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Breed and Environmental Effects on Faecal Egg Counts in Sheep of Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author BSD designed the study, performed the statistical analysis and wrote the draft manuscript. Author STM wrote the protocol. Author GSD managed the literature searches. All authors read and approved the manuscript.

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ABSTRACT

This study was conducted on the Jos Plateau to investigate the influence of genotype and some non genetic factors on resistance of Nigerian sheep to helminthosis. The study sheep included initial stock of 64 yearlings (12 each of Balami, and Uda, and 20 each of Yankasa, and West African Dwarf, WAD, in a sex ratio of 1:1 per breed) and later their 156 offspring were included. Faecal samples were collected 6-weekly according to breed, sex, age, date, parity, birth type, and body condition score (BCS), and analysed for worm faecal egg counts (FEC) in eggs per gramme of faeces (epg) over a period of three years using modified McMaster method. Gastrointestinal helminths observed were *Strongyles, Strongyloides, Trichuris, Nematodirus* and *Moniezia* among which effect of investigated factors varied accordingly. Based on mean total helminths faecal egg counts (THFEC), rankings were: WAD (693.1 epg) > Yankasa (633.2) > Balami (494.5) = Uda (484.5); $p<0.001$, for breeds; late rainy (620.1) > early rainy(561.4) = early dry(556.4) > late dry(525.5), $p<0.05$ season. Females and adults had higher THFEC than males and lambs respectively. Higher FEC were associated generally with lower body condition scores (BCS). Year, birth type and parity did not affect FEC Generally.

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Conclusion: Nigerian sheep breeds vary in resistance and tolerance to helminthosis and this suggests that there is a genetic basis for FEC. This could be exploited through selective breeding for improvement.

Keywords: Nigeria; sheep; breed; environmental factors; helminthosis; faecal egg counts.

1. INTRODUCTION

The contribution of sheep to Nigeria's economy and their advantages over other farm animal species, cannot be over emphasized. However, optimum productivity is hampered by many constraints, severe one of which is gastrointestinal nematodes infection [1-3]. Losses occur through mortalities, reduced production due to subclinical parasitism and direct cost associated with control [4-11].

Endoparasites control options are limited in Nigeria as in most other sub-saharan countries of Africa. Existing procedures rely almost exclusively on the use of antihelmintics and grazing organization. However, the use of anti-helmintics by smallholder livestock producers is often hampered by cost or unavailability (1); or even by the fact that gastrointestinal worms have become resistant to some commonly used brands [12-14]. In addition, the use of antihelmintics has led to public health concern about chemical residue in animal products and environment [15]. Grazing management system that could help control worm infection are often impracticable and expensive to implement. Furthermore, the communal pastoral systems do not allow for regulated grazing as a means of lowering exposure to infective larvae on pasture. The pervasive occurrence of helminthos [16], the associated loss of production and increasing drug resistance are all major concerns [17,18]. Situations like these elicit the need to develop alternative or complementary worm control measures. Exploiting genetic (inherent) variation in host resistance is an attractive option for worm control and therefore improving the production efficiency of small ruminants.

Resistance is the ability of the host to prevent or evict infection, while tolerance is the ability of the host to maintain performance in the face of parasitic challenge [19-22]. Faecal egg counts (FEC), assessed as the number of eggs per gramme (EPG) of faeces, is a measure of resistance [19] and it best correlates with parasitic burden in sheep and thus far represents the best marker for resistance [20].

There have been many reports of variation among sheep breeds in resistance to internal parasites [23-33]. These reports except [28,31,32] are on non-Nigerian breeds of sheep. Information on differences among Nigerian sheep breeds is therefore scanty. The objective of the study is to use FEC to phenotypically assess parasitic resistance of sheep. The study is to specifically evaluate the effect of sheep breed (Balami , Uda, West African Dwarf - WAD and Yankasa), sex, age, parity, birth type, body condition score (BCS), year and season on FEC. This is with a view to open selective breeding as alternative worm control option that is simple, cheap, sustainable, does not result in anthelmintic resistance and free from problems of chemical residue in animal products.

Objective: This study shows that, Effect of breeding and climate to body condition score (BCS), and analysed for worm faecal egg counts (FEC) in sheep eggs.

2. MATERIALS AND METHODS

2.1 Location and Climate

The research was carried out at the teaching and research farm of Federal College of Education Pankshin, Jos Plateau. The Jos Plateau is a pear-shaped upland located in the middle of Nigeria between latitude $8^o$and 10^0north and longitudes 7^0 and 11^0 east, at an average attitude of 1,200m above sea level and reaches the highest peak in the Shere Hills where it stands at 1,766m. The upland stretches for approximately 104 km from north to south and 80 km from east to west covering an area of about 8,600km^2 (860,000 hectares). It is characterised by rocky hills separated by extensive plains, exhibiting a variety of land forms which provide excellent picnic resorts.

Jos Plateau has near temperate climate with average monthly temperatures ranging between 18^0 and 25^0C. It experiences an average humidity of 60% and rainfall of 14,00mm. Most of it is covered by extensive grassland and few trees. Light forests are however still found along some water courses. Mbap and Ngere [34] aptly described the vegetation as montane. The grasses are generally green and nutritive during rainy season (April- October) but less so during the dry season (November - March). .

2.2 Sheep Used and their Management

The research commenced with a stock of 64 yearling sheep which comprised 12 each of Uda and Balami and 20 each of West African Dwarf (WAD) and Yankasa in a sex ratio 1: 1 per breed. The Uda and Balami were bought from Railway market in Bauchi, North Eastern Nigeria while the Yankasa and WAD were sourced from local farmers and markets within Plateau. At the time of purchase, the sheep were apparently healthy with good BCS ranging from 3.0-3.5. The animals were quarantined and acclimatized for 2 months. Later, 156 offspring of the starting stock produced from controlled breeding (only within breed mating) were included.

The sheep were housed in pens constructed with concrete blocks, floored and roofed with corrugated iron sheets. The females and a breeding ram of the same breed were kept together and all other males were collectively housed. Few days to lambing pregnant ewes were isolated and housed in a well littered lambing pen. After lambing, all necessary cleaning and identification processes were observed. New born lambs were kept with their ewes under close observation for 24 hours to ensure that they were suckled with colostrums. Ewes were allowed to graze without their lambs after 3 weeks of lambing. Throughout the period of the experimental study (January, 2012-December, 2014). Animals were grazed separately by sex on locally available pasture from 9:00am to 5:00pm. Crop residues such as legumes and corn stalks, leafy shrubs and herbs were made available. In the evening they were returned to the pen and provided with salt lick and supplementary maize offals, groundnut haulm, cowpea and corn husks. Drinking water was supplied *ad libitum*. Before the start of experiment, animals were dewormed twice at monthly intervals with levamisole and albendazole at dose rates of 7.5 and 5.0mg/kg body weight respectively and no deworming thereafter. Asuntol solution bath was carried out at quarterly intervals to control ectoparasites. Prophylactic treatment with oxytetracycline long acting (LA) was undertaken twice a year to prevent bacterial infections.

2.3 Faecal Sample Collection and Analysis

Faecal samples were collected directly from the rectum and sometimes as the animals defaecated using clean polythene bags. The collection was carried out 6-weekly. Samples were properly labelled with a masking tape showing breed, age, sex, parity, birth type, date of collection and body condition score (BCS). They were then stored at 4^0C until examination within three days.

Faecal samples were examined for the presence of eggs of various helminth species and faecal egg counts (FEC), measured as number of eggs per gramme of faeces (EPG) using the modified McMaster technique [35]. The eggs were identified as described [36].

2.4 Body Condition Scores

The body condition scores (BCS) were assessed by combining palpation of the sheep in the lumber region and around the backbone in the loin area immediately behind the last rib, as suggested [37]. The scores used in the study were 1.0, 2.0, 3.0, 4.0 and 5.0 for emaciated, thin, average, fat and obese respectively. Cases which did not fit these categories properly, i.e fell between whole numbers were assigned half scores as recommended [38] and additional scores of 1.5, 2.5 and 3.5 were therefore used.

2.5 Statistical Analysis

Data were analyzed using the General Linear Model of Statistical Package for Social Sciences version 22.0. Differences among breed, sex, year, season, age, parity, body condition score and birth type in terms of mean faecal egg count (FEC) were determined. Ryan-Einot-Gabriel-Welsch post hoc-test was performed to separate any more-than-two means that were statistically different.

Faecal egg counts data were ($\log_{10}$) transformed to correct for heterogeneity of variance. Preliminary analysis revealed non-significant interaction effects between fix factors. Interaction effects were therefore not included in the final model. The final linear model fitted is as follows:

$$Y_{ijklmnqr} = \mu + G_i + S_j + P_k + B_l + T_m + C_n + N_p + E_q A_r + e_{ijklmnpqr}$$

Where:

$Y_{ijklmnqr}$ = observable characteristic;
μ = overall mean;
G_i = i^{th} effect of breed (i = 1, 2, 3, 4);
Sj = j^{th} effect of sex (j = 1, 2);
P_k = k^{th} effect of parity (k = 1, 2, 3);
B_l = l^{th} effect of birth type (l = 1, 2, 3);
T_m = m^{th} effect of age (m = 1, 2);
C_n = n^{th} effect of body condition score (1, 2, 3, 4, 5, 6, 7);
N_p = p^{th} effect of season (p = 1, 2, 3, 4);
E_q = q^{th} effect of year (q = 1, 2, 3) and
$e_{jklmnpqr}$ = Random error effect.

3. RESULTS AND DISCUSSION

3.1 Breed

Faecal egg counts (FEC) in eggs per gramme (EPG) are presented in Table 1. There was significant (p<0.001) difference among breeds in mean FEC of individual helminth species and the total helminths except *Nematodirus*. West African Dwarf had the highest mean *Strongyles* FEC followed by Yankasa, Balami and Uda which did not vary significantly. Yankasa had the highest mean FEC of *Strongyloides* followed by WAD, Balami and Uda which also did not vary significantlty. Furthermore, for *Moniezia* mean FEC in Yankasa, WAD and Balami did not vary appreciably but Yankasa and WAD had significantly (p<0.001) higher mean FEC than Uda which inturn differed only slightly from Balami. Similarly, significantly (p<0.001) higher mean FEC of *Trichuris* was observed in WAD, followed by Uda, whose value did not vary statistically from Yankasa and Balami; while those of Balami and Yankasa also did not vary appreciably. Total helminths mean FEC was highest in WAD, followed by Yankasa, Balami and Uda which did not significantly differ.

Generally, Balami and Uda were the most resistant followed by Yankasa and WAD. Many reports have similarly indicated breed differences in sheep resistance to helminthosis [25,28,39,40,41,32]. It was reported that susceptibility to parasite varies according to breeds [42]. The following breeds were ranked in the order of increasing susceptibility to *Haemonchus contortus* as judged by FEC: Red Maasai, Blackhead Persian, Merino, Corriedale and Hampshire [25]. Rhoen sheep was found to have higher FEC than Merino [41]; while [42,43] stated that resistance to *H. contortus* as judged by FEC was better developed in Merino than Rhoen sheep. Katahdin and Barbado Blackbelly x St. Croix Lambs in South Virginia were more resistant with lower FEC than Dorset and Dorper breeds [40]. Similar to the present result [32] found Uda and Balami more resistant than Yankasa under communal management system on the Jos plateau. This further corroborated the report that Yankasa was more burdened by *Moniezia expansa, Trichostrongylus colubriformis and H. contortus* than Uda and Balami [31]. However, a report [28] stated that Uda sheep is more susceptible than Balami and Yankasa; while another did not find any significant difference between sheep breeds in helminthosis and attributed differences in results to differences in animal management and environment [44,45].

Variations in sheep breed resistance to helminthosis found in this study like in other previous ones strongly suggest genetic basis for resistance to infection. It was suggested [46] that there is significant association between parameters of resistance (faecal egg counts) and gene markers OAr, Cp73, DYMSI and BMI815. It has been [47] shown that the quantitative trait loci (QTL) for resistance to *T. colubriformis* in Merino sheep is located on chromosome 6. Many workers [2,48-53] have shown the significant role of major histocompatibility complex (MHC) in ruminant resistance to parasite. Accordingly, the MHC, interferon gama (IFNG) IgE, DRB genes and microsatellites on chromosomes 1,5 and 6 are involved in the resistance of ruminants to helminthosis. The polymorphism of MHC which varies with breed increases the range of parasites recognized by the immune mechanisms [2].

3.2 Sex

Females had significantly (p=0.001) higher *Strongyles* mean FEC than males (1568.4 EPG). Similarly, females' *Strongyloides, Trichuris* and total helminths mean FEC were significantly (p=0.001) more affected than males. *Moniezia* and *Nematodirus* egg counts did not show any significant difference between sex.

In the present finding, female sheep were generally susceptible. This conforms with many reports in literature [28,54-59] which showed that female sheep harboured higher worm loads than their male counterparts. The reason for higher worm burden in females than males could be attributed to peripaturient rise in faecal egg counts resulting from lowered immunity in ewes

[60] and post parturient lactation stress in ewes increases susceptibility to newly acquired infection during the periparturient period [44,61].

However, the present finding does not agree with some reports [23,62-65] who found higher densities of worms in males than female sheep. It was explained that female hormones (estrogens) had inhibiting effects on helminth parasites in contrast to those of male androgens [23]. Similarly it was suggested [66,67] suggested that sex differences in worm burden could probably be due to variation in hormones. In the present study, sex did not influence FEC of *Moniezia* and *Nematodirus*. This suggests that the effect of sex on helminthosis probably varies with helminth species.

3.3 Age

Young sheep had significantly (p=0.001) lower FEC of *Strongyles*, *Strongyloides, Trichuris*, *Nematodirus* and total helminths than older ones. No significant difference was observed between the age groups in mean FEC of *Moniezia.*

That suckling lambs in this study generally had lower FEC than older sheep concurs with some previous reports. Higher FEC have been reported in adult than young sheep [28,44,59,68-70]. Worm burden was found to increase with age [55]. The higher FEC in adults could be due to long exposure to infective stages in grazing fields which could have resulted in build- up of infection. The lower FEC in lambs may be attributed to the fact that they were not allowed to graze as frequently as older ones thereby lowering the possibility of infection. In addition, lambs fed mostly on milk.

In contrast to the present, some previous reports in East Africa [71], Nigeria [10,32,59] and Ghana [62] showed that young animals were more susceptible and less resilient to helminth infections than older ones. That *Moniezia* FEC was not influenced by age suggests that it might have not been a factor of infection in for some worm species. According to [58] the influence of age varied with worm species as they observed significantly lower *Strongyle* FEC in young that older sheep while the reverse was the case for *Strongyloides* and *Moniezia* FEC; while age did not influence *Trichuris* FEC.

3.4 Season

Significant differences were observed among seasons in *Strongyles*, *Moniezia* and total helminths FEC. *Moniezia* FEC was highest (p=0.001) in late rainy, followed by early rainy, early dry season and lowest in late dry season. Total helminths mean FEC of 561.4, 620.1, 556.4 and 535.5 EPG for early rainy, late rainy, early dry and late dry seasons respectively, significantly ($p<0.05$) differed. The highest value was observed in late rainy followed by early rainy and early dry which did not vary significantly while the lowest was in the late dry which only differed slightly from that of the early dry season. However, there was no significant difference among seasons in FEC values of most nematode species (*Strongyloides, Trichuris* and *Nematodirus*).

The FEC were generally higher in the rainy than dry seasons. This finding agrees with [31] and [58] in Bauchi and Maiduguri respectively, and [72] for nematode FEC in Kenyan sheep; while [73] recorded FEC values of 2710 in young and adult (2087) sheep in peak rainy which were significantly higher than the dry season values. It reported [74] reported that in Nigeria, worm larvae are most abundant on vegetation from May to October when large numbers are ingested with pasture. The period (May- October) coincides with the rainy season and therefore it confirms rainfall as one of the most epizootiological factors that affect egg and larva development [55,75]. It is reported [5] that in January which is dry season worm egg dropped to a minimum. In Kenya it was found that the levels of *Strongylid* infections tended to follow a relatively seasonal pattern from one year to another where peaks and troughs of variable magnitude occurred. The major peaks in egg output of Dorper yearlings were observed between December and August and were attributed to infections that occurred during and soon after the rain [76].

The present result also corroborates the fact that “worms work by the weather”[77]. Blood *et al.* (1983)78 stated that the most suitable condition for the translation of egg larvae in most helminth is a warm wet weather [78], and the most suitable climatic factors that determine the larval survival on pasture are temperatures, moisture and rainfall [79]. However, in contrast to the present result higher FEC of *Strongyle* in the dry than rainy season was reported in Brazil [80].

3.5 Body Condition Score

Body condition scores had effect on FEC of combined and individual helminths species except *Strongyloides*. Lower FEC values were generally associated with sheep with higher BCS and vice versa. For Strongyle FEC, lowest (p=0.01) value (709.6 EPG) was observed in sheep with BCS of 4.0 followed by 3.5 (1415.3 EPG), then 3.0 (1891.2 EPG), 2.5 (2067.6 EPG) and 2.0 (2055.3) which did not differ significantly, but were lower than for 1.5 (2481.0 EPG) while the highest was observed in animals with BCS of 1.0. Similarly, *Moniezia* FEC was significantly (P=0.01) higher in animals with BCS 1.0 and 1.5 with respective values of 102.1 and 73.2 EPG which only differed slightly as compared to those with BCS of 2.0 - 4.0. *Trichuris* FEC was highest (p=0.001) in animals with BCS of 1.0 (541.0 EPG) followed by BCS of 1.5 (216.0 EPG) and lowest in those with BCS 2.0, 2.5, 3.0, 3.5 and 4.0 with respective values of 133.7, 135.0, 91.1, 97.8 and 85.8 which did not statistically vary.

Furthermore, *Nematodirus* FEC was significantly (p=0.05) higher in animals with BCS of 1.0 and 1.5 with respective values of 573.2 and 545.5 EPG than those with BCS of 2.0, 2.5 and 3.0 which had respective values of 304.3, 307.1 and 307.1 that did not statiscally differ. Lowest value (258.0 EPG) was observed in animals of BCS 3.5 which was higher (p=0.05) than the 208.0 EPG of BCS 4.0. Similarly, significantly (p=0.001) higher total FEC was observed in

Table 1. Faecal egg counts (FEC) of Nigerian Sheep by breed and environmental factors

	All helminths	Str	Sld	Tri	Mon	Nem
Overall	568.3 ± 36.6	1946.8± 91.2	341.5 ± 34.3	171.5 ± 14.6	55.7 ± 9.4	366.2 ± 33.4
Breed						
Balami	494.5±47.4[a]	1619.1±122.9[a]	233.3±46.2[a]	135.0±19.7[a]	63.8±12.6[ab]	420.7±45.0
Uda	484.5±51.2[a]	1645.7±123.9[a]	164.4±46.6[a]	172.9±19.8[b]	63.5±12.7[a]	360.9±45.4
WAD	93.1±63.1[c]	2470.3±122.6[c]	357.6±46.1[b]	226.0±19.6[c]	82.1±12.6[b]	369.5±45.0
Yankasa	633.2±60.2[b]	2052.1±119.6[b]	610.6±45.0[c]	152.1±19.2[ab]	77.2±12.2[b]	313.8±43.8
Sex						
Male	465.5 ± 29.9[a]	1568.4±107.6[a]	268.5± 40.5[a]	128.7± 17.2[a]	55.4 ± 11.0	346.5 ± 39.4
Female	671.2 ± 38.0[b]	2325.2±101.3[b]	414.4± 38.1[b]	214.2± 16.2[b]	56.0 ± 10.4	386.0 ± 37.1
Age (Months)						
0-4	114.19± 4.34[a]	232.28±93.43[a]	100.54±34.84[a]	105.97±16.04[a]	40.38 ±10.73	91.78±16.04[a]
>4	555.40±102.50[b]	1872.9±71.49[b]	357.90±26.66[b]	143.51±12.27[b]	64.51 ± 8.21	338.18±25.20[b]
Season						
Early rainy	561.4 ± 43.1[b]	2885.2±119.4	332.1 ± 44.9	179.0 ± 19.1	61.9 ± 12.3[C]	388.7 ± 43.7
Late rainy	620.1 ± 44.1[c]	2030.3±121.8	405.0 ± 45.8	198.8 ± 19.6	86.7 ± 12.5[d]	419.6 ± 44.6
Early dry	556.4 ± 41.2[ab]	1938.3±117.8	331.5 ± 44.3	159.0 ± 18.9	46.0 ± 12.1[b]	347.3 ± 43.1
Late dry	535.5± 44.7[a]	1933.5±119.9	297.2 ± 45.1	149.1 ± 19.2	28.2 ± 12.3[a]	309.4 ± 43.9
Year						
2012	558.7 ± 25.8	1952.3±104.2	309.6 ± 39.2	173.0 ± 16.7	48.5 ± 10.7	350.2 ± 38.2
2013	577.9 ± 29.9	1941.3 ±99.3	373.2 ± 37.4	169.9 ± 15.9	62.9 ± 10.2	382.3 ± 36.4
2014	575.7 ± 23.7	2009.4±103.3	364.2 ± 40.2	174.5 ± 70.2	52.3 ± 10.3	357.4 ± 39.3
BCS						
1.0	3936.6±333.0[d]	2968.± 463[e]	383.0±103.7	541.0±44.2[c]	102.1±9.4[b]	573.2±101.1[c]
1.5	3891.9±559.1[d]	2481.0±275[d]	266.6±174.2	216.0±74.1[b]	73.2±15.41[b]	545.5±169.6[c]
2.0	2829.8±110.4[c]	2055.3±91[c]	322.3±34.4	133.7±416[a]	62.7±7.2[a]	304.3±33.5[b]
2.5	2928.7±207.8[c]	2067.6±172[c]	402.1±64.8	135.0±27.6[a]	66.9±17.7[a]	307.1±25.5[b]
3.0	2723.0±84.1[c]	1891.2±69[c]	351.1±26.2	91.1±11.2[a]	51.5±26.7[a]	307.1±63.1[b]
3.5	2151.8±1809.9[b]	1415.3±149[b]	307.2±97.8	97.8±24.0[a]	34.9±17.5[a]	258.0±95.2[a]
4.0	1420.0±313.8[a]	709.6±259[a]	358.0±56.4	85.81±14.7[a]	31.6±17.0[a]	208.5[a]±54.9
Birth type						
Single	341.33±53.12	433.89± 62.70	81.02±11.01	72.81±16.15	75.91±15.25	113.53±19.59
Twins	352.40±57.44	473.64±73.59	72.23±12.93	81.78±18.96	73.14±17.90	116.60±22.99
Triplet	356.47±60.	484.41±127.7	54.78±22.43	99.60±32.89	72.31±31.06	112.69±39.89
Parity						
1	366.70±80.30	551.76± 72.57	74.75±12.75	64.39±18.69	77.61±17.65	120.81±22.67
2	342.7±72.83	395.63±76.68	63.26±13.51	100.77±19.81	82.57±18.70	126.86±24.02
3	332.84±68.32	444.55±104.8	70.01±18.41	89.03±27.0	61.173±25.49	95.15±32.74

Str= Strongyles, Sld=Strongyloide, Tri= Trichuris, Mon= Moniezia, Nem=Nematodirus. Means in the same column with different superscripts differ significantly, (p<0.05) animals with BCS 1.0 and 1.5 with respective values of 3936.6 and 3891.9 EPG which did not significantly differ. These were followed by BCS of 2.0, 2.5 and 3.0 with respective values of 2829.8, 2928.4 and 2723.8 EPG which did significantly differ, but were higher than BCS 3.5 with 430.4 EPG, while lowest value (284.0 EPG) was in animals with BCS of 4.0.

The present result indicated a negative association between BCS and FEC. Significant differences between the FEC of fat, thin, emaciated and average sheep was reported. Thin and emaciated sheep had higher FEC than sheep with average/moderate ones [59]. This may be associated with pathogenic effects of gastrointestinal parasites. The main features of helminth in ruminants include anaemia, diarrhea and heamorrhagic gastroenteritis which causes protein- loss enteropathy, hypoproteinamia, poor weight gain and low body condition [59,81,82,83]. However, it has been reported that there is no association between BCS and FEC [84].

3.6 Year, Parity and Birth Type

There was no significant difference among years in FEC of total helminths and individual species (*Strongyles, Strongyloides, Moniezia, Trichuris, Nematodirus*). The FEC ranged from 558.7±25.8 EPG in 2012 to 577.9±29.9 EPG in 2014. Similarly, there was no significant difference among birth types in FEC of total and individual helminth species. Total FEC ranged from 341.33±53.12 EPG in single birth type to 356.47±60.00 EPG in triplet birth type. Similarly, no significant difference was observed among parities in FEC of all and individual helminths. The total FEC ranged from 332.84±68.32 EPG in third parity to 366.70±80.30 EPG in first parity. That effect of year, birth type and parity on FEC were not significant could have been due to stability in climatic condition and the uniform management practiced. Conversely, significant differences in log transformed FWEC were found among lambs born in different years [85].

4. CONCLUSIONS AND APPLICATIONS

Nigerian sheep breeds vary in susceptibility to helminthosis; Yankasa and WAD being more susceptible but tolerant compared to Balami and Uda. Helminth infections are higher in female and older sheep than males and suckling lambs respectively. Helminth infection is higher in wet than dry season. Sheep with low BCS have high FEC. Year, parity and birth type had no influence on resistance.

Breed variation in resistance and tolerance to helminthosis should be exploited through selection and cross breeding to control the disease without or with minimal use of anthelminthics. The tolerance of WAD and Yankasa requires further investigation. Greater attention should be paid to older sheep (≥ 4 months), females and rainy seasons in worm control.

CONSENT

It is not applicable.

ETHICAL APPROVAL

Animal Ethic committee approval has been taken to carry out this study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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