Interactions between gastrointestinal parasitism and pneumonia in Nigerian goats

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Abstract This study was carried out to determine the burden and interactions between parasitism and pneumonia in Nigerian goats. A total of 430 goats were examined for gastrointestinal (GIT) parasites by faecal analysis using sedimentation by gravity, Modified Winconsin sugar floatation method, McMaster egg counting techniques and for lung consolidation, pathology and morphometry of pneumonia were evaluated by standard techniques. The results from the faecal examination revealed the presence of nine (9) gastrointestinal parasites namely *Eimeria*, *Trichuris*, *Oesophagostomum*, *Strongyloides*, *Moniezia*, *Haemonchus*, *Bunostomum*, *Trichostrongylus*, and *Nematodirus* species and at an overall high prevalence of 74%. *Eimeria* species was found to have the highest prevalence of 26% for single infection, while co-infection of *Eimeria* and *Trichuris* species 21% was highest amongst other parasites, and of the breeds of goats examined for GIT parasites, the Red Sokoto (RS) breed had the highest infection rate 37%. The results from the lungs analysis showed 59% prevalence with the highest consolidation in RS (48.2%), followed by WAD (34.2%). The age of the goats was key in the infection rate of both parasites and pneumonia, which was seen to be highest in younger goats, with a significant ($2.10 \pm 0.4 \times 10^3$) GI parasite burden in >1–2 years group. The prevalence of GIT infection with lung consolidation in the goats, was observed to influence their Body condition scores (BCS) ($p < 0.05$). This study

showed that body condition score, age and breed of goats may be predisposing factors to gastrointestinal parasites and pneumonia in Nigerian goats. There was a strong correlation ($+0.243$, $p = 0.00$) of occurrence of gastrointestinal parasitism and pneumonia in this study. Possibility of combined prophylactic measures should be considered in the nearest future.

Keywords Co-infections · Parasites · Pneumonia · Red Sokoto · Small ruminant · West African Dwarf

Introduction

Infectious diseases of ruminants are the cause of morbidity and mortality across the world, especially in developing and underdeveloped countries. Of the total world population of 674.1 million goats, 95% is found in developing countries of the tropics while approximately 26.2% found in Africa (FAO 1997) are in semi desert and rural areas (Getachew et al. 2016). Goats are of economic importance to rural household because of their high reproductive rate, lower cost of purchase, and their ability to live on low quality diet in harsh environmental conditions (Mellado 2008; Edosomwan and Shoyemi 2012).

Goats (over 26 million) make up 42.3% of Nigerian ruminant livestock, which has been able to contribute about 12.7% of the total agricultural gross domestic product (Ademosun 1987; Emikpe et al. 2013).

The breeds of goats are largely indigenous in Nigeria; including West African Dwarf (WAD), Sahel/desert goat known as West African Long-Legged goat; and Red Sokoto/Maradi (Ademosun 1987; Fabusoro et al. 2007), while the Kalahari goat breed of South Africa origin is gradually being adapted to the Nigeria's ecological zones

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(Lawal-Adebowale 2012). The WAD goat is more in the south and the RS is more in the north (FAO 2001). Goats have been managed under different husbandry practices (Chiejina 2001). The commonest practices include confinement, free ranging and semi-extensive management (Chiejina et al. 2015).

These animals are a source of investment and of immense socio-economic benefits to most rural households in Nigeria across Africa (Anyaeunam and Okafor 2013). Thus, proactive measures improving goat yield may have an immediate impact on livelihood of rural communities (Emikpe et al. 2013).

However, in most developing countries like Nigeria, these benefits are seriously affected by high mortality and low productivity in these small ruminants (Over et al. 1996; Omoike 2006; Anaeto et al. 2009). Infectious diseases such as parasitism and pneumonia constitute a major limiting factor in livestock production. These diseases are often triggered by adverse environmental influences, stress and poor management practices including inadequate health control measures (Akhtar et al. 2012). Ensuing economic losses could be direct through mortality or indirectly in the form of weight loss, poor milk, meat and wool production, carcass and offal condemnation, impaired reproductive performance, cost of treatment etc. (Regassa et al. 2006; Idika et al. 2012).

Gastrointestinal tract (GIT) parasites are quite ubiquitous, and numerous helminths have been identified in goats including nematodes (Stehman and Smith 2004), cestodes, trematodes and also *Eimeria species* (Zahid et al. 2005; Oluwayiose et al. 2014). Pneumonia on the other hand has been an important disease in goats in sub Saharan Africa (Emikpe and Akpavie 2012). Managemental and environmental factors have been identified to contribute to occurrence of pneumonia in small ruminant (Hunter 1996).

Clinical indices or assessment are considered physical examination of animals for determining health and or nutritional status (Detweiler et al. 2008). Poor body score has been established as a feature of gastrointestinal tract (GIT) helminth infections (Holmes 1993; Coop and Kyriazakia 1999; Idika et al. 2012). However, the high prevalence of pneumonia in goats and the continuous endemicity of gastrointestinal parasites in our environment remains a perennial problem (Emikpe et al. 2013; Oluwayiose et al. 2014), while much is yet to be known on the interaction of these two conditions and the common interplay of factors in Nigerian goats.

Since effective chemotherapeutic treatment does not address the root cause of infection and re-infection, hence identifying risk factors, clinical indices, and diagnostic measures may be important for welfare of goats. Thus it is necessary to investigate the incidence of parasitism and pneumonia in goats, in order to devise effective control

measure to curb the rising threat of these two conditions to ruminant health.

Materials and methods

Study area

The study was carried out in the University of Ibadan Zoological garden. The Zoological garden is located on Latitude 7°26'33" north and 3°53'43" east. In terms of its aerial extent, it lies between Latitude 7°46'29" north to 7°26'36" north and between 3°53'39" east to 3°53'48" east.

Animals

Randomly selected 430 goats, supplied for feeding captive carnivores, were used for the study. The goats comprised <1–1 year, >1–2 years and >2–3 years. Prior to slaughtering, each animal was carefully examined by checking for the sex of the goat which was determined physically, age of the goat which was done by the dentition method as described by Ethiopia Sheep and Goat Productivity Improvement Program (ESGPIP 2009), the general body condition was determined by feeling the level of muscling and fat deposition over and around the vertebrae in the loin region, and was evaluated systemically on a nominal scale of 0–2 (good, fair and poor).

Faecal analysis

Faecal sample was collected from the rectum of each of the animals into universal bottles, which were well labelled with animal identification number and date. Faecal examination was done by sedimentation by gravity, Modified Winconsin sugar flotation, and McMaster methods and various parasites eggs were identified on the basis of their morphological features as described by Soulsby (1982).

Assessment of pneumonia and lung morphometry

Picture and sections of the lungs of each animal was taken for gross pathology and morphometry of pneumonia. This was done, by observing changes in consistency, texture, colour and degree of distribution as described by Lopez (2011). The extent of pneumonia was also determined by visual observation, palpation and measurement of the lesion. This was then manually plotted onto a lung diagram for estimation as a percentage of each lobe and for morphometric evaluation. The degree of pulmonary consolidation as a percentage of the total lung volume was estimated (Emikpe and Akpavie 2011).

Statistical analysis

Data was summarized as means $\pm$ standard errors of the means (S.E.M). The percentage pulmonary consolidation scores were expressed and descriptively analysed. Means were compared by Chi square test, Correlation, ANOVA at 5% significance using SPSS version 16.

Results

Prevalence of GIT parasites in the examined goats

Of the 430 goats examined, the overall prevalence of GIT parasites infection was 316 (74%), with eggs and oocyst of nine genera of parasites observed, and 114 (26%) negative for GIT parasites. The GIT parasites include 7 genera of nematode, 1 genus of cestode, and 1 protozoan (*Eimeria* sp.). 120 (28%) had single infection while 196 (46%) had multiple GIT parasitic infection.

Of these, 39 (9%) had nematode infection, and 81 (19%) had coccidian infection. *Eimeria* species was most prevalent 81 (19%), followed by *Trichuris* species 22 (5%), while the least were *Bunostomum*, *Trichostrongylus* and *Nematodirus* species, with a prevalence of 1 (0.2%) each (Table 1).

In the multiple parasitic infections, two or more parasites co-existed. *Eimeria* sp and *Trichuris* sp co-existed more with 65 (15% prevalence), followed by *Eimeria* sp, *Trichuris* sp, and *Oesophagostomum* spp with a prevalence of 32 (7.4%), while *Eimeria* sp and *Oesophagostomum*, sp had 29 (7%) prevalence. The difference observed in parasite prevalence was not statistically significant ($p > 0.05$) (Table 1).

Prevalence of GIT parasites in relation to breeds, age and body condition score (BCS) of the examined animals

All the three breeds examined were positive for GIT parasites; the RS had the highest prevalence for parasite 37%, while the cross had the least prevalence 13%. The mean eggs per gram ($2.03 \pm 0.4 \times 10^3$) of the WAD breed was higher compare to the RS and Cross breeds, though there was no significant difference ($X^2 = 3.4$; $df = 2$; $p > 0.05$) in the prevalence and mean EPG of faeces across the different breeds. The animals in the age group of <1–1 year had the highest prevalence for GIT parasites, with the highest number of eggs per gram ($2.10 \pm 0.4 \times 10^3$) recorded in animals of age >1–2 years as compared to others. However, there was no significant difference ($X^2 = 0.50$; $df = 2$; $p > 0.05$) in the prevalence of parasites across the various group.

Effect of gastrointestinal parasites on BCS in examined breeds of goat

Most [224 (52.1%)] of the animals examined had a fair body condition and the breed with the highest number of animals with a fair body condition was the RS having 108 (25%), while the least was the cross breed having 49 (11%).

The prevalence of GIT Parasites across the various BCS of the examined animals was seen to be highest in those with fair body condition 59 (26.3%), while the least was found in animals with a good body conditions having 3 (23.1%) prevalence. The highest number of eggs per gram ($1.92 \pm 0.3 \times 10^3$) was recorded in animals with a poor body condition, with no significant difference ($X^2 = 12.8$; $df = 6$; $p > 0.05$) in the prevalence and mean EPG of faeces across the various BCS (Table 2).

Prevalence of pneumonia

Of the 430 lungs examined, 251 (58.4%) were found to be pneumonic, while 179 (41.6%) were normal. The Lung Consolidation Score (LCS) was estimated across the examined breeds. The highest consolidation was observed in RS (121) with 48.2% degree consolidation, followed by WAD (86), having 34.2% degree of consolidation, while the least was observed in the cross breed (44) which had 17.5% degree of consolidation.

Of the three breeds, the RS had the highest prevalence of both pneumonia and GIT parasite 24.2%, which was followed by the WAD having 15.3% prevalence rate and the least was seen in the cross breed with 8.6% prevalence rate. Most [207 (48.1%)] of the goats had both pneumonia and gastrointestinal parasites, with an odd ratio (risk estimate) of 3.18 ($p < 0.05$) as compared to the other goats negative for both GIT parasites and Pneumonia 79 (18.4%). There was a strong positive correlation ($+0.243$, $p = 0.00$) of occurrence of GIT parasite and Pneumonia ($p < 0.05$) across the breeds of goat.

The Lung Consolidation Score (LCS) was also estimated across the BCS of the animals. The highest degree of consolidation was seen in animals with poor body condition (65%), and the least degree of consolidation was seen in animals with good body condition (38%). The highest prevalence of GIT infection with lung consolidation was seen in animals with poor body conditions 109 (25.3%), which were followed by animals with fair body condition 94 (21.9%).

Gastrointestinal worm load and histological classification of pneumonia

There are differences in the intensity of parasites across different histological classifications of pneumonia

Table 1 The prevalence of gastrointestinal parasites in the examined goats

GIT parasites	Number positive	Prevalence (%)
Single infection		
<i>Eimeria</i> spp.	81	19
<i>Trichuris</i> species	22	5
<i>Oesophagostomum</i> species	14	3.3
<i>Bunostomum</i> species	1	0.2
<i>Trichostrongylus</i> species	1	0.2
<i>Nematodirus</i> species	1	0.2
Mixed infection		
<i>Eimeria</i> + <i>Trichuris</i>	65	15
<i>Eimeria</i> + <i>Oesophagostomum</i>	29	6.7
<i>Trichuris</i> + <i>Oesophagostomum</i>	5	1.2
<i>Eimeria</i> + <i>Trichuris</i> + <i>Oesophagostomum</i>	32	7.4
<i>Eimeria</i> + <i>Trichuris</i> + <i>Oesophagostomum</i> + <i>Strongyloides</i>	10	2.3
<i>Eimeria</i> + <i>Oesophagostomum</i> + <i>Strongyloides</i>	12	2.8
<i>Trichuris</i> + <i>Oesophagostomum</i> + <i>Strongyloides</i>	3	0.7
<i>Oesophagostomum</i> + <i>Strongyloides</i>	1	0.2
<i>Eimeria</i> + <i>Trichuris</i> + <i>Oesophagostomum</i> + <i>Strongyloides</i> + <i>Haemonchus</i>	1	0.2
<i>Trichuris</i> + <i>Oesophagostomum</i> + <i>Moniezia</i>	3	0.7
<i>Trichuris</i> + <i>Moniezia</i>	2	0.5
<i>Eimeria</i> + <i>Trichuris</i> + <i>Moniezia</i> + <i>Trichostrongylus</i>	1	0.2
<i>Eimeria</i> + <i>Moniezia</i> + <i>Trichostrongylus</i>	1	0.2
<i>Eimeria</i> + <i>Trichuris</i> + <i>Moniezia</i>	4	0.9
<i>Eimeria</i> + <i>Moniezia</i>	4	0.9
<i>Eimeria</i> + <i>Oesophagostomum</i> + <i>Moniezia</i>	1	0.2
<i>Eimeria</i> + <i>Trichuris</i> + <i>Oesophagostomum</i> + <i>Bunostomum</i>	1	0.2
<i>Bunostomum</i> + <i>Haemonchus</i>	2	0.5
<i>Eimeria</i> + <i>Bunostomum</i>	2	0.5
<i>Trichuris</i> + <i>Haemonchus</i>	1	0.2
<i>Eimeria</i> + <i>Trichuris</i> + <i>Oesophagostomum</i> + <i>Strongyloides</i> + <i>Haemonchus</i>	1	0.2
<i>Eimeria</i> + <i>Trichuris</i> + <i>Oesophagostomum</i> + <i>Haemonchus</i>	1	0.2
<i>Eimeria</i> + <i>Trichuris</i> + <i>Haemonchus</i>	2	0.5
<i>Eimeria</i> + <i>Trichostrongylus</i>	2	0.5
<i>Eimeria</i> + <i>Nematodirus</i>	6	1.4
<i>Trichuris</i> + <i>Nematodirus</i>	4	0.9
Total	316	74

($p > 0.05$). Granulomatous pneumonia had the highest intensity (Table 3).

Discussion

This study showed that goats are still commonly infected with a variety of gastrointestinal parasites in our environment. This was accompanied with high faecal egg count, and infectious agents associated with respiratory conditions. The findings on the GIT parasites are slightly higher to reports of Oluwayiose et al. (2014) with helminthes

prevalence of 38.7% and Biu et al. (2009) who also reported prevalence of 51.3% in ruminants. This may not be unconnected to the study duration and seasonal influences.

The prevalence rate for different classes of parasite found in goats this study was in agreement to findings of Hassan et al. (2013), who reported *Ascaris lumbricoides*, *Bunostomum trigonocephalum*, *Chabertia*, *Haemonchus contortus*, *Oesophagostomum columbianum*, *Strongyloides papillosus*, *Trichostrongylus columbriformis*, *Fasciola hepatica*, *Paramphistomum*, *Moniezia expansa* and *Eimeria* in goats from northern Nigeria. Another similar study was carried out in the South-eastern part of Nigeria by

Table 2 The prevalence of GIT parasites in relation to breed, age and body condition score

Breed	Number examined	Number infected
RS	209 (48.6%)	159 (37.0%)
WAD	133 (30.9%)	99 (23.0%)
Cross	88 (20.5%)	58 (13.5%)
Total	430 (100%)	316 (73.5%)
Age		
<1–1	26 (6.0%)	20 (76.9%)
>1–2	159 (37.0%)	119 (74.8%)
>2–3	245 (57.0%)	177 (72.2%)
Total	430 (100%)	316 (73.5%)
Body condition score		
Good	13 (3.0%)	3 (23.1%)
Fair	224 (52.1%)	59 (26.3%)
Poor	193 (44.9%)	38 (19.7%)
Total	430 (100%)	100 (23.3%)

Fakae (1990) who reported *Strongyle* 260 (73.4%), *Strongyloides* 28 (7.9%), Tape worm 3 (0.8%), *Trichuris* 3 (0.8%), *Coccidia* 16 (46.6%), and *Moniezia* *expensa*.

The high prevalence of *Eimeria* species in this study is similar to that observed by Gorski et al. (2004) and Solomon-wisdom et al. (2014), who in their study recorded *Eimeria* species to be the overall highest prevalence rate of single infection at 24.1 and 41.60% respectively. Likewise, Kanyari (1993) reported high prevalence of coccidiosis in Kenyan livestock. This high prevalence may be due to the fact that *Coccidia* oocyst is highly resistant to adverse environmental conditions, and they can survive in the environment for a long period of time.

The high prevalence of nematode species indicates the resistance of these parasites because of their efficient life cycle and complicated biology (Smyth 1996). Our observation corroborates the reports of Edosomwan and Shoyemi (2012) on gastrointestinal helminth parasite especially *Trichuris* species infecting cattle and goats.

However, the absence of trematode in this study may be due to unfavourable conditions required for the development and transmission of the parasite (Soulsby 2006) and or resistance in the host. Also, the rate of *Moniezia* species co-infection with other parasites, agrees with the findings of 6.8% prevalence by Amadi et al. (2012). Urquhart and Amour (1997) suggested low occurrence of species amongst the helminth infections of ruminants. Cestodes were however, rarely reported in most environments probably due to their complex life cycles, while oribatid mites play critical role in transmission of *Moniezia* species (Kumsa et al. 2011).

The prevalence of helminth co-infection was high as compared to single helminth infection. This could be due to

tolerance and or immunosuppression in the host animals. This is in agreement with the findings of Githigi et al. (2005) and Kumsa et al. (2011). The high prevalence of multiple helminth infection in the animals may also be due to the nature of management of these goats. Poly-parasitism has been suggested to be an important contributor to economic losses in sheep and goat production (Wang et al. 2006; Kumsa et al. 2010).

The Red Sokoto breed was found to have the highest rate of helminth infection as compared to the other breeds. This agrees with the reports of Baker et al. (2001) and Hassan et al. (2013) who reported breeds differences in small ruminants. However, the parasite intensity was significant in the WAD, as observed by Onyenwe et al. (2005). However, the high parasite intensity in the WAD goats may be attributed to the ecological adaptation in the breed. In contrast, the less humid zone of the Savannah which is characterized by dry and hot weather condition may account for the low parasite intensity in RS goats. The observed low EPG in the cross breed may be due to increased immunity acquired over time and or resistance (Bisset et al. 1996).

The influence of age on the prevalence of GIT parasitism was highlighted, and more susceptibility of younger animals to the parasites. Shirale et al. (2001) reported 85.2% prevalence of parasite in suckling goats. Bashir et al. (2012) reported 97.99% prevalence. Studies of Sissay (2007) and Solomon-wisdom et al. (2014) also reported a high prevalence of gastrointestinal parasite prevalence in younger goats. Raza et al. (2007) also considered age as an important risk factor in gastrointestinal helminthiasis. This could probably be that older animals have developed resistance to infection from repeated exposure (Urquhart et al. 1996; Tasawar et al. 2010; Dagnachew et al. 2011). Furthermore, the EPG load of animals >1–2 years was significant compared to animals in the other age groups, however, this is in contrast to findings of Regassa et al. (2006), who reported no association between EPG and age of animals.

Likewise the high prevalence of pneumonia in this study underscores its importance in this livestock. The high consolidation RS, and goats with poor body condition may reflect the role of transport stress and breed predisposition to pneumonia (Asare et al. (2016). Study conducted also by Asare et al. (2016) reported 4.07% prevalence of pneumonia in slaughtered goats in Ghana while Omoike (2006) also reported 20.3% prevalence of pneumonia in goats from other parts Nigeria. These suggest that pneumonia is still a common respiratory disease of goat, and that its co-existence with gastrointestinal parasites may further aggravate loss of condition in small ruminants.

The increase incidence of pneumonia corresponded with gastrointestinal parasitism in these animals. Gastrointestinal parasitism with lung consolidation was more in goats with poor body conditions. This underscores systemic

Table 3 The distribution of eggs per gram of GIT parasites across BCS, breed, age and pattern of pneumonia in examined goats

BCS	Total number	Intensity (epg) mean $\times 10^3$	<i>p</i> value
Good	13	0.46 $\pm$ 0.2	0.44
Fair	224	1.85 $\pm$ 0.3	
Poor	193	1.98 $\pm$ 0.3	
Total	430	1.84 $\pm$ 0.2	
Breed			
WAD	133	2.03 $\pm$ 0.4	0.32
RS	209	1.96 $\pm$ 0.3	
Cross	88	1.27 $\pm$ 0.2	
Total	430	1.84 $\pm$ 0.2	
Age			
<1–1 year	26	3.32 $\pm$ 0.1	0.05
>1–2 years	159	2.09 $\pm$ 0.4	
>2–3 years	245	1.52 $\pm$ 0.2	
Total	430	1.84 $\pm$ 0.2	
Pneumonia			
Normal	164	1.43 $\pm$ 0.3	0.05
Bronchopneumonia	176	2.24 $\pm$ 0.3	
Interstitial pneumonia	71	1.79 $\pm$ 0.5	
Good	13	0.46 $\pm$ 0.2	
Fair	224	1.85 $\pm$ 0.3	
Poor	193	1.98 $\pm$ 0.3	
Embolic pneumonia	3	3.88 $\pm$ 1.7	
Atelecstasis	2	0.10 $\pm$ 0.1	
Verminous pneumonia	1	9.00 $\pm$ 0.0	
Vascular change	5	1.05 $\pm$ 0.5	
Emphysematous	6	2.03 $\pm$ 1.1	
Granulomatous pneumonia	2	3.28 $\pm$ 0.8	
Total	430	1.84 $\pm$ 0.2	

involvement of these conditions manifested clinically as debilitation. The differences in worm loads in goats with different histological classifications of pneumonia were not remarkable. However, the strong correlation observed with occurrence of helminthes and granulomatous pneumonia suggests humoral signaling with downplay of cellular immune response. More so, our observation has shown that the goats are often dehydrated and of course there is loss of protein (protein losing gastroenteropathy) from the overwhelming gastrointestinal parasitism, which may lead to fluid imbalance and accumulation of fluid in tissue spaces. Fluid accumulation in the lung (pulmonary oedema) would impede pulmonary defense mechanisms thus allowing normal flora in the respiratory tract or other pathogens to precipitate pneumonia.

In conclusion, body condition scoring may be a reliable indicator for clinical assessment of gastrointestinal parasitism and pneumonia in goats. More so, breed and age may predispose goats to helminthiasis and pneumonic conditions. Seasonal variation may also contribute to the enzootic nature of these conditions in our environment. Also, hypoproteinaemia arising from gastrointestinal parasitism may not be unconnected to pulmonary oedema and pneumonia. Further studies are being carried out to elucidate the possible mechanisms involved in the observed interactions. Possibility of combined vaccines is also being considered in the nearest future.

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Author's contribution MOA and EBO conceptualised the project. AMT and JTA took samples and carried out laboratory analysis, and drafted the manuscript. EBO and MOA interpreted findings, and edited manuscript.

Compliance with ethical standards

Conflict of interest All the authors declare that they have no conflict of interest.

Ethical approval All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

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