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Seasonal prevalence of gastrointestinal nematodes of calves in Sokoto northwestern Nigeria

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ABSTRACT

This study was conducted with the aim of determining the prevalence and distribution of gastrointestinal nematodes of calves in Sokoto metropolis. A total of 216 faecal samples from 54 calves were examined using Simple faecal floatation and Modified McMaster techniques for morphological egg differentiation and count of worm-egg per gram of faeces respectively. Positive samples were cultured to differentiate between morphologically indistinguishable nematode genera. An overall prevalence was found to be 133 (61.57%). The seasonal prevalence was found to be highest 40 (74.07%) during the early dry season, while the lowest prevalence was observed to be 19 (35.18%) in the early rainy season. Eight different nematode genera were identified with *Cooperia* spp being highest in prevalence (28.78%) followed by *Haemonchus* spp (26.76%) and the least was *Toxocara* spp (0.50%). The prevalence was generally higher in females (56.39%) than in males (43.61%). Statistically significant association ($p<0.05$) between the prevalence of the parasites and the different seasons was observed. Prevalence was low in indigenous breeds, Sokoto Gudali (15.04%) which is relatively resistant to helminthosis compared to crossbreeds (32.33%) and exotic, Friesian (52.63%) breeds. It is concluded that

the late rainy and early dry seasons are conducive for the successive perpetuation of these parasites and therefore enhances subsequent transmission to susceptible hosts.

1. Introduction

Parasitic nematode infections are one of the major causes of production losses in both tropical and temperate regions of the world (Maclean *et al*., 1992; Gasbarre *et al*., 2004, Ballweber, 2006), with the majority of these infections involving the intestinal lumen-dwelling nematodes. Although nematode parasitism is common in animals of all age classes, calves entering the first grazing season are generally the most susceptible age group (Tizard, 1996; Nesru, 1998). In young developing animals, nematode infections may cause retardation of growth that persists even after elimination of the infection (Morley and Donald, 1980; Hansen and Perry, 1994; Maichomo *et al*., 2004; Nwosu *et al*., 2007).

The epidemiology of gastrointestinal nematodes in livestock varies in different localities, depending on the local climate, season and management system (Hansen and Perry, 1994). The design of an integrated approach of gastrointestinal nematodes control requires adequate knowledge of epidemiology (Torres-Acosta and Hoste, 2008). Production practices and seasonal weather patterns affect the dynamics of infestation by nematode parasites so that pasture contamination by free-living stages varies throughout the grazing season and is dependent on weather conditions (Shaw *et al*., 1997; Almeria and Uriarte, 1999; Claerebout *et al*., 2000).

In Nigeria, gastrointestinal nematode infection was predicted as an obstacle to expansion of cattle industry in a study conducted by Lee (1955) in south western states of Nigeria where rainy season is prolonged. Records compiled by Sprent (1946) listed thirteen (13) species of nematodes from the alimentary tract of cattle in Nigeria. A checklist was also compiled by Schillhorn van Veen *et al*. (1975) comprising 16 different species of gastrointestinal nematodes of cattle in northern Nigeria.

The aim of this study was to investigate the prevalence of gastrointestinal nematodes and causative nematodes genera and to determine the seasonal distribution of gastrointestinal nematode parasites of calves in the study area.

2. Materials and methods

2.1. Study area

Sokoto is the capital of Sokoto State, located in the North Western part of Nigeria. With a land area of approximately 56,000 square kilometers, it is located between longitudes 11° 30" to 13° 50" East and latitude 4° to 6° North (Anon, 2001). The state is bordered in the North by Niger Republic, Zamfara State to the East and Kebbi State to the South and West (Anon, 2001).

Sokoto is located in the Sudan Savannah vegetation belt with sandy soil and a humidity of below 40% year round except during the rainy season when it rises to 60% (Iloeje, 1971). The two dominant seasons are the wet (June-October) and dry (November-May) seasons. The former begins in June and lasts up to October, while the latter begins in November and last up to May (Anon, 2001).

2.2. Sampling technique

Farms within Sokoto metropolis were identified and based on the consent of the proprietors; the total numbers of calves on each farm were sampled. Convenience sampling (census) technique was employed. Five farms were identified with a total of 54 calves and were sampled throughout the four classified seasons. A total of 216 faecal samples were collected from the calves. Individual rectal or freshly voided faecal samples were collected using labeled polythene bags. Each sample contained the following data: sex, age (Alexander and Robert, 1986) and breed, and were transported to the Parasitology and Entomology Laboratory of the Faculty of Veterinary Medicine, Usmanu Danfodiyo University, Sokoto, Nigeria, during the two major seasons (dry and wet) to determine the seasonal infection pattern of gastrointestinal nematode parasites.

For sampling convenience, the year was divided into four seasons namely:

(i) Early dry season (Nov-Jan)
(ii) Late dry season (April-May)
(iii) Early rainy season (June-July)
(iv) Late rainy season (Sept-Oct)

2.3. Methods of examinations

2.3.1. Faecal nematode egg counting and morphological differentiation

Following collection of samples, the faeces were microscopically examined for eggs of gastrointestinal nematodes. Morphological differentiation was based on microscopic appearance of the eggs encountered, compared to those in standard texts. Microscopic egg-count (EPG) was carried out using Modified McMaster method (Thienpont *et al*., 1986; Taylor *et al*., 2007).

2.3.2. Cultivation and differentiation of infective larvae

Further distinction between genera of the Strongylida-order from the positive samples was made by larval culture of a dung-sterile faeces (burnt and dried bulk faeces) mixture. Faecal cultures were made by the modification of the technique described by Roberts and O'Sullivan (1950) where 5grams of the sample was used instead of 3grams. Identification of the L_3 was based on their morphological characteristics described by Soulsby (1982) and Gruner and Raynaud (1980). These were then examined under x40 and measurements of the following were noted:

a. Head (Shape) characteristics
b. Number of gut (intestine) cells
c. Length of the sheath tail

The observed characteristics were compared to those available from the literature in Table 1 below to determine the species of trichostrongyles or strongyles involved.

Table 1
Key characteristics used in the identification of third-stage larvae of some ruminant nematodes.

Genus	Intestinal cell number	Head characteristics	Tail sheath characteristics
Nematodirus spp	8	Broad round	Filamentous
Teladorsagia spp	16	Squared	Short sheath
Trichostrongylus spp	16	Tapered	Short sheath
Haemonchus spp	16	Narrow round	Medium sheath
Cooperia spp	16	Squared with refractile bodies	Medium sheath
Bunostomum spp	16	Pointed round	Short filamentous
Oesophagostomum spp	32	Broad round	Filamentous sheath
Chabertia spp	32	Broad round	Filamentous sheath

Adopted from Taylor *et al.*, 2007.

2.4. Statistical analysis

Results are presented in tables and charts Chi Square was used to test for any association between the prevalence of the parasites and the following variables; sex, breeds and age groups, and among the seasons, using Instat3 Statistical software.

3. Results

Five well fenced (cemented blocks) farms were identified with a total of 54 calves of different sexes, breeds and age groups (Table 2). The overall prevalence of gastrointestinal nematodes was found to be 133 (61.57%) and the seasonal prevalence of the gastrointestinal nematodes was 40 (74.07%) for the Early Dry Season (Nov-Jan), 38 (70.37%) for the Late Dry Season (April-May), 19 (35.18%) for the Early Rainy Season (June-July) and 36 (66.66%) for the Late Rainy Season (Sept-Oct) (Table 3). From the results of this study, gastrointestinal nematode infections

were observed with a prevalence of 51 (57.95%) in calves less than six months and at an increased prevalence of 78 (65.00%) in calves six to twelve months (Table 4). Overall, females 75 (56.39%) were more infected than males 58 (43.61%) (Table 5).

Table 2
Sample distribution by farms, sex, age and breed.

		Age	(Months)		Sex		Breed		
Farms	**n**	**<6**	**6-12**	**13-18**	**Male**	**Female**	**SG**	**CR**	**FR**
A	8	2	6	0	5	3	3	3	2
B	10	5	5	0	5	5	2	3	5
C	17	10	7	0	6	11	0	5	12
D	12	5	7	0	5	7	3	4	5
E	7	0	5	2	3	4	0	4	3
Total	54	22	30	2	24	30	8	19	27

SG= Sokoto Gudali
CR= Crossbreed
FR= Friesian
n= number of calves

Table 3
Overall and seasonal prevalence of gastrointestinal nematodes of calves in Sokoto metropolis

		Farms						
Season	**n**	**A**	**B**	**C**	**D**	**E**	**Number Positive**	**Prevalence (%)**
EDS	54	8	6	10	10	6	40	(74.07)
LDS	54	6	7	12	8	5	38	(70.37)
ERS	54	1	0	12	6	0	19	(35.18)
LRS	54	6	5	14	5	6	36	(66.66)
n	216	21	18	48	29	17	133	(61.57)

(P<0.05)
EDS= Early dry season
LDS= Late dry season
ERS= Early rainy season
LRS= Late rainy season
n= number of samples

Table 4
Prevalence of gastrointestinal nematodes in calves by age groups in Sokoto Metropolis

Age groups (Months)	**Sex**		**Number of samples**	**Number positive**	**Prevalence (%)**
	Male	**Female**			
<6	44	44	88	51	57.95
6-12	0	8	120	78	65.00
13-18	52	68	8	4	50.00
Total	96	120	216	133	61.57

(P>0.05)

The worm-egg counts using McMaster counting technique yielded a range between 400-2400 egg per gram of faeces in the early dry season. Whatever the dominant breed, age or season, egg counts seldom exceeded 200 epg of faeces during the late dry season. Of the 19 (35.18%) positive samples examined during the early rainy season (June-July), there was a range between 200-1200 epg of faeces, while a range between 200-8900 epg of

faeces was examined in the late rainy season (Table 6). Based on breeds, prevalence of gastrointestinal nematodes was low in Sokoto-Gudali 20 (15.04%) breed compared to crossbreed 43 (32.33%) and Friesian breed 70 (52.63%) (Table 7). Eight different nematode genera were identified and severe to light worm burdens differ among seasons (Table 8). From the overall seasonal distribution of gastrointestinal nematodes identified, *Cooperia* spp was highest with 57 (28.78%) followed by *Haemonchus* spp with 53 (26.76%) and the least was *Toxocara* spp with 1 (0.50%) (Table 8). *Haemonchus* spp predominated in both the late dry season (April-May) with 13 (24.53%) and in the late rainy season (Sept-Oct) with 20 (34.74%), while *Cooperia* spp predominated in both the early dry season (Nov-Jan) with 23 (40.35%) and the late rainy season (Sept-Oct) with 16 (28.37%) (Table 8).

Table 5

Prevalence of gastrointestinal nematodes in calves by sex in Sokoto Metropolis.

Sex	No. of samples	Number positive	Prevalence (%)
Male	96	58	43.61
Female	120	75	56.39
Total	216	133	100

(P>0.05)

Table 6

Faecal worm-egg count per gram of faeces in the different seasons of the year

Seasons	Range of worm-egg count (epg)	Mean ± SEM
Early dry season	400-2400	1402.56 ± 124.17
Late dry season	0-200	162.16 ± 8.08
Early rainy season	200-1200	644.4 ± 86.02
Late rainy season	200-8900	828.57 ± 107.26

Table 7

Prevalence of gastrointestinal nematodes in calves in relation to breeds in Sokoto Metropolis

Breeds	Sex		Number of samples	Number positive	Prevalence (%)
	Male	Female			
Sokoto Gudali	9	23	32	20	15.04
Friesian	45	63	108	70	52.63
Cross breed	42	34	76	43	32.33
Total	96	120	216	133	100

(P>0.05)

Table 8

Percentage prevalence of gastrointestinal nematodes in calves at different seasons of the year

Nematode parasites	Seasons				n	(%)
	EDS	LDS	ERS	LRS		
Strongyloides spp	0	6	0	0	6	3.04
Trichuris spp	0	5	0	0	5	2.53
Oesophagostomum spp	7	10	7	4	28	14.14
Haemonchus spp	12	13	8	20	53	26.76
Cooperia spp	23	10	8	16	57	28.78
Trichostrongylus spp	7	11	7	7	32	16.16
Bunostomum spp	9	5	0	2	16	8.09
Toxocara spp	0	0	1	0	1	0.50
Total	58	60	31	49	198	(100)

EDS= Early dry season
LDS= Late dry season
ERS= Early rainy season
LRS= Late rainy season
n= 198 (number of appearance of worm eggs/larvae)

There was no statistical significant evidence of association ($p>0.05$) in the results between the sexes, breeds and age categories in all the seasons (Table 4, 5 and 7). However, there was a statistical significant association ($p<0.05$) between the seasons (Table 3). *Toxocara* spp, *Strongyloides* spp, *Trichuris* spp, and *Bunostomum* spp were identified by means of morphological egg characteristics while *Cooperia* spp, *Haemonchus* spp, *Oesophagostomum* spp, and *Trichostrongylus* spp by larval morphological characteristics.

4. Discussion

Studies conducted on beef and dairy cattle from several countries have shown that gastrointestinal parasitism is a widespread condition with no herds reported free from infections (Jacobson and Worley, 1961; Cox and Todd, 1962; Leland *et al*., 1973). This study indicated a high prevalence of gastrointestinal nematodes (61.57%) in calves in selected farms which is in agreement with some studies in other countries with a savannah type of vegetation; Kenya 86.8% (Waruiri *et al*., 1998) and 97.2% in the lower plains of southern highlands of Tanzania (Keyyu *et al*., 2003), but contrary to the findings of Swai *et al.* (2006) who reported a prevalence of 14.2% in Ngorongoro district, Tanzania.

Cooperia spp and *Haemonchus* spp were present in the highest numbers of 28.78% and 26.76% followed by *Trichostrongylus* spp (16.16%) and *Oesophagostomum* spp (14.14%) species respectively, as also observed in studies from Kenya, 28.5% and 52.5% followed by 5.6% and 6.9% respectively (Waruiri *et al*., 1998), in Zimbabwe, 44% and 29% followed by 4% and 13% respectively (Pandey *et al*., 1993) and in Tanzania, 67.8% and 24.7% followed by 1% and 5.1% respectively (Keyyu *et al*., 2003).

Contrary to the findings of Lima (1998) in Brazil and Waruiru *et al.* (1998) in Kenya who reported highest worm burden (86.8%) during the rainy season, the result of this research found the highest prevalence of (74.07%) in the early dry season (Nov-Jan). However, the result of this finding concur with those found in Zimbabwe by Pandey *et al.* (1993) and in the eastern Tanzania by Mellau (1997) where the highest worm-egg count occurred during the late rainy season (Sept-Oct) which may be as a result of improper or lack of strategic anthelmintic medication. In this study, some of the high worm burdens/egg count observed in the dry seasons might be the survivors from infections acquired during the late rainy season (Sept-Oct) because the animals rarely receive anthelmintic treatment at the early onset of dry season.

The high worm burdens/egg counts at the late rainy/early dry season in this study indicated that peak pasture contamination occurred at the end of the rainy season as also reported in eastern Nigeria by Chiejina and Emehelu (1984) and in southern Tanzania by Keyyu *et al.* (2003). It therefore appears that there was a slow and gradual build-up of pasture infectivity during the rains.

Contrary to the findings of Lee *et al.* (1960) at Shika, Northern Nigeria, egg counts during the late dry season (April-May) rose in *Cooperia* spp, *Trichostrongylus* spp and *Oesophagostomum* spp which may probably be related to the management system. There was a fall in the populations of all the parasites in all the farms during the early rainy season (June-July) that may be related to anthelmintic treatment.

Prevalence of gastrointestinal nematodes was low in Sokoto-Gudali 20 (15.04%) breeds (*Bos indicus*) which are relatively resistant to helminthosis (Williamson and Payne, 1978) compared to crossbreed 43 (32.33%) and Friesian 70 (52.63%) which is exotic breeds (*Bos taurus*). The findings of higher prevalence rate in females 75 (56.39%) than in males 58 (43.61%) may be due to differences in exposure to infection as a result of the variation in stocking density (sex ratio). The findings of higher prevalence rate found at the age range of six to twelve months 78 (58.65%) suggests a possibility of early introduction of calves to grazing fields and subsequent increase in larval uptake.

5. Conclusion

From the results of the present study it can be concluded that, the seasonal fluctuations in worm egg shedding in the study animals observed, indicated that late rainy and early dry seasons are favorable for the development of gastrointestinal nematodes.

References

Alexander, de L., Robert, E.H., 1986. Applied Veterinary Anatomy, W.B. Saunders Como. Philadelphia.

Almeria, S., J., Uriarte, 1999. Dynamics of pasture contamination by gastrointestinal nematodes of cattle under extensive management systems: Proposal for strategic control. Veterinary Parasitology. 83: 37–47.

Anon, 2001. Sokoto State - the seat of the Caliphate, In: Sokoto State Government diary. Pp 2-8.

Ballweber, L.R., 2006. Diagnostic methods for parasitic infections. Veterinary Clinics Food Animal. 22: 695-705.

Claerebout, E., J. Agneessens, D. Demeulenaere, and J. Vercruysse 2000. Control of helminth diseases on dairy cattle farms in Flanders: results of a questionnaire survey. Vlaams Dierg. Tijdschrift. 69:108–115.

Chiejina, S.N., Emehelu, C.O., 1984. Seasonal changes in pasture populationsof infective larvae of gastrointestinal nematodes of cattle in eastern Nigeria. Research in Veterinary Science. 37:144-147.

Cox, D.D., Todd, A.C., 1962. Survey of gastrointestinal parasitism inWisconsin dairy cattle. JAVMA. 141: 706-709.

Gasbarre, L.C., T., Sonstegard, C.P., VanTassell, R., Araujo, 2004. Using host genomics to control nematode infections. Veterinary Parasitology. 125: 155–161.

Gruner, L., and J. P. Raynaud, 1980. Technique allegee´ de pre´le`vements d'herbe et de nume´ration, pour juger de l'infestation des paˆturages de bovins par les larves de ne´matodes parasites. Rev. Me´d. Vet. 131:521–529.

Hansen, J., Perry, B., 1994. The Epidemiology, Diagnosis and Control of Helminth Parasites of Ruminants; (ILRAD, Nairobi, Kenya), Pp 123-141.

Iloeje, N.P. 1971. Where is Nigeria and who are Nigerians? In: A New Geography of Nigeria, Vol. I., Pp14.

Jacobson, R.H., Worley, D.E., 1969. Incidence and distribution of Helminth parasites and Coccidia in Montana cattle. American Journal of Veterinary Research. 30: 1113-1117.

Keith, R. K. 1953. The Differenciation of the infective larvae of some common nematode parasites of cattle. Australian Journal of Zoology. 1: 223-235.

Keyyu, J.D., Kassaku, A.A., Kyvsgaard, N.C. and A.L. Willingham, III 2003. Gastrointestinal nematodes in indigenous zebu cattle under pastural and nomadic management systems in the lower plain of southern highlands of Tanzania. Veterinary Research Communications. 27:371-380.

Leland, S. E., Jr., Caley, H. K. and R. K. Ridley 1973. Incidence of gastrointestinal nematodes in Kansas Cattle. American Journal of Veterinary Research. 34: 581-585.

Lee, R. P. 1955. Report on preliminary investigation of bovine parasitic gastroenteritis in Western Region of Nigeria. Federal Department of Veterinary Research, Vom, Nigeria. 28pp.

Lee, R. P., Armour J. and Ross, J.G 1960. The seasonal variations of strongyle infestations in Nigerian Zebu cattle. British Veterinary Journal 116: 34-46.

Lima, W. S. 1998. Seasonal infection of gastrointestinal nematodes of beef cattle in Minas Gerais State, Brazil. Veterinary Parasitology. 74: 203-214.

Maclean, J. M., K. Bairden, P. H. Holmes, W. Mulligan, and P. N. McWilliam, 1992. Sequential in vivo measurements of body composition of calves exposed to natural infections with gastrointestinal nematodes. Research in Veterinary Science. 53: 381–389.

Maichomo, M.W., Kagira, J.M. and Walker, T. 2004. The point prevalence of gastrointestinal parasites in calves, sheep and goats in Magadi division, south-western Kenya. Ondersterpoort Journal of Veterinary Research. 71: 257-261.

Mellau, L.B.S. 1997. Factors associated with diseases and mortality of calves in Morogoro, MVM dissertation, Sokoine University of Agriculture.

Morley, F.H.W. and Donald, A.D. 1980. Farm management and systems of helminth control. Veterinary Parasitology. 6: 105-134.

Nwosu, C.O., Madu, P.P. and Richards, W.S. 2007. Prevalence and seasonal changes in the population of gastrointestinal nematodes of small ruminants in the semi-arid zone of north-eastern Nigeria. Veterinary parasitology. 144: 118-124.

Nesru, H.M. 1998. Study on calf mortality of Adami Tulu Research Center In: Proceedings of 5th conference of ESAP (Ethiopan Society of Animal Production) Addis Ababa, Ethiopia.

Pandey, V.S., Chitate, F. and Nyanzunda, T.M. 1993. Epidemiological observations on gastrointestinal nematodes in communal land cattle from the highveld of Zimbabwe. Veterinary Parasitology. 51: 99-106.

Roberts, F.H.S. and O'Sullivan, P.J. 1950. Methods for egg counts and larval cultures for strongyles infecting the gastrointestinal tract of cattle. Australian Journal of Agriculture Research, 1: 99-102.

Schillhorn van Veen, T. W., Shonekan, R.A.O. and Fabiyi, J.P. 1975. Host-parasite checklist of helminth parasites of domestic animals in northern Nigeria. Bulletin of Epizootic Diseases of Africa.

Shaw, D. J., J. Vercruysse, E. Claerebout, J. Agneessens, and P. Dorny, 1997. Gastrointestinal nematode infections of first-season grazing calves in Belgium: general patterns and the effect of chemoprophylaxis. Veterinary Parasitology. 69: 103–116.

Soulsby, E.J.L. (1982): Helminths, Arthropods and Protozoa of Domesticated Animals. ELBS. Bailliere Tindall, London.

Sprent, J. F. A. 1946. Some observations on the bionomics of Bunostomum phlebotomum; a hookworm of cattle. Parasitology. 37: 202-210.

Swai, E.S., Mtui, P.F., Mbise, A.N., Kaaya, E., Sanka, P. and Loomu, P.M. 2006. Prevalence of gastrointestinal parasite infections in Maasai cattle in Ngorongoro District, Tanzania. Livestock Research for Rural Development. Volume 18, Article #8. Retrieved September 5, 2006, from http://www.lrrd.org/lrrd18/8/swai18107.htm

Taylor, M. A., Coop, R. L. and Wall, R. L. 2007. Veterinary Parasitology 3rd ed. Blackwell Publishing Ltd. 771pp.

Thienpont D. , Rochette F. and Vanparijs O.F.J. 1986. "Diagnose van verminosen door coprologisch onderzoek", Janssen Research Foundation, Beerse, Belgium, pp. 19-43.

Tizard, I. B. 1996. Veterinary immunology. An introduction; Immune response of new borne animals, 5th edn. Department of Pathology, the Texas Veterinary Medicine Centre, Texas A&M University, College Station, Texas, 241-250.

Torres-Acosta, J.F.J. and Hoste, H. 2008. Alternative or improve methods to limit gastrointestinal parasitism in grazing sheep and goats. Small Ruminant Research. 77: 159-173.

Waruiru, R.M., Nansen, P., Kyvsgaard, N.C., Thamsborg, S.M., Munyua, W.K., Gathuma, F.L., Bogh, H.O. 1998. An abattoir survey of gastrointestinal nematode infections in cattle in the central highlands of Kenya. Veterinary Research Communications, 22: 325-334.

Williamson, G., Payne, W.J.A. 1978. An Introduction to Animal Husbandry in the Tropics. 2nd edn (Longmans, London), 171.