediment. Intensity of *Oesophagostomum* infections in the different animal hosts in the different study communities are presented in Figs. 20, 21, 22 and 23.

Fig. 20 presents intensity of *Oesophagostomum* infection in cattle, sheep, goats and pigs in

Kulbia (endemic community). Intensities were higher in the rainy season. Pigs recorded the highest in the rainy season and the lowest in the dry season. Significant differences were

observed only between cattle\* and pigs during the dry season ( $P = .05$ ), the level being higher in cattle than in the pigs.

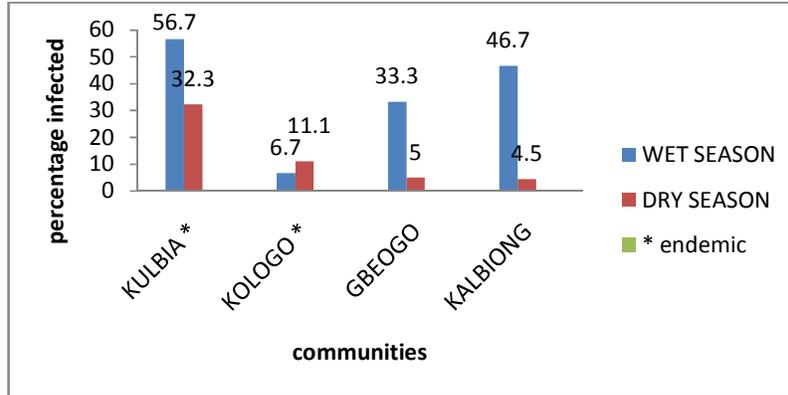


Fig. 14. Prevalence of *Strongyloides* infection in goats

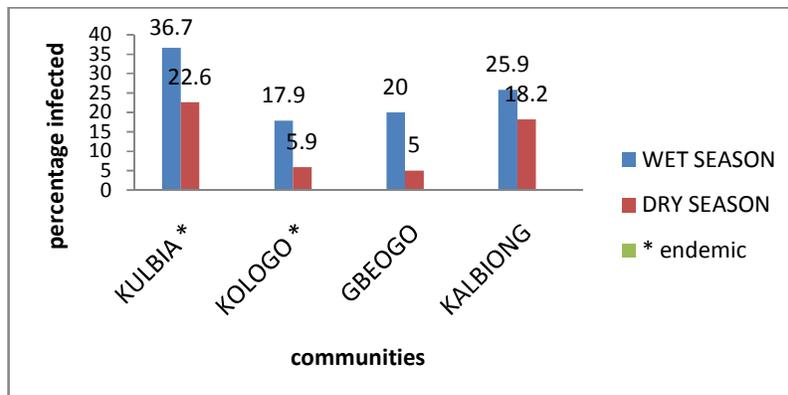


Fig. 15. Prevalence of *Strongyloides* infection in pigs

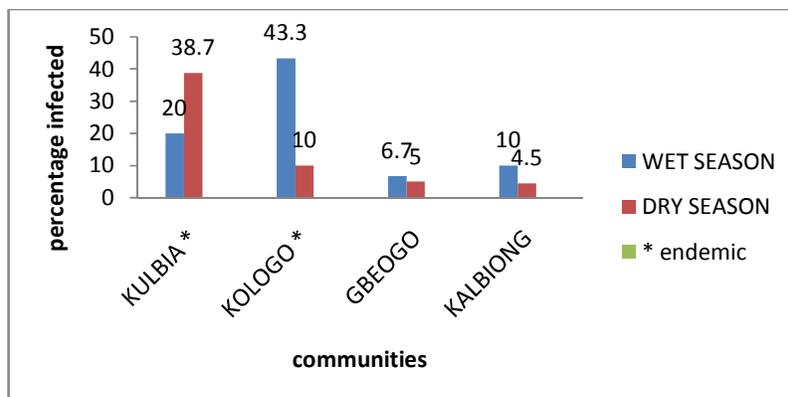


Fig. 16. Prevalence of *Trichostrongylus* infection in cattle

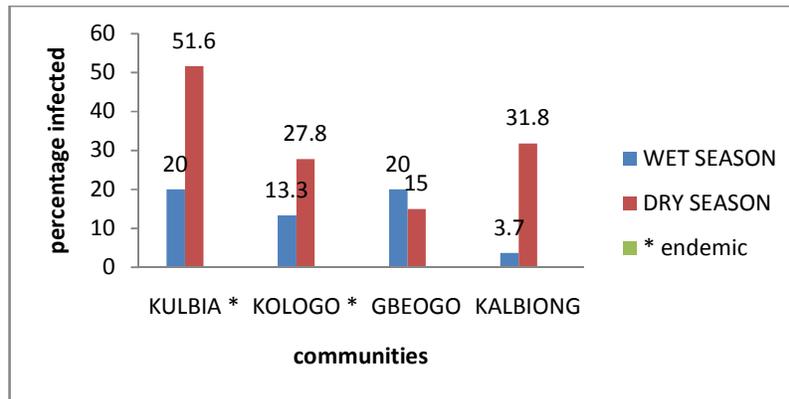


Fig. 17. Prevalence of *Trichostrongylus* infection in sheep

Table 1. Prevalence of hookworm infection in cattle, sheep, goats and pigs

Community	Animal host							
	Wet season				Dry season			
	Cattle	Sheep	Goat	Pig	Cattle	Sheep	Goat	Pig
Kulbia*	6.7	0.0	3.2	0.0	0.0	0.0	0.0	16.1
Kologo*	0.0	6.7	6.7	3.6	0.0	0.0	0.0	11.8
Gbeogo	0.0	0.0	0.0	10.0	0.0	0.0	0.0	15.0
Kalbiong	0.0	3.3	0.0	0.0	0.0	0.0	0.0	18.2

\* human *Oesophagostomum* endemic community

In Kologo, (Fig. 21) significant differences were observed in intensities of *Oesophagostomum* infections between goats\* and cattle ( $P = .016$ ) during the rainy season. Generally, intensities were higher in the rainy season. The highest intensity was observed in goats followed by sheep. The lowest was observed in cattle. In the dry season, cattle recorded the highest value and sheep the lowest value. Significant differences were also recorded in intensities of *Oesophagostomum* infections between goats and pigs\* ( $P = .016$ ) in the rainy season.

In Gbeogo, (community not endemic for human *Oesophagostomum* infection) intensities of *Oesophagostomum* infection showed cattle recording the lowest and pigs\* recording the highest in the rainy season with significant differences in intensities ( $P = .033$ ). During the dry season, sheep recorded the highest value and cattle the lowest value. However no significant difference was observed between them ( $P = .208$ ). Significant differences were however, observed between pigs\* and goats during the rainy season ( $P = .033$ ) Fig. 22.

Fig. 23 presents intensities of *Oesophagostomum* infection in the animals sampled in Kalbiong (a community not endemic

to human *Oesophagostomum* infections). Intensities were relatively higher in the rainy season. Significant differences were observed in infection between pigs\* and cattle both during the rainy ( $P = .017$ ) and dry ( $P = .018$ ) seasons.

#### 4.6 Intensity of Hookworm Infection in Ruminants and Pigs in the Study Communities

In Table 2 are intensities of hookworm infections recorded. The highest intensities recorded were for goats in Kulbia (51.4 larvae/100  $\mu$ l) during the rainy season. Significant differences were found in the dry season in Kologo (*Oesophagostomum* endemic community) between pigs\* and the other animal hosts, ie Pigs and cattle ( $P = .038$ ), Pigs and sheep ( $P = .043$ ), Pigs and goats ( $P = .040$ ) also in Kulbia, (*Oesophagostomum* endemic community) during the dry season, a  $P$  value of ( $P = .004$ ) was observed between pigs\* and the other animal hosts. In Gbeogo, (*Oesophagostomum* non endemic community) during the rainy season, a value of ( $P = .040$ ) was recorded between pigs\* and the other animal host whereas in the dry season, ( $P = .013$ ) was observed between pigs and the other animals. Also during the dry season,  $P = .013$

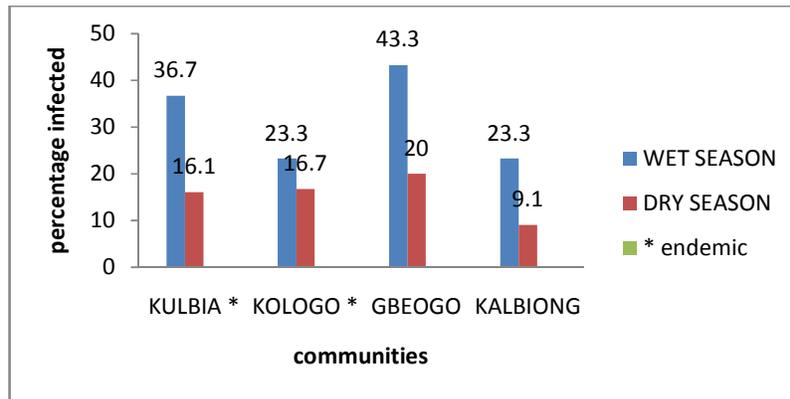


Fig. 18. Prevalence of *Trichostrongylus* infection in goats

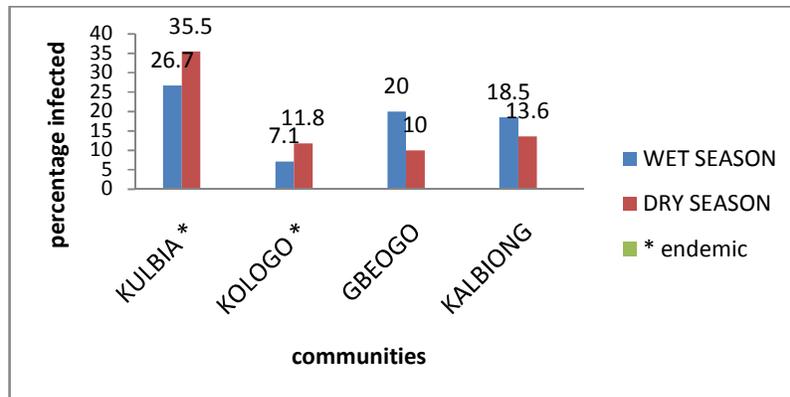


Fig. 19. Prevalence of *Trichostrongylus* infections in pigs

was recorded between pigs and the other animals in Kalbiong (*Oesophagostomum* non endemic community).

#### 4.7 Intensity of *Strongyloides* Infection in the Study Communities

In most cases the intensities were higher during the rainy season than in the dry season. High intensities were recorded for pigs in Kologo and Gbeogo. In Kologo however, goats showed a relatively high intensity (759.9 larvae/100  $\mu$ l of sample) while the other animal hosts showed comparatively, low intensities (Table 3). Significant differences in intensity of *Strongyloides* infection were recorded in goats\* and the other animal hosts in Kulbia during the rainy season ( $P = .000$  for goats and cattle;  $P = .001$  for goats and sheep and  $P = .003$  for goats and pigs). During the dry season, a difference of  $P = .042$  was observed between goats\* and cattle. Also during the rainy season, in Kalbiong, significant differences were observed between

goats and the other animal host at  $P = .004$  for goats\* and cattle,  $P = .010$  for goats\* and sheep and  $P = .007$  for goats\* and pigs.

#### 4.8 Intensity of *Trichostrongylus* Infection in Cattle, Sheep, Goats and Pigs

Generally, intensities of *Trichostrongylus* were higher during the rainy season. Fig. 24 shows intensity of *Trichostrongylus* infection in ruminants and pigs in Kulbia where significant differences were observed in intensities between goats\* and cattle ( $P = .014$ ), goats\* and sheep ( $P = .014$ ) as well as goats\* and pigs ( $P = .040$ ) in the rainy season. Significant difference was also observed between sheep\* and goats in the dry season ( $P = .046$ ).

In Kologo, sheep showed the highest intensity in the rainy season whereas pigs showed the highest in the dry season (Fig. 25). No significant difference was observed in *Trichostrongylus* infection in Kologo.

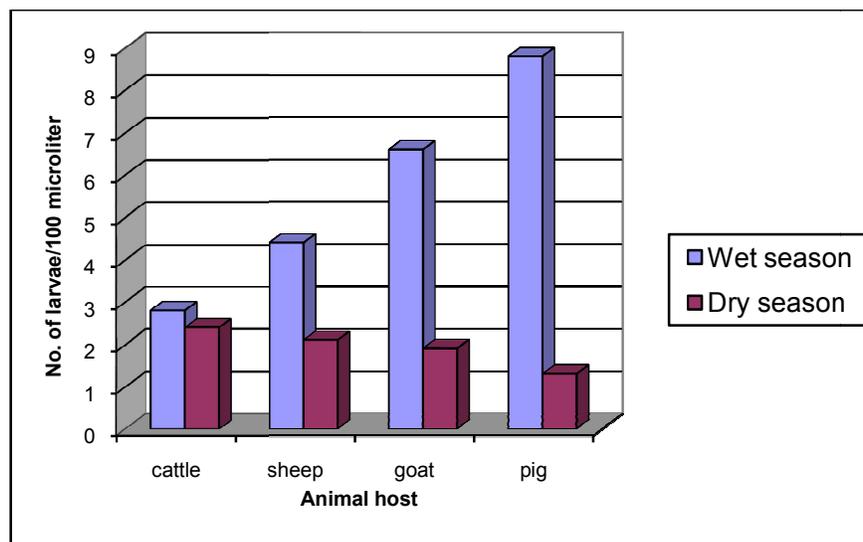


Fig. 20. Intensity of *Oesophagostomum* infection in ruminants and pigs in Kulbia\*

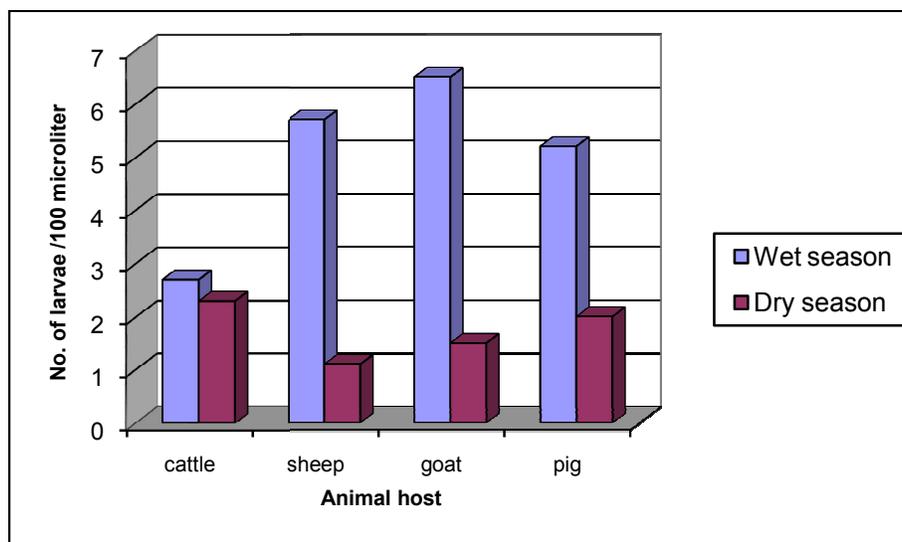


Fig. 21. Intensity of *Oesophagostomum* infection in ruminants and pigs in Kologo\*

Intensity of *Trichostrongylus* infection recorded in Gbeogo is presented in Fig. 26. Intensities were low except in cattle and pigs where intensities recorded were higher in the rainy season. A significant difference was observed in intensities between pig\* and sheep ( $P = .025$ ) in the rainy season.

In Kalbiong (Fig. 27,) intensities of *Trichostrongylus* were higher in the rainy season. Pigs showed the highest both during the rainy and dry season, however, the difference was not significant.

## 5. DISCUSSION

### 5.1 Strongylid Nematodes of Ruminants and Pigs

The nematodes of highest prevalences recorded in the livestock sampled are *Oesophagostomum* and *Strongyloides*. *Oesophagostomum* infections in livestock have been well documented. Transmission is reported to occur by the oral route through the ingestion of infective third stage larvae ( $L_3$ ) in contaminated food and water [12]. The differences in prevalences recorded in the communities may be related to environmental

or behavioral factors playing a role in determine the geographical distribution of the transmission. It is known that the requirements of the adult nematodes [17].  
the infective larva and its previous stages

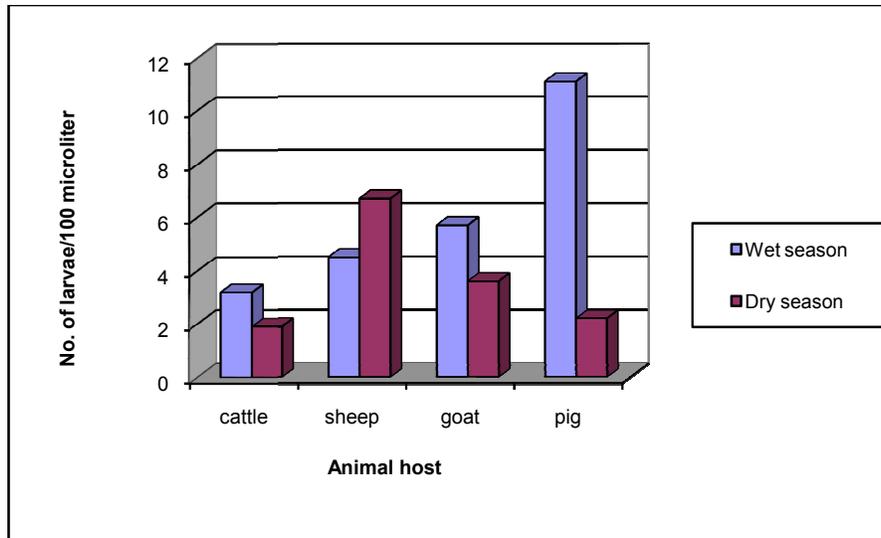


Fig. 22. Intensity of *Oesophagostomum* infection in ruminants and pigs in Gbeogo

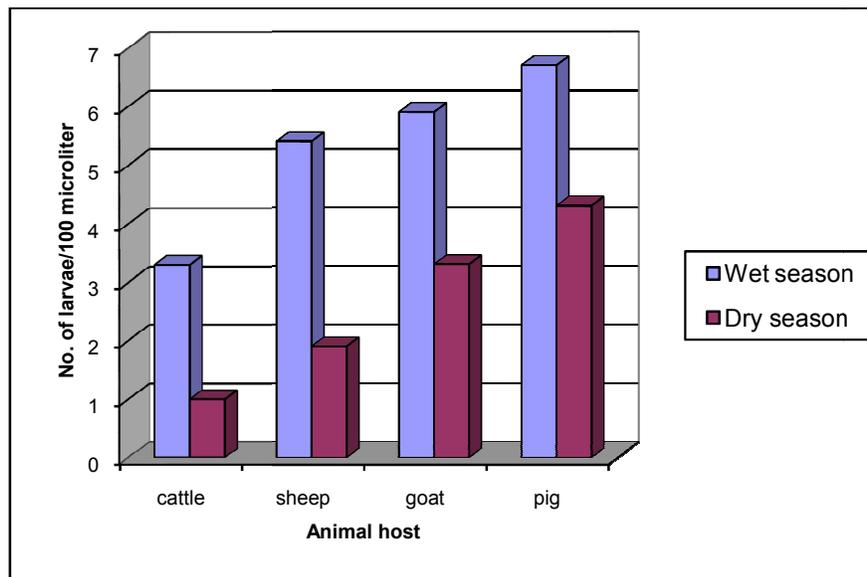


Fig. 23. Intensity of *Oesophagostomum* infection in ruminants and pigs in Kalbiong

Table 2. Intensity of hookworm infection

Community	Animal host							
	Wet season				Dry season			
	Cattle	Sheep	Goat	Pig	Cattle	Sheep	Goat	Pig
Kulbia*	4.5	0.0	51.4	0.0	0.0	0.0	0.0	1.7
Kologo*	0.0	6.7	1.4	6.0	0.0	0.0	0.0	1.4
Gbeogo	0.0	0.0	0.0	9.9	0.0	0.0	0.0	0.3
Kalbiong	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.6

\* Human *Oesophagostomum* endemic community

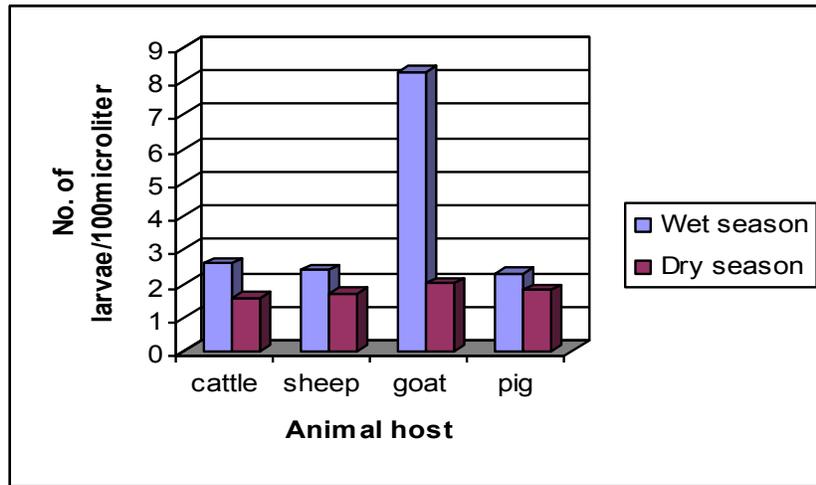


Fig. 24. Intensity of *Trichostrongylus* infection in ruminants and pigs in Kulbia

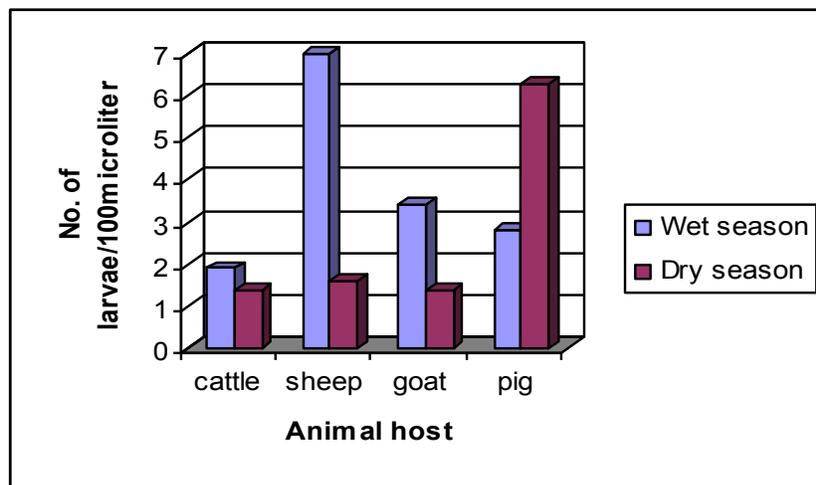


Fig. 25. Intensity of *Trichostrongylus* infection in ruminants and pigs in Kologo

In northern Ghana domestic animals are confined during the rainy season to prevent them from destroying crops. These animals are, however, left to roam during the dry season hence they could be exposed to sources of infection. The comparatively lower prevalences of *Oesophagostomum* recorded during the dry season, could be due to arrested larval development (ALD) which had been observed in livestock [18]. Ingested L<sub>3</sub> larvae of *Oesophagostomum* penetrate the intestinal wall where they develop to young adults. The duration of this tissue-dwelling phase may be influenced by various factors notable among them being harsh environmental conditions. It has been postulated that larval stages of some

*Oesophagostomum* species do not normally continue their development to adulthood after the start of the dry season. The tissue-dwelling stage enters a dormant phase, to continue much later. Larvae of *O. radiatum* and *O. columbianum* have been shown to remain dormant for up to one year [18]. This postponement of development offers certain advantages to the parasite, so that the production of eggs will be highest during the season when conditions outside the host will be favorable for transmission. Also, it has been postulated that L<sub>3</sub> larvae undergo some form of aestivation during dry seasons. The rainy season, thus, provides suitable environmental conditions for the survival and transmission of the L<sub>3</sub> larvae, since the first and second stage

larvae (L<sub>1</sub> and L<sub>2</sub>) require abundant moisture to develop to the L<sub>3</sub>. Desiccated L<sub>3</sub> larvae collected from defaecation grounds have been shown to regain their motility and infectivity after they have been rehydrated under laboratory conditions [17]. An infective larva under favorable conditions can complete its cycle to adulthood within 41 days after infection. Thus an infected host can start releasing eggs 41 days after infection. This implies that *Oesophagostomum* species can develop through a number of generations during the rainy season. This could account for the higher prevalences observed during the rainy season.

Prevalence of *Strongyloides* were also generally higher during the rainy season. Only in a few isolated cases were higher prevalences recorded during the dry season. High prevalence was observed for sheep in Kulbia during the dry season. *Strongyloides* larvae develop best in water-saturated soils with abundant organic material [19]. These conditions become available during the rainy seasons, thus favouring the transmission which occurs both orally and percutaneously. *Strongyloides* larvae have only slight resistance to desiccation or marked

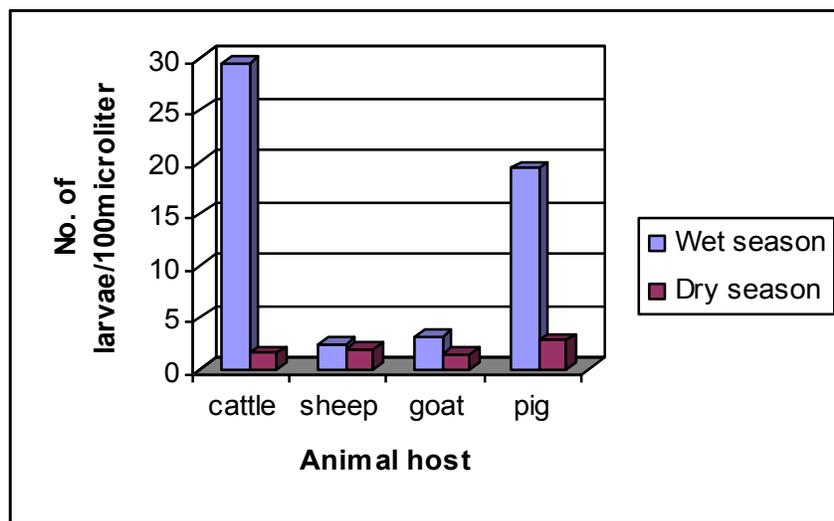


Fig. 26. Intensity of *Trichostrongylus* infection in ruminants and pigs in Gbeogo

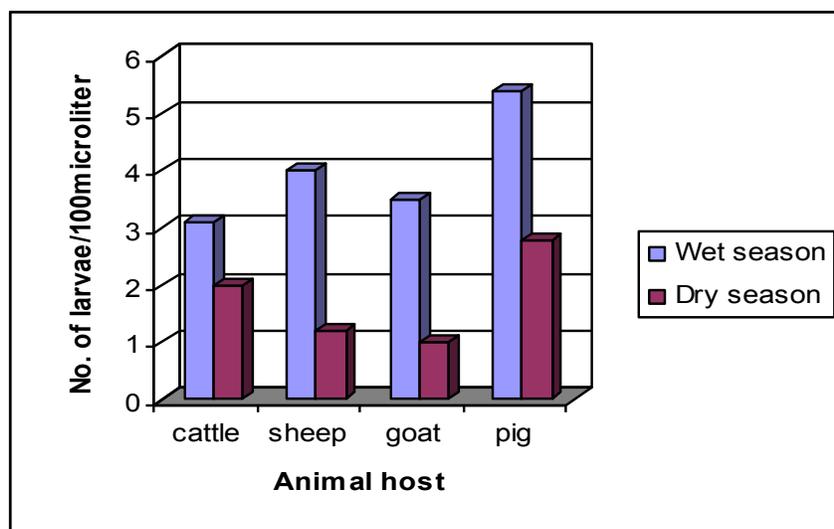


Fig. 27. Intensity of *Trichostrongylus* infection in ruminants and pigs in Kalbiong

**Table 3. Intensity of *Strongyloides* infection**

Community	Animal host							
	Wet season				Dry season			
	Cattle	Sheep	Goats	Pigs	Cattle	Sheep	Goats	Pigs
Kulbia*	2.1	4.1	34.1	4.5	1.0	1.1	1.6	1.7
Kologo*	8.9	20.6	759.9	76.2	2.0	2.0	2.0	1.0
Gbeogo	7.5	5.7	12.4	94.1	1.6	1.0	1.0	7.0
Kalbiong	5.0	4.3	16.2	4.4	0.0	5.0	2.0	2.1

\* Human *Oesophagostomum* endemic community

changes in temperature. This suggests that the rate of transmission may be reduced during the dry season.

The isolated cases of hookworm infections in the ruminants sampled suggested that these ruminants are not natural hosts to the parasite. However, when they are exposed to a constant source of infection, they could become infected. Pigs, on the other hand, are known to feed on human excreta, so that a pig that feeds on hookworm infested stool will develop the infection. This was demonstrated by Steenhard et al. [13] where four parasite-free pigs were fed with fresh faeces from people heavily infected with *Oesophagostomum* and *Necator* whereupon third stage larvae of the two parasites were retrieved from the faeces of the pigs after coproculture.

Ova and larvae of *Trichostrongylus* species require high humidity, abundant shade and the presence of grass or carpet vegetation for their survival. Infection with *Trichostrongylus* in animals occurs by ingestion of infective larvae on grass or vegetation. The rainy season thus provides the best condition for transmission. However, if the above conditions are present in the local rearing environment of these animals during the dry season, high prevalences can be observed. This could account for the higher prevalences recorded during the dry season in cattle, sheep, and pigs (Figs. 24, 25 and 27).

Generally, filariform larvae show tropisms which are characteristic of all strongylid larvae [20]. They are negatively geotropic, where they climb to the top of soil particles and positively phototropic to mild light. Thus, they will crawl up blades of grass in the early morning, towards the evening and at other times of the day during dull weather [12]. They are also markedly thermostatic and are rapidly stimulated into activity by the warmth of a nearby animal [20]. Moisture is necessary for these movements. All

these tropisms would tend to increase the chance of infecting a passing host.

The intensity of *Oesophagostomum* infection (no. of larvae/100µl of sample) derived from the geometric mean values shows pigs as having the highest intensity in almost all the study communities during the wet season except in Kologo. This comparatively high intensity value, however, cannot be attributed only to the coprophagic habits of pigs since the endemicity of a community to human oesophagostomiasis has not been shown to bear any correlation to the level of infection in pigs. It is also known that pigs harbour certain host-specific *Oesophagostomum* parasites such as *O. dentatum*, *O. brevicaudum*, *O. georgianum*, *O. quadrispinulatum* and *O. granatensis* [12].

The varying intensity levels for hookworm infections observed within each study community in the UER could be due to local rearing hygienic conditions.

The intensity of *Strongyloides* infection was highest in goats both in Kulbia and Kologo and also for pigs in Kologo and Gbeogo (Table 3). This differed significantly from the levels in the other animals. In the study communities, sheep and goats are usually penned together, so that the differences observed could be due to differential host susceptibility of sheep and goats and to specific rearing conditions. Again, no specific reason can be given for the varying levels of *Trichostrongylus* infections in the animals except that this could be a result of the specific behavioural or animal husbandry practices in the various communities.

A comparison using ANOVA revealed no significant differences in the intensity of *Oesophagostomum* infection among the different animal hosts in Kulbia (community endemic for human oesophagostomiasis) during the rainy season. In the dry season, however, significant differences were observed between cattle and

pigs, the level of infection (worm burden) being more in cattle than in the pigs. In northern Ghana, most pig owners sell some of their animals soon after the rainy season.

In Kologo (community also endemic for human oesophagostomiasis) significant differences were observed between the infection in goats and cattle as well as goats and pigs in the rainy season. The worm burden being more in the goats than in the pigs and cattle. The dry seasons, however, revealed no significant differences.

Gbeogo and Kalbiong are communities not endemic for the human infection. In Gbeogo the level of infection in pigs was significant when compared to those of the other animal hosts during the rainy season. No significant differences were observed during the dry season. In Kalbiong, however, significant differences were observed between pigs and cattle both during the rainy and dry seasons.

When the endemic and non-endemic communities were compared, no significant differences were observed in the prevalences of infection both during the wet and dry seasons.

The intensity of infection nonetheless differed significantly during the dry season between the endemic and non-endemic communities being higher in the endemic communities.

## 6. CONCLUSION AND SUGGESTIONS

The present study showed that *Oesophagostomum* infections occur in cattle, sheep, goats and pigs in the study communities endemic and non-endemic to the human infections in the Upper East Region.

Also, infection of cattle sheep goats and pigs by the other strongylid nematodes occur in all the communities sampled. Differences in the levels observed could be attributed to differences in the levels of sanitation.

A further study on the species *Oesophagostomum* infecting the various animal hosts is recommended in order to ascertain their similarity and/or ability to infect humans. Such studies should include DNA analysis and characterization of the various species.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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