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Relative resistance to gastrointestinal nematode parasites in Dorper, Katahdin, and St. Croix lambs under conditions encountered in the southeastern region of the United States

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Abstract

A study was conducted to evaluate the relative resistance to a natural or induced gastrointestinal (GI) nematode infection in hair and wool breeds of lambs. In Experiment 1, natural GI nematode infection was evaluated among fall born Dorper crossbred (DO; $n = 17$) or St. Croix (SC; $n = 17$) lambs. Ewe and wether lambs were weaned at 84 ± 1.1 days of age and dewormed. Fecal egg counts (FECs) and blood packed cell volume (PCV) were determined between weaning and 56 days later. In Experiment 2, natural GI nematode infection was evaluated among spring born DO (7/8 or 3/4 Dorper; $n = 24$), Katahdin (KA; $n = 26$), SC ($n = 8$), and Suffolk (SU; $n = 10$; wethers only) ewe and wether lambs from weaning (60 ± 1.3 days of age; April) to 115 ± 1.3 days of age (June). In both studies, lambs grazed bermudagrass overseeded with ryegrass, previously grazed with sheep, and were supplemented with 225–500 g of corn/soybean meal supplement. In Experiment 3, the relative resistance was examined among DO ($n = 8$), KA ($n = 8$), and SC ($n = 9$) ewe lambs to induced GI nematode infection (20,000 *Haemonchus contortus* L3). Lambs were weaned at 62 ± 2.3 days of age, dewormed 22 days later and inoculated 6 days later (Day 0). In Experiment 1, FEC was greater ($P < 0.04$) at weaning in DO lambs and PCV was similar between DO and SC lambs. In Experiment 2, FEC was greatest and PCV least in DO lambs when compared with other breeds (breed × time, $P < 0.003$). In Experiment 3, FEC was greater in DO and KA lambs compared with SC lambs ($P < 0.02$). By Day 42, four DO, six KA, and three SC lambs had been dewormed. With a low to moderate challenge, resistance to infection was similar among the three hair breeds examined and greater than the wool breed lambs. When the challenge escalated, St. Croix lambs were most resistant and Dorper crossbred lambs were similar or less resistant than Katahdin lambs.
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Keywords: Lamb; Hair breeds; Parasite tolerance

1. Introduction

Hair sheep can be integrated into a small to mid-sized sustainable farming system for meat production and vegetation management (Savage and Swetnam, 1990; Mueller et al., 1999; Fraser et al.,

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2001; Burke and Burner, unpublished observations of sheep in peach orchard, 2001). Management requirements of hair breeds is relatively low compared with traditional wool breeds because shearing is unnecessary and treatment for GI nematode parasites may be reduced due to resistance to infection (Courtney et al., 1985; Zajac et al., 1990; Gamble and Zajac, 1992; Wildeus, 1997). The latter is of utmost importance because current anthelmintics available, as well as some approved for other species, have become ineffective for controlling *Haemonchus contortus* (Miller and Barras, 1994; Wooster et al., 2001), one of the most economically and physiologically devastating GI nematode parasites affecting small ruminants.

St. Croix (Courtney et al., 1985; Zajac et al., 1990; Gamble and Zajac, 1992) and Katahdin sheep (Presson, 1986) are relatively resistant to GI nematode parasite infection. Dorper lambs, a South African breed of sheep introduced to the US in 1995, have not been evaluated under southeastern US conditions for parasite resistance. Mature Dorper crossbred ewes were nearly as resistant to nematode infection as St. Croix and Katahdin ewes and more resistant than Hampshire ewes with a moderate infection level (Burke and Miller, 2002). However, studies conducted in Kenya determined that Dorper sheep were less resistant to parasite infection than the Red Maasai (Mugambi et al., 1996, 1997; Baker et al., 1999). Lambs under 6 months of age are more susceptible to infection than older sheep (Schallig, 2000). The objective of these experiments was to compare the GI nematode parasite resistance of weaned Dorper lambs to that of St. Croix, Katahdin, and the more susceptible Suffolk breed to a natural pasture infection or an experimental *H. contortus* infection.

2. Materials and methods

All experimental procedures were reviewed and accepted by the Agricultural Research Service Animal Care and Use Committee in accordance with the NIH guide for the care and use of laboratory animals.

2.1. Experiment 1

The objective of Experiment 1 was to compare Dorper crossbred (DO; 1/2 Dorper–1/4 Romanov–1/4 St. Croix or 3/4 Dorper–1/4 Romanov; ewe: $n = 11$; wether: $n = 6$) with St. Croix (SC; ewe: $n = 7$; wether: $n = 10$) lambs for relative resistance to GI nematode infection under winter grazing pasture conditions. Lambs were born in October 2000 and weaned at 84 ± 1.1 days. Lambs were vaccinated against *Clostridium chauvoei*, *C. septicum*, *C. novyi* Type B, *C. haemolyticum*, *C. tetani*, and *C. perfringens* Types C and D (Covexin 8®) at weaning and 43 days later. Lambs were dewormed with ivermectin (Ivomec®, 0.2 mg/kg) at weaning (Day 0), typical of past management. Pastures consisted of 2.8 ha of bermudagrass overseeded with annual ryegrass. The bermudagrass remained dormant throughout the trial. The pastures had been recently grazed by sheep and were considered to be contaminated with GI parasites. All lambs were pastured together. Lambs were provided with up to 500 g per lamb per day of corn/soybean meal supplement (15.0% CP, DM) and had trace mineralized salt available ad libitum.

Fecal egg count (FEC), as determined by a modified McMaster technique (Whitlock, 1948), and body weight data was collected at Days 0, 28, and 56 post weaning. Blood packed cell volume (PCV) was determined at 14 days intervals. The study was terminated after the Day 56 fecal and blood collection.

2.2. Experiment 2

The objective of Experiment 2 was to compare Dorper crossbred (DO: 7/8 Dorper, $n = 9$; DS: 3/4 Dorper–1/4 St. Croix, $n = 15$) with Katahdin (KA; $n = 26$), St. Croix (SC; $n = 8$), and Suffolk (SU; $n = 10$) lambs for relative resistance to GI nematode parasite infection under summer grazing pasture conditions. Lambs born in February and March 2001 were weaned at 60 ± 1.3 days (Day 0). Hair breeds included both ewe and wether lambs, whereas SU breed included wethers only. All hair breed lambs were produced by the Agricultural Research Service, Booneville sheep flock. The SU lambs were purchased from a local producer at weaning. Hair breed lambs were not dewormed at weaning and had been exposed to infective pastures with dams before weaning. Lambs were vaccinated as described above. All lambs were pastured together on 2.8 ha of primarily bermudagrass at approximately 24 lambs/ha and were supplemented with up to 225 g per lamb

per day of corn/soybean meal mix. Lambs had access to free choice trace mineralized salt. All lambs within a breed group were dewormed with ivermectin (Ivomec®, 0.2 mg/kg) when FEC for that breed group was greater than 1000 epg.

FEC, PCV and body weight data was collected at Days 0, 28 and 56. The FEC for all breeds was greater than 1000 epg on Day 28, therefore, all lambs were dewormed with ivermectin (Ivomec® Sheep Drench, 0.2 mg/kg). Based on a FEC reduction test comparing Days 0 and 28, there was a 3.6-fold increase in FEC which indicated that the treatment was ineffective. Therefore, all lambs were dewormed with moxidectin (Cydectin®, 0.2 mg/kg) on Day 59 and study was terminated. A follow up FEC was conducted on Day 84 to evaluate the effect of moxidectin. Eggs in the feces collected on Day 56 were cultured to determine predominant genera of nematode.

2.3. Experiment 3

The objective of Experiment 3 was to evaluate Dorper crossbred (3/4 or 7/8 Dorper; $n = 8$) compared with KA ($n = 8$) and SC ($n = 9$) ewe lambs for relative resistance to GI nematode parasite infection to an induced infection with *H. contortus*. Lambs born in October 2001 were weaned at 62 ± 2.4 days of age and vaccinated as described previously. Lambs were housed in an open-sided barn with a concrete floor with free access to bermudagrass hay and trace mineralized salt. Lambs were supplemented with 500 g per head per day of a corn/soybean meal mix. Lambs were dewormed with levamisol (Tramisole soluble drench powder®; 8.0 mg/kg) and 6 days later FEC was determined to be less than or equal to 50 epg. Lambs then were inoculated with 20,000 *H. contortus* L3 (Day 0). FEC was determined every 7 days between Days 14 and 42 and PCV determined twice weekly during that time. Individual lambs were dewormed with moxidectin (Cydectin®, 0.2 mg/kg) if PCV was $\leq$15, and removed from the study. Lambs were weighed on Days 0 and 28. Too few animals remained on study (12 lambs removed) by Day 42 for meaningful comparison of body weight at that time. If lambs did not require anthelmintic treatment, for statistical comparison, number of days to treatment was considered 42.

2.4. Statistical analyses

Data were analyzed using the mixed models procedure of SAS (1996). The mathematical model used for PCV, FEC, and body weight included breed, sex, the interactions (Experiments 1 and 2), and a repeated statement for date of measurement (Littell et al., 1996). In Experiment 1, the 1/2 DO and 3/4 DO were pooled because they were not statistically different. Contrasts were determined using the PDIFF option in SAS. FEC data were log transformed: ln(FEC+1). Statistical differences among breeds between the two analyses were similar, therefore statistical inferences were made on transformed data and untransformed LS means were presented.

3. Results

3.1. Experiment 1

FEC were reduced 66.4% between Days 0 and 28 for both breed types in response to ivermectin. The FEC was greater in DO compared with SC lambs on Day 0 ($P < 0.04$), but similar after lambs were dewormed (breed × time, $P > 0.10$; Fig. 1A). The PCV was similar between breeds of lambs (Fig. 1B). Body weight was greater for DO compared with SC lambs on Days 0 ($19.6 > 17.4$ kg), 28 ($23.0 > 19.2$ kg) and 56 ($27.2 > 24.1$ kg; breed × time, $P < 0.03$). All variables examined were similar between ewe and wether lambs. Lambs gained between 119 (St. Croix) and 135 (Dorper) g per day ($P > 0.10$).

3.2. Experiment 2

On Day 56, FEC was greater and PCV least in DO lambs compared with all other breeds (breed × time, $P < 0.003$; Fig. 2). The FEC was greater in KA wether compared with KA ewe lambs ($2152.3 > 1682.0$ epg, $P < 0.02$), but FEC between sexes of DO, DS, and SC lambs and PCV between sexes of all breeds was similar. Fecal cultures indicated that *H. contortus* was the predominant (80–100%) nematode species, followed by *Cooperia* (8–18%) and *Trichostrongylus* (0–4%).

Body weight between sexes was similar. The SU lambs were heaviest and SC lambs lightest throughout the trial ($P < 0.001$; Fig. 3). If the initial body weight

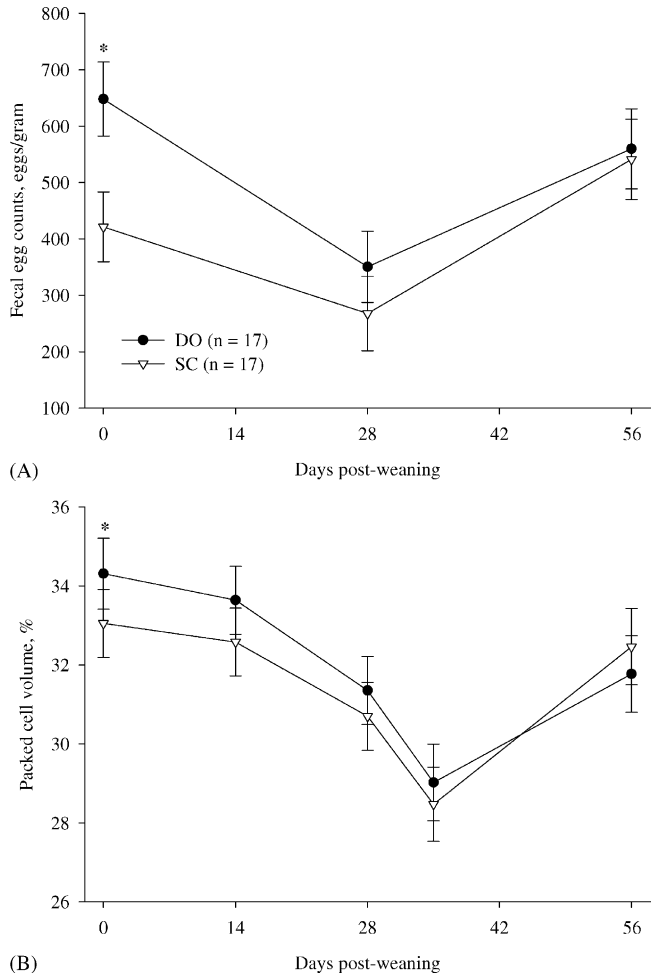

Fig. 1. Least squares means and standard errors of fecal egg counts (A) and packed blood cell volume (B) in Dorper crossbred (DO; closed circle) and St. Croix lambs (SC; open triangle) during winter natural pasture challenge infection. A breed × time interaction was detected for FEC ($P < 0.09$). The asterisk (*) indicates treatment with ivermectin (Ivomec®, 0.2 mg/kg).

was used as a covariate, body weights increased to a greater extent in SU compared with SC lambs (breed × time, $P < 0.001$). Or average daily gains were greater in SU (158 g per day) compared with SC (102 g per day) and KA (129.3 g per day) lambs ($P < 0.05$). Average daily gain of Dorper type lambs (DO, 127 g per day; DS, 132 g per day) was similar to other breed types.

3.3. Experiment 3

When lambs were artificially challenged with *H. contortus*, on all days measured, FEC was greater in DO compared with SC lambs (8602 > 4217 epg; $P < 0.005$) and tended to be greater in KA (5170 epg) compared with SC lambs ($P < 0.07$; breed effect, $P < 0.02$; Fig. 4A). FEC was similar between DO and KA lambs. PCV was greater in SC compared with KA lambs on Days 21 ($P < 0.02$) and 28 ($P < 0.08$; Fig. 4B), but otherwise was similar among breed types. The number of days before anthelmintic treatment was necessary tended to be greater for SC compared with KA lambs (DO: 35.9 days; KA: 31.8 days; SC: 38.1 ± 2.4 days; $P < 0.08$). By Day 42, 50% (four of eight) DO, 75% (six of eight) KA, and 33% (three of nine) SC lambs had been

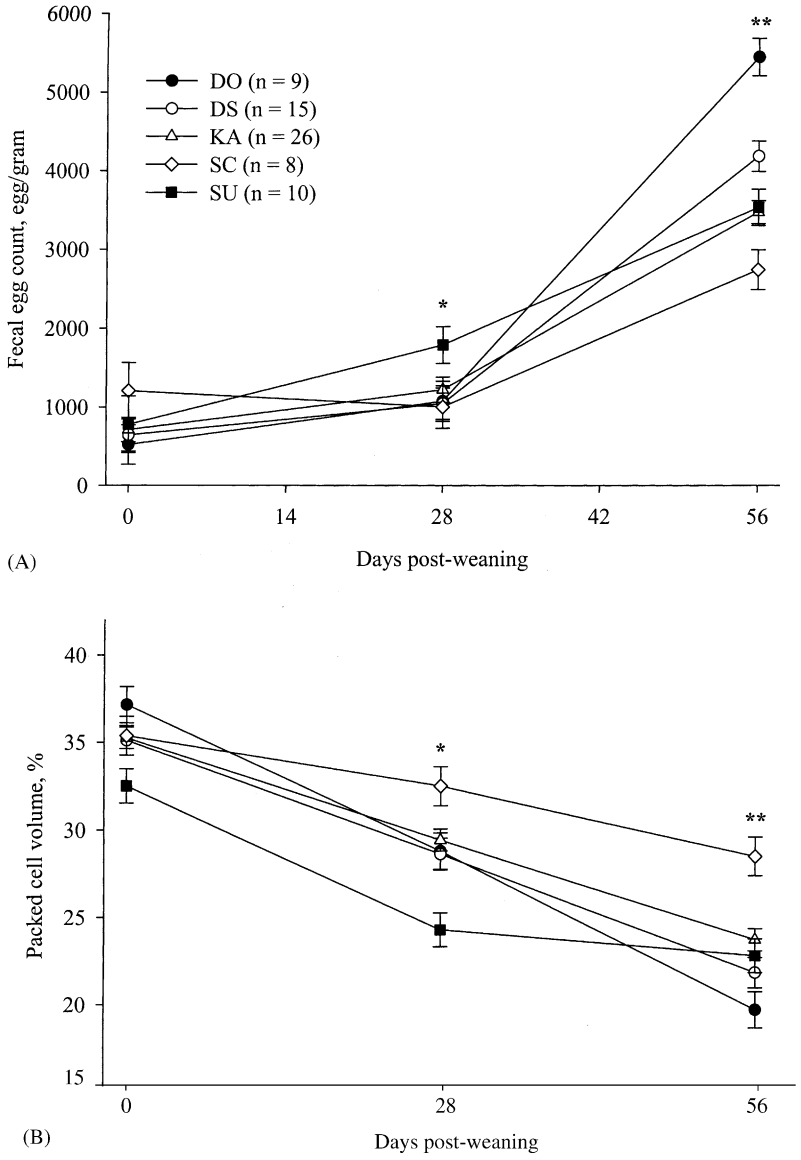

Fig. 2. Least squares means and standard errors of fecal egg counts (A) and blood packed cell volume (B) in 7/8 Dorper crossbred (DO; closed circle), 3/4 Dorper–1/4 St. Croix (DS; open circle), Katahdin (KA; open triangle), St. Croix (SC; open diamond), and Suffolk lambs (SU; closed square) during a summer natural pasture challenge infection. A breed × time interaction was detected for both variables ($P < 0.003$). The asterisk (*) indicates treatment with ivermectin (Ivomec®, 0.2 mg/kg) for all lambs. The double asterisks (**) indicate treatment with moxidectin (Cydectin®, 0.2 mg/kg).

dewormed. Number of lambs that remained in the study for FEC and PCV evaluation for each breed is indicated in Fig. 4 for each day of determination. The DO lambs were heaviest on Day 0 (DO: 26.2 kg; KA: 20.4 kg; SC: 19.0 ± 0.9 kg) and Day 28 (DO: 27.1 kg; KA: 20.6 kg; SC: 19.4 ± 0.9 kg; $P < 0.001$), but weight gain was similar among breed types.

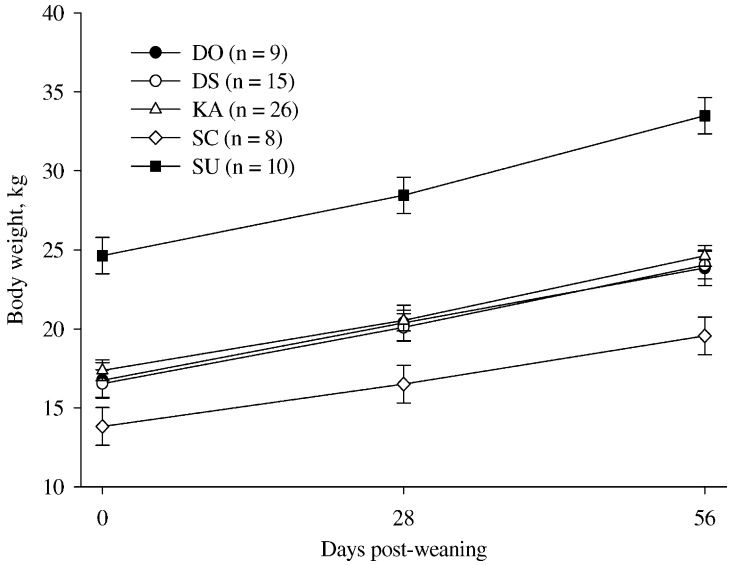

Fig. 3. Least squares means and standard errors of body weight in 7/8 Dorper crossbred (DO; closed circle), 3/4 Dorper–1/4 St. Croix (DS; open circle), Katahdin (KA; open triangle), St. Croix (SC; open diamond), and Suffolk lambs (SU; closed square). A breed effect was detected ($P < 0.001$).

4. Discussion

When the natural nematode challenge was relatively low (Experiment 1) or moderate (Experiment 2), FEC of Dorper lambs was greater compared with St. Croix or Katahdin lambs, but PCV, for most observations, was similar among the hair breeds. This suggests that under these conditions, physiological response to nematode infection was similar among hair breeds. When FEC was similar between Dorper and Suffolk lambs, PCV was greater for Dorper lambs, suggesting greater tolerance to the effects of haemonchosis. Resistance to infection in St. Croix lambs has been documented previously (Courtney et al., 1985; Zajac et al., 1990; Gamble and Zajac, 1992). Greater tolerance in Dorper compared with Hampshire sheep has also been documented (Preston and Allonby, 1979). When the challenge infection escalated (FEC $>$ 2500 epg) in association with the pasture acquired *H. contortus*, Dorper lambs were less resistant than any other breed. However, when lambs were experimentally inoculated with *H. contortus*, infection was similar between Dorper and Katahdin lambs. Although FEC declined in Katahdin lambs after 28 days (untransformed data), only two of eight lambs that had remained on the study were represented compared with five of eight Dorper lambs on Day 35 and four of eight lambs on Day 42 after inoculation. In fact, PCV in the Katahdin lambs declined at a greater rate between Days 14 and 21 after inoculation compared with Dorper and St. Croix lambs. The fact that more Katahdin lambs required anthelmintic treatment and that those treatments were administered sooner than those required for Dorper lambs suggests that they were more susceptible than Dorper lambs.

Resistance was similar in mature Katahdin and St. Croix ewes to a natural nematode infection (Burke and Miller, 2002). If Katahdin lambs are more susceptible to nematode infection than St. Croix lambs, this suggests that the host response that contributes to parasite resistance may be slower to develop in the Katahdin breed. Watson et al. (1994) attributes a similar immune unresponsiveness in Merino sheep to lower numbers of CD4+ and CD8+ cells and lower levels of specific antibodies. In addition, Schallig (2000) described increased peripheral blood eosinophils and mast cells in the abomasum of older compared with younger lambs, and suggested a deficiency exists in the Th_2 response to nematode infection in younger animals.

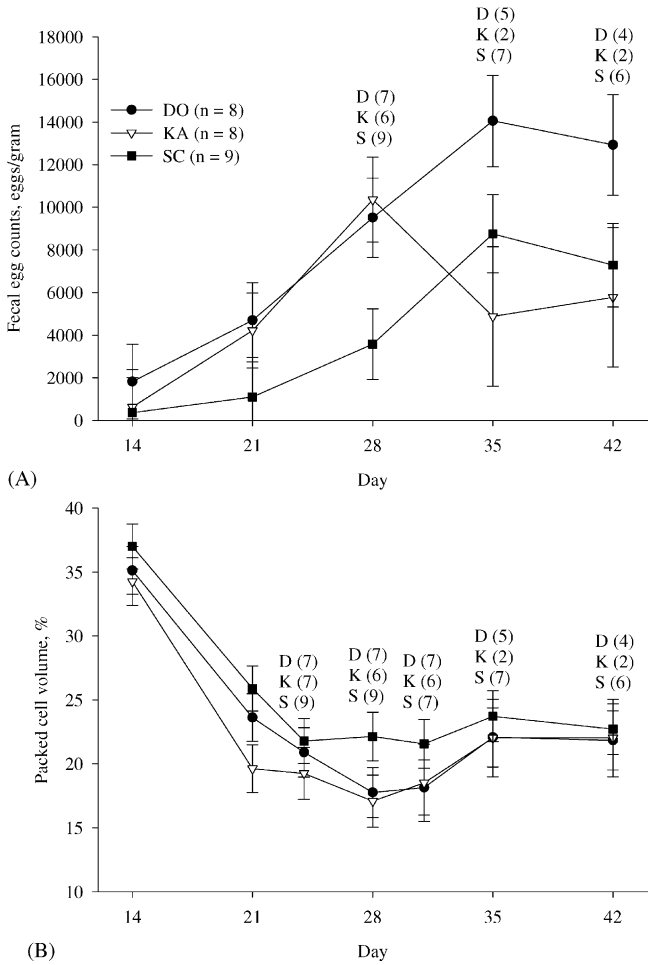

Fig. 4. Least squares means and standard errors of fecal egg counts (A) and blood packed cell volume (B) in Dorper crossbred (DO; closed circle), Katahdin (KA; open triangle), and St. Croix lambs (SC; closed square) after experimental infection with 20,000 *H. contortus* infective larvae (Day 0: day of inoculation). A breed × time interaction was detected for FEC ($P < 0.05$). Number of lambs per breed that remained in the study is indicated for each day of determination after treatment with anthelmintic became necessary.

Similarly, Gamble and Zajac (1992) and Bahirathan et al. (1996) noted that an age-related resistance was more pronounced in St. Croix compared with Dorset lambs and Gulf Coast Native compared with Suffolk lambs, respectively. More so, Courtney et al. (1985) reported earlier resistance in St. Croix compared with crossbred wool lambs.

Katahdin wether lambs were apparently more susceptible to nematode infection than ewe lambs in Experiment 2. Courtney et al. (1985) noted greater resistance of ewe compared with ram lambs after reaching puberty. A mechanism for a sex difference is unclear. The FEC, although significantly less in Katahdin ewe lambs, only differed by 606 epg.

The influence of St. Croix on infection levels was apparent in the 3/4 Dorper–1/4 St. Croix lambs compared with the 7/8 Dorper lambs in terms of FEC in Experiment 2. The St. Croix crossbreeding appeared to offer an advantage when the natural challenge escalated. Studies have demonstrated that F_1 crosses of a resistant and susceptible breed display an intermediate response to infection (Amarante et al., 1999a; Li et al., 2001). On the other hand, Amarante et al. (1999b) reported similar resistance of F_1 and resistant

(Florida Native) ewes compared with the susceptible (Rambouillet) breed, suggesting that maturity of animals used in the latter study was involved in resistance. Studies have shown that the Romanov breed, also used in the Dorper crossbreeding, appear to be susceptible to parasite infection (Gruner et al., 1986, 1992). Baker et al. (1999) noted that Red Maasai × Dorper ewes were as susceptible to *H. contortus* nematode infection as Dorper ewes, whereas the Red Maasai possessed parasite resistance. It is possible that the percentage Dorper lambs used in this study represent a more parasite resistant population compared with other Dorper sheep derived from South Africa due to the crossbreeding used in this flock. Nonetheless, the Dorper–St. Croix lambs used in this study seem to possess some parasite resistance.

Nematode resistance to ivermectin was apparent in Experiments 1 and 2 based on the observation that FEC were reduced by 66.4% in Experiment 1 and increased 3.6-fold in Experiment 2 after ivermectin treatment. Culture of fecal eggs indicated that *H. contortus* was the predominant (80–100%) nematode species. Ivermectin resistance by *H. contortus* has been documented (Miller and Barras, 1994; Wooster et al., 2001). The failure of treatment with ivermectin gave rise to an important observation that the lambs acquired a more intense nematode infection quickly. Subsequent treatment with moxidectin effectively eliminated the nematode infection and terminated the study.

In Experiment 1, St. Croix lambs gained less than Dorper lambs. Similarly, St. Croix and Katahdin lambs gained less than Suffolk lambs in Experiment 2. A desired rate of gain for wool breed lambs would be between 200 and 300 g per day (NRC, 1985) and has not been determined in hair sheep. The continuous nematode infection likely contributed to poor gains during these studies along with hot summer conditions in Experiment 2. In Experiment 3, lambs did not gain at all while under observation, which may be attributed to the relatively heavy challenge of the nematode infection as well as the stress of being housed on concrete.

5. Conclusion

Parasite resistance among hair breed lambs was similar when the nematode challenge was relatively low. Dorper lambs were more resistant to the infection than Suffolk lambs when infection was low in Experiment 2. However, as the nematode challenge escalated, resistance was greatest in St. Croix lambs, followed by Katahdin and Dorper lambs. Under the conditions of this study, it appears that the Dorper breed compares favorably with other hair breeds under low, but not high infection level conditions, as might be encountered throughout the southeastern United States.

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