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An Analysis of the Dynamics of Gastro-Intestinal Nematode Infection in Small Ruminants in the Northern Region of Rwanda

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Abstract: In Rwanda, small ruminants have an important socio-economic and cultural role in the livelihoods of rural farmers. However, productivity is negatively affected by the incidence of nematodes. In this context, a study on dynamics of gastro-intestinal nematodes in small ruminants was conducted for one year period from September 2009 to August 2010 in ISAE farm. The farm is located on the high land region of Rwanda at 2200 m above sea level. It is one of the coldest and moist zones of the country, with an average annual temperature of 15.6ºC, relative humidity of 85.4%, and average annual rainfall of 1630.3 mm. During this study, 15 sheep and 9 goats born at the end of July and August 2009 were followed from birth until the age of one year. Coproscopical analyses were made by Mc master's quantitative method. The results showed that sheep and goats are parasitized by the same species of nematodes. Ten nematode species namely *Oesophagostomum* sp., *Nematodirus* sp., *Haemonchus* sp., *Trichostrongylus* sp., *Ostertagia* sp., *Cooperia* sp., *Chabertia* sp., *Bunostomum* sp., *Gaigeria* sp. and *Trichuris* sp. were found. *Haemonchus* sp. was the most endemic species while *Trichuris* sp. was found as a rare nematode. Excretion of eggs was initially observed at the end of third week with an infection rate of 88.9% in kids and 73.3% in lambs after introducing them on pasture. All animals were infected by the 4th week. Seasonal characteristics had an influence on the eggs excretion, where eggs excretion was higher in the short dry season from January to February with a maximum of 2664 epg per lamb and 2577 epg per kid. These findings have important implications on the appropriate strategies that can be adopted by the government of Rwanda to control the incidence of nematodes in small ruminants.

Key words: Dynamics, eggs excretion per gram (epg), prevalence, Rwanda, season, species and nematodes

INTRODUCTION

In East Africa, small ruminants play an important role in the livelihoods of rural poor farmers through the provision of food and household income (Verbeek *et al*., 2007). This largely stems from easy accessibility, high fertility and fecundity rates, prolificity, early maturity and adaptability to different environments (Winrock International, 1983).

In Rwanda, goats and sheep have an essential and overaching role in buttressing the lives of farmers. In 2007, the country had 1,270,903 goats and 371,766 sheep (MINAGRI, 2007). Optimal productivity of small ruminants is seldom reached in most developing countries mainly as a result of gastro-intestinal parasitosis. Gastro-intestinal infections are responsible for significant losses globally particularly in the developing world where climatic conditions are conducive for their replication and multiplication (Waller, 1997). Various studies in the region have been carried out to assess the economic losses attributable to nematodes. Generally infections result in lower fertility, involuntary culling, a reduction in food intake and reduced weight gain, lower milk production, higher treatment costs, and mortality in heavily parasitized animals (Githigia *et al*., 2005).

In a context characterized by climate change, it is essential to understand the spectrum and seasonality of parasites. It is also a prerequisite to effective planning to prevent and to minimize the losses due to those infections. Because of the inherent differences in each region, it is critical to develop region-specific strategies for prevention of parasites. The main objective of this study is to determine the time of initial infection in lambs and kids when exposed to natural pasture and to analyze the dynamics of infection from birth to one year.

MATERIALS AND METHODS

An overview of the study zone: The study was undertaken within the farm of the Higher Institute of Agriculture and Animal Husbandry (ISAE) located in the Northern Province of the Republic of Rwanda from

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September 2009 to August 2010. The zone is located between 1460 and 4507 m of altitude while the station is located at 2200 m above sea level. The area is characterized by four seasons, including a long rainy season which is between February and June, a long dry season between June and September, a short rainy season which is between September and December and a short dry season between December and February. The climate is moderate and heavily influenced by altitude. Data recorded during the period of research shows that the annual rainfall was 1630.8 mm with an average of 135.8 mm/month while the average annual temperature was 15.9ºC with an average of annual maximal temperature of 22.0ºC and an average annual minimal temperature of 10.4ºC. The annual average of relative humidity was 85.4%.

Animals used in the study: The researchers used lambs and kids born at the end of July and in August 2009 in ISAE farm. The set of animals composed of 15 lambs of the "White mountain" breed and 9 kids of Boer goat breed. Among the 15 lambs, 7 were males and 8 were females. Among the 9 kids, 3 were males and 6 were females. Ear tags were used to identify animals at birth.

Breeding system used during the study period: The practice in ISAE farm is a semi-extensive breeding. Sheep and the goats graze together during the day and return to their shelter at night. The young and the adult animals use the same pasture composed of *Kikuyu grass* and there is no feed supplementation.

Methods: Samples for laboratory analysis were taken twice per month during one year of study. To determine the correct time of the beginning of excretion of eggs in the kids and lambs, coprological examinations were made weekly during four weeks after exposure of new-borns on the pasture. The examination of faecal samples was done by using quantitative method of Mc Master and qualitative method of sedimentation.

Statistical analysis: The results were analyzed by using GenStat discovery Edition 3 program and Microsoft Excel. The average number of eggs per animal was calculated and comparisons facilitated through analysis of variance. Animal species and period were used as the main parameters in the analysis.

RESULTS

Determination of the period of initial egg excretion by new-borns: The lambs and kids were introduced to the pastures one month after birth. No eggs were observed in the faeces at that age. However, coprological analysis was conducted on a weekly basis while they were on pasture.

Table 1: Prevalence rate of different species and their epg

Species	Prevalence rate (%)	Epg.
Oesophagostomus sp.	46.7	87.7
Haemonchus sp.	46.7	108.8
Cooperia sp.	46.7	45.0
Chabertia sp.	46.7	72.9
Bunostomum sp.	26.7	3.5
Nematodirus sp.	20.0	82.5
Ostertagia sp.	20.0	50.0
Trichostrongylus sp.	13.3	75.0
Gaigeria sp.	6.7	16.0

According to results of the coprological analysis, the first excretion of eggs in faeces was observed in the third week. It is therefore assumed that experimental animals were directly infected after exposure to pasture.

The general infection rate in the lambs in the third week was 73.3%. The researchers further characterized the species found in animal faeces. Nine species were present and these are *Oesophagostomus*, *Haemonchus*, *Cooperia*, *Chabertia*, *Bunostomum*, *Nematodirus*, *Ostertagia*, *Trichostrongylus* and *Gaigeria*. Results are shown in Table 1.

Considering the excretion of eggs by animals, the higher epg was 420 and an average of 196 epg per animal has been found.

In kids, the general infection rate at the end of the third week was 88.9%. The same species of nematodes were found where *Haemonchus* sp. had a prevalence rate of 77.8% with an epg of 240. Other species were *Ostertagia* sp. with a prevalence rate of 55.6% and an epg of 54.0, *Nematodirus* sp. and *Trichostrongylus* sp. with a prevalence rate of 33.0% with and an epg of 100.0 for both species. *Oesophagostomum* sp., *Chabertia* sp. and *Bunostomum* sp. were also identified with prevalence rates of 22.2% each and an epg of 80.0, 45.0 and 105.0, respectively. On the other hand *Gaigeria* sp. and *Cooperia* sp. was relatively lower with a prevalence rate of 11.1% and an epg of 60 for both species. The maximum epg found in animals was 630 and an average epg of 327 per animal.

A comparison of species and epg in lambs and kids at the end of 3rd week of pasture shows that both were infected by the same species and the eggs excretion is higher in kids than in lambs, with an average of 327 and 196 per animal respectively. Some species namely *Haemonchus* sp., *Bunostomum* sp. and *Gaigeria* sp. had higher epg in kids than in lambs, where *Chabertia* sp. had a higher epg in lambs than in kids. Analysis of variance shows that the difference between animal species and between nematode species is not significant ($p>0.05$).

At the end of 4th week, all lambs had been infected with all the nine species of nematodes having been found. *Haemonchus* sp. had the highest eggs excretion with an average epg of 334. Other species with high eggs excretion were *Chabertia* sp. with an epg of 123.7 and a prevalence rate of 53.3% and *Oesophagostomum* sp.

which had an epg of 112.5 and prevalence rate of 73.3%. The epg varied between 480 and 1020 with an average of 728 epg per animal. A similar pattern was observed in kids, as all were infected by the end of the 4th week. Similar species of nematodes were also identified. However, *Haemonchus* sp. had the highest eggs excretion of 330.0 when compared with other nematode species. Other significant nematode species were *Nematodirus* sp. and *Trichostrongylus* sp. The total epg varied between 1290 and 390 with an average of 763 epg per animal and the prevalence rate by species varied between 33.3 and 100%.

Comparison of infection rate between lambs and kids at the end of 4th week of pasture: Comparison of the infection rates by different species between kids and lambs one month (4 weeks) after exposure to pasture showed that kids were more infected than lambs. However, nematode species found were the same. The infection rates of different nematode species were not very different, but *Trichostrongylus* sp. was more frequent in the lambs (93.3%) while in kids it represented 44, 4%. The incidence of *Ostertagia* sp. was higher in kids with a prevalence rate of 100.0% (Fig. 1 and 2). The mean epg for kids was 763 whereas it was 728 for lambs and were not statistically different ($p>0.05$).

Dynamics of eggs excretion in lambs: During the year, eggs excretion by *Haemonchus* sp. was higher than others with an average of 534 epg per animal per month (Fig. 3). Higher epg values were observed in January and February with 887 and 902, respectively. Medium epg values were observed for *Nematodirus* sp. -189, *Osteratgia* sp. -172, *Bunostomum* sp. -152, *Cooperia* sp. -135, *Oesophagostomum* sp. -134, *Chabertia* sp. -125 and *Gaigeria* sp. -84. The peak of excretion is observed also in January and February.

The eggs excretion by *Trichostrongylus* sp. and *Trichuris* sp. was low with an average of 48 epg and 0.3, respectively. *Trichuris* sp. was found to be a rare nematode. There was a significant difference in the excretions of eggs by different nematode species ($p<0.05$).

Influence of different weather factors on dynamics of infection in lambs: According to Fig. 4, the rate of excretion of eggs by different nematodes species closely follows the rainfall pattern. The short rainy and dry seasons, seem to have a positive impact on the eggs excretion while the long rainy and dry season have a negative impact on the excretion of eggs. This is largely attributed to rainfall quantity per month coupled with the the low temperatures observed mainly in the long dry season. There is a negative correlation between epg and rainfall.

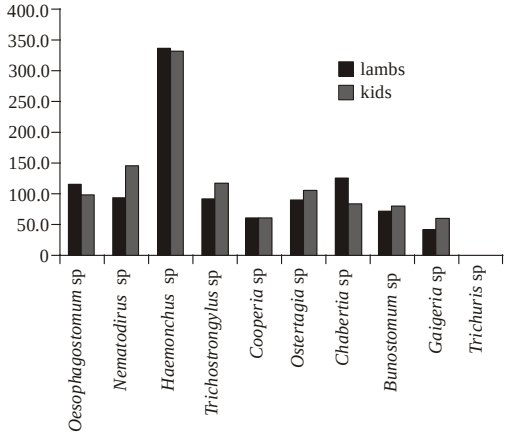

Fig. 1: Comparison between the epg of different species in lambs and kids at the 4th week on the pasture

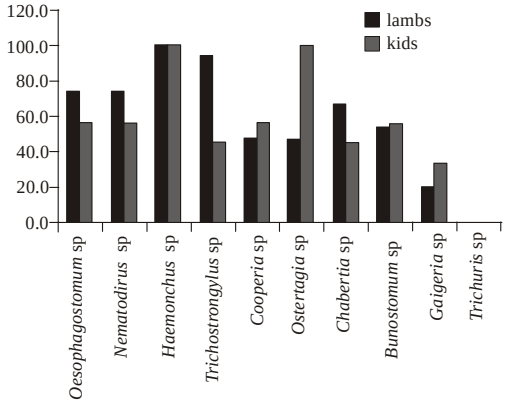

Fig. 2: Comparison between the prevalence of different species in lambs and kids at the 4th week on the pasture

The month of February had the highest incidence of eggs excretion with an average of 2664 epg per animal. This could be explained by conducive weather conditions experienced during the short dry season, where temperature and the humidity are favourable for the development of larvae. The relatively high rainfall of March (254 mm) and April (271.1 mm) had a negative impact. Lower eggs excretion was experienced in August and September with an average of 767 and 741 epg respectively (Table 2). This coincided with the commencement of the experiment as well as the low temperature registered in July (8.7ºC) which had a negative impact on the development of larvae (Fig. 4). Prevalence rates were statistically different across the different months ($p<0.05$).

Dynamics of infection in kids: Table 3 depicts the ten nematode species found in kids during the study period. According to results, eggs excretion by *Haemonchus* sp.

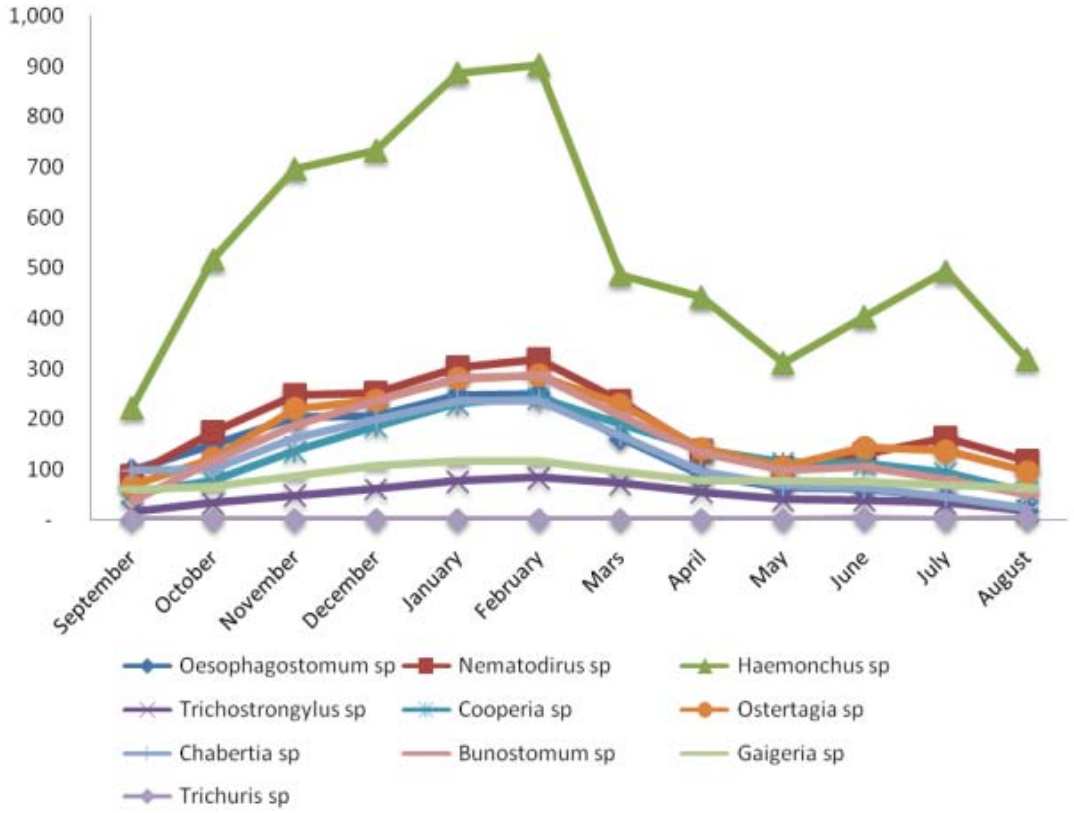

Fig. 3: Dynamics of eggs excretion by different species according to the months in lambs

was higher than others during year with a peak of 582 epg per animal per month. Other nematodes with a medium epg are *Osteratgia* sp. -228, *Oesophagostomum* sp. -174, *Chabertia* sp. -165, *Trichostrongylus* sp. 148, *Nematodirus* sp. -136, *Bunostomum* sp. -101 and *Gaigeria* sp. -89. The peak of excretion was observed in January and February. *Cooperia* sp. and *Trichuris* sp. had lower epg values with an average of 55 epg per animal for *Gaigeria* sp. and 0.3 for *Trichuris* sp. epg per animal per month. Analysis of variance shows that the difference between nematode species found is significant ($p<0.05$). Highest eggs excretion rates were experienced in February with an average of 2572 epg per animal while the lowest eggs excretion was found in August with an average of 693 epg per animal.

Influence of different weather factors on dynamics of infection in kids: As shown by Fig. 5, the short rainy and dry seasons had a positive impact on eggs excretion, while the long rainy and dry seasons had a negative impact on the excretion of eggs. Analysis of variance shows that there is a significant difference between general epg in kids and weather factors such as rain, temperature and relative humidity while it is not significant between months.

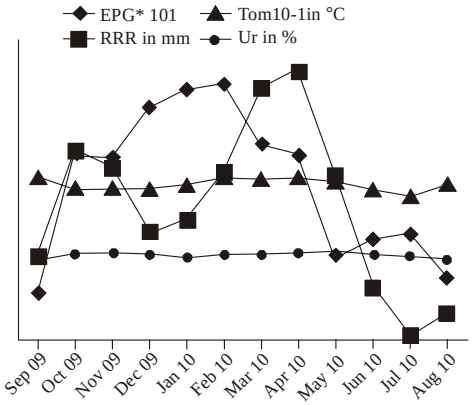

Fig. 4: Influence of different weather factors on dynamics of eggs excretion in lambs

A similar scenario is observed between the different months, whereby the highest eggs excretion was observed in February with an average of 2634 epg per animal (Fig. 6). The high rainfall of March and April seems to have had a negative impact. Lower eggs excretion was found in August and September with an average of 956 and 693 epg, respectively.

Table 2: Dynamics of eggs excretion according to the months and nematode species found in lambs

Months	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	Jun.	Jul.	Aug.	Total	Aver/ month
Oesophagostomum sp.	99	150	204	208	249	251	163	90	66	62	45	19	1,606	134
Nematodirus sp.	88	174	249	253	304	319	236	137	103	131	163	118	2,275	190
Haemonchus sp.	221	516	696	733	887	902	486	441	311	403	493	318	6,407	534
Trichostrongylus sp.	17	34	49	62	77	84	73	56	41	39	34	19	585	49
Cooperia sp.	53	77	137	186	231	242	189	139	114	111	94	56	1,629	136
Ostertagia sp.	69	122	221	238	281	287	229	141	105	144	137	96	2,070	172
Chabertia sp.	98	101	163	199	236	236	167	96	69	64	47	24	1,500	125
Bunostomum sp.	37	118	188	236	283	287	206	133	99	105	81	51	1,824	152
Gaigeria sp.	60	66	86	107	116	116	96	79	77	75	69	64	1,011	84
Trichuris sp.	-	-	-	-	-	-	-	-	-	2	-	2	4	0.3

Table 3: Evolution of infection according to the months and nematode species found in control kids

Nematode species	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	Jun.	Jul.	Aug	Total	Aver/ month
Oesophagostomum sp.	88	210	214	274	296	300	221	221	90	90	60	19	2083	174
Nematodirus sp.	122	210	158	180	195	206	158	158	60	68	75	45	1635	136
Haemonchus sp.	285	731	649	814	866	885	709	709	266	371	445	258	6988	582
Trichostrongylus sp.	107	120	150	206	221	233	199	199	105	98	86	56	1780	148
Cooperia sp.	60	75	45	64	75	83	64	64	38	38	34	15	655	55
Ostertagia sp.	78.5	188	236	319	356	364	266	266	109	173	225	161	2742	228
Chabertia sp.	63.75	173	225	270	285	285	188	135	109	109	90	53	1986	165
Bunostomum sp.	91.5	139	116	161	165	165	120	79	53	49	49	26	1214	101
Gaigeria sp.	60	75	105	113	113	113	105	90	86	75	68	60	1063	89
Trichuris sp.	0	0	0	0	0	0	0	0	0	4	0	0	4	0.3
Total	956	1921	1898	2401	2572	2634	2030	1921	916	1075	1132	693	20149	1679

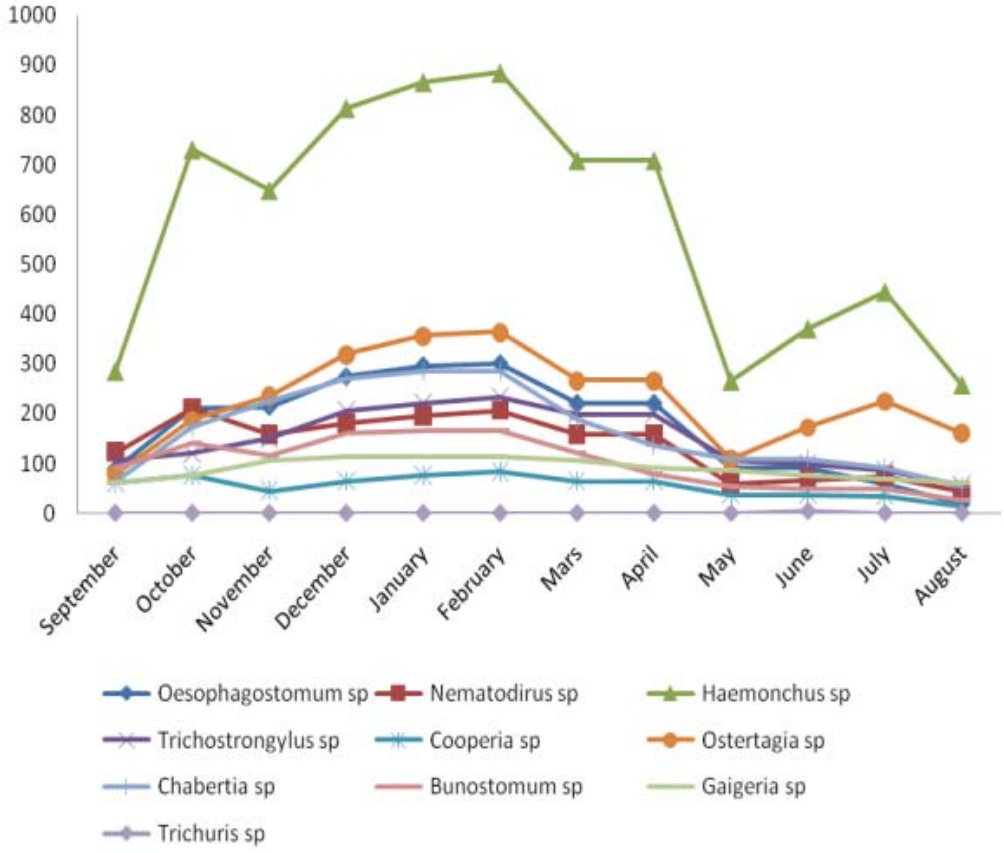

Fig. 5: Dynamics of eggs excretion by different species in kids

The dynamics of eggs excretion are the same for different nematode species, excludin *Tricuris* sp. which appeared after nine months of exposure.

Comparison of dynamics of infection between lambs and kids: Variations in the infection of lambs and kids were observed within the year. However, the peak was in January and February (Fig. 7). On the other hand, low eggs excretion was found in September for both animal species. During the study period, the epg of *Trichostrongulus* sp. was found to be high in lambs than in kids while the converse is true for *Ostertagia* sp.

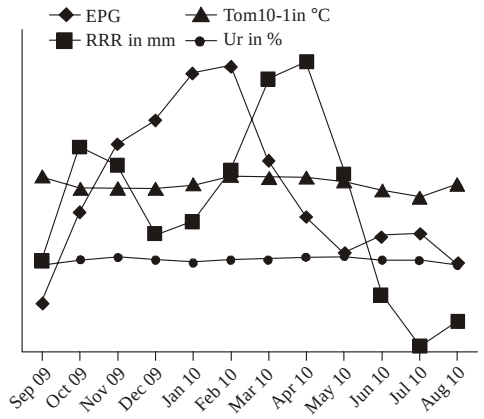

Fig. 6: Influence of different weather factors on the infection of kids

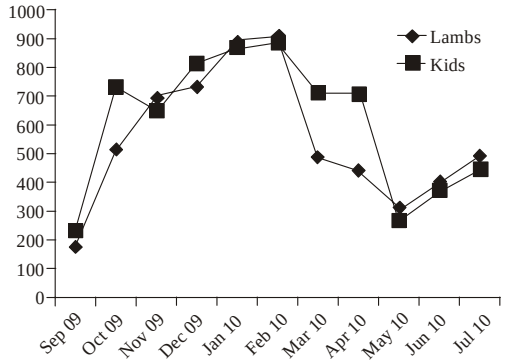

Fig. 7: Comparison of general dynamics of infection between lambs and kids within the year

DISCUSSION

The results of this study have shown that the eggs excretion began at the end of third week of grazing with a prevalence of 88.9% for kids and 73.3% for lambs. Nine species of nematodes were found in kids and lambs. All animals were infected by the end of the 4th week of the experiment. No infections were observed in the first two weeks since animals had not been exposed to natural pasture. These results of this study are corroborated by Hansen and Perry (1994) who observed in Ethiopia that *Trichostrongyles* mature and start egg production about 3 weeks after infection. However, results are at variance with Tedontkeng *et al*. (2000) in Cameroon who noted that the infection of kids began after the end of second week of birth, where the kids have passed from the milk diet to forage diet in the rainy season. This phenomenon is termed "early infection". In the context of this study, it was observed the kids were more infected than lambs in the third and fourth weeks on the pasture.

The researchers identified ten nematode species in lambs and goats namely *Oesophagostomum* sp., *Nematodirus* sp., *Haemonchus* sp., *Trichostrongylus* sp., *Ostertagia* sp., *Cooperia* sp., *Chabertia* sp., *Bunostomum* sp., *Gaigeria* sp. and *Trichirus* sp. *Haemonchus* sp. was the most endemic with a peak eggs excretion in the short dry season. The endemic nature of *Haemonchus* sp. was also observed in Cuba by Garc *et al*. (2007). Contrastingly, Achi *et al*. (2003) conducted a study in Ivory Coast and identified *Trichostrongylus colubriformis* as the most common nematode species with a prevalence rate of 88% in sheep. *Haemonchus* sp. was the second most common species with a prevalence rate of 66%.

In this study, *Trichuris* sp was a rare nematode in small ruminants with almost 1 epg per animal per month. Several authors have observed that this nematode species is rare (Taylor *et al*., 2007). The highest eggs excretion by nematode species was found in February with an average of 2724 in lambs and 2573 in kids. The lowest eggs excretion were seen in September 2009 with an average of 741.8 in lambs and 480 in kids and August 2010 with an average of 767.0 in lambs and 633 in kids. These months concided with initial grazing and the low temperatures had a negative impact on the larvae development. These findings are different from Achi *et al.* (2003) in Côte d'Ivoire who argued that higher eggs excretion was in October. They are also different from results of Boulkaboul *et al*. (2006) in Algeria who noted that the peak of eggs excretion was in November. This could be attributed to inherent differences in the climatic conditions in each region. Lateef *et al*. (2005) conducted a study in Pakistan and noted that the highest eggs excretion by nematode species were July, August and September.

The excretion of eggs increased in the short rainy season with a peak in the short dry season. With increasing temperatures coupled with moderate rainfall and relative humidity, there was a higher excretion of eggs which resulted in a peak of eggs excretion that was observed in January and February. This trend is confirmed by Achi *et al*. (2003) in Côte d'Ivoire who observed that there were seasonal variations but the peak of eggs excretion was related to high temperatures experienced in the rainy season.

CONCLUSION

This study was done during a period of one year from August 2009 to August 2010 to analyze the nematode species dynamics in sheep and goats. Seasonal characteristics influenced the incidence of nematodes. *Haemonchus* sp. was found to be the most endemic nematode species on the farm. These nematodes have important economic implications since they can cause severe anaemia, protein loss and death in goats and sheep. Infection was observed at the end of 3rd week after grazing with rates of 88.9% for kids and 73.3% for lambs. Within the year, eggs excretion by gastrointestinal nematode species varied in the same way in lambs and kids.

The highest eggs excretion in lambs and kids was observed in the short rainy and dry seasons. The peak was observed in the short dry season. These results have an important bearing on the strategies that can be adopted by the government of Rwanda to control the incidence of nematode species.

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AUTHOR'S CONTRIBUTION

Prof. Juvenal Nshimiyimana was the principal researcher involved in the conception of the research idea, writing the research proposal, looked for funding and guidance to the research assistants involved in the project. Nyiramana Carine and Septiple Jean d'arc were involved in the collection of data related to the project. Mutandwa Edward was involved in statistical analysis in the research project particularly the computations of ANOVA. He also edited the final document to be sent for review.