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Short communication

Evaluation of parasite resistance to commonly used commercial anthelmintics in meat goats on humid subtropical pasture

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ABSTRACT

Anthelmintic-resistant gastrointestinal nematode parasites are a threat to small ruminant industry sustainability. Meat goat does were administered one of four anthelmintics orally (ivermectin (n = 18), moxidectin (n = 18), levamisole hydrochloride (n = 17), or albendazole (n = 19)) or water (n = 18). Fecal samples were collected pretreatment and 12 days post-treatment. Fecal egg counts (FEC) were determined by the modified McMaster technique. The FEC reduction percentages (FECR%) were calculated using three equations. Log transformed FEC means were analyzed by treatment, sire breed of doe, and doe age. Sire breed affected ($P < 0.05$) pretreatment FEC, but not post-treatment FEC ($P = 0.12$). Pretreatment FEC did not differ ($P = 0.21$) by treatment group. Posttreatment FEC varied ($P < 0.05$) by treatment. Anthelmintic resistance determinations were based on FECR% falling below 90% or 80%, dependent on equation applied. Resistance was detected to all four anthelmintics using each equation. These results suggest the need for alternative methods of internal parasite control in goats.

1. Introduction

Producers are having trouble with sustainable goat production due to a primary reliance on a commercial anthelmintics to treat and prevent outbreaks of gastrointestinal nematode parasites (GIN) in their herds (Calvete and Uriarte, 2013). A major global threat goat producers now face is anthelmintic resistance (Coles et al., 2006; Howell et al., 2008). Reduced productivity and increased morbidity and mortality rates are consequences of anthelmintic resistance in goat herds in parasite-rich environments. The most common way to test for anthelmintic resistance is the Fecal Egg Count Reduction Test (Calvete and Uriarte, 2013; McKenna, 2014). There are different equations used to determine anthelmintic resistance and the most effective equation is still debated (McKenna, 2013; Falzon et al., 2014).

The main anthelmintic classes are benzimidazoles, imidazothiazoles, and macrocyclic lactones (Mortensen et al., 2003; Coles et al., 2006). Some studies found GIN resistance to every class (Zajac and Gipson, 2000; Terrill et al., 2001; Abubakar et al., 2015). Macrocylic lactones (ivermectin, moxidectin), an imbazothiazole (levamizole), and a benzimidazole (albendazole) were compared on this study for resistance using different resistance equations.

2. Material and methods

2.1. Study animals

In June and July, 90 young does were managed on pasture for determination of anthelmintic resistance. Herd management protocols were approved by the Tennessee State University Animal Care and Use Committee. Does were crossbred and straightbred progeny of Boer (1 doe from 1 sire), Kiko (27 does from 8 sires), Myotonics (21 does from 4 sires), Savanna (28 does from 5 sires), and Spanish (13 does from 5 sires) sire breeds. The study population consisted of 22 primiparous 2-yr-old does (body weight = 27.6 kg (19.3–34.1 kg); packed cell volume = 21% (11–26%)) and 68 nulliparous yearlings does (body weight = 25.7 kg (18.6-33.2 kg); packed cell volume = 21.5% (13–27%)).

Does were semi-intensively managed in a humid subtropical area receiving 1222 mm of precipitation annually on the Tennessee State University research facility located along the Cumberland River (36°10′ N, 86°49′ W). The does grazed cool-season pastures containing predominantly tall fescue (*Festuca arundinacea*) and pastures consisting primarily of bermudagrass (*Cynodon dactylon*) during the warm season. The collections for this experiment took

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place in June and July when they were grazing predominantly bermudagrass. Grazing areas also contained several additional species of grasses, clovers, broadleaf weeds, and woody browse species. The herd received water and minerals for *ad libitum* consumption. The goat mineral mix contained a minimum of 13.5% Ca, 7% P, 1100 ppm Cu, 60 ppm Se, and 5000 ppm Zn.

The 2-yr-old does were administered LEV at parturition per routine herd management protocol, roughly 3 months before the study. The yearlings had not been dewormed as a group since weaning per routine herd health management, 12 months prior to this study. A few individual yearling does were treated primarily with LEV and ALB secondarily on an as-needed basis from 12 months to 3 month before the study.

2.2. Data collection and analysis

Does within each age group were divided into 5 similarly sized treatment groups balanced across sire breed. Groups orally received 795.2 mg (7 ml) of albendazole (n = 19, ALB, Valbazen Cattle, Sheep, and Goat Drench®, Zoetis Inc. Kalamazoo, MI), 30 mg (3 ml) of ivermectin (n = 18, IVE, Ivomec Cattle Injectable®, Merial Ltd., Duluth, GA), 417 mg (3 ml) of levamisole (n = 17, LEV, Prohibit Cattle and Sheep Drench®, Agrilabs Ltd., St. Joseph, MO.), 15 mg (3 ml) of moxidectin (n = 18, MOX, Cydectin Cattle Pour-on®, Boehringer Ingelheim Inc., St. Joseph, MO), and 5 ml of non-medicated water (n = 18). On average animals were administered anthelmintic dosages above recommended levels (IVE, 303%; MOX, 153%; LEV, 129%; ALB, 162%; Kaplan and Scharko, 2014). All goats on the study received anthelmintic dosages that exceeded recommended levels.

Fecal samples were collected immediately before treatment and 12 days after treatment. A small number of does (approximately 10%) were collected between 13 and 14 days due to inability to obtain sample after 12 days. The fecal samples were processed using the McMaster technique (Coles et al., 2006) to determine FEC with a detection limit of 50 eggs/g. Initial FEC (FEC1) and the post-treatment FEC (FEC2) were evaluated for significant differences based on treatment, age, and sire breed. The FEC values were transformed by log 10 (FEC + 1) for statistical analysis and back-transformed to geometric means. The FEC changes post-treatment were compared using three equations:

$$RT1 = 100(1 - [T2/T1]) \quad (1)$$

$$RT2 = 100(1 - [T2/T1] * [C1/C2]) \quad (2)$$

$$RT3 = 100(1 - [T2/C2]) \quad (3)$$

where T1 is FEC1 for a given treatment, T2 is FEC2 for a given treatment, C1 is FEC1 for the control group, and C2 is FEC2 for the control group. Each equation (Eq. (1), McKenna, 2013; Eq. (2), Dash et al., 1988; Eq. (3), Coles et al., 1992) has been recommended as a means of determining anthelmintic resistance. Anthelmintic resistance was considered present if Eq. (1) or Eq. (3) reduction of FEC was ≤ 90%. For Eq. (2), resistance was present if the reduction was ≤ 80%.

Statistical modeling was used to further evaluate treatment responses. Mixed model procedures of SAS (Cary, NC) were used to evaluate log transformed FEC1 and FEC2, relative change in log transformed FEC, and treatment responses using each reduction test. Doe age, sire breed of doe, and treatment were sources of variation tested. The Boer-sired doe was classified as Savanna, since the two breeds represent the same biological type of South African origin. For significant sources of variation, means were separated using the Tukey-Kramer test ($\alpha = 0.05$). Chi-square was used to assess the proportion of does meeting the threshold value for each reduction test equation.

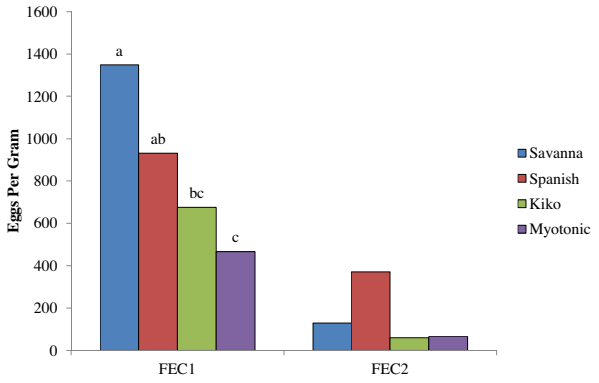

Fig. 1. Effect of sire breed on geometric mean fecal egg counts (FEC). FEC1 = Pretreatment FEC; FEC2 = Post-treatment FEC. [a,b,c]Means without a common superscript differ (P < 0.05).

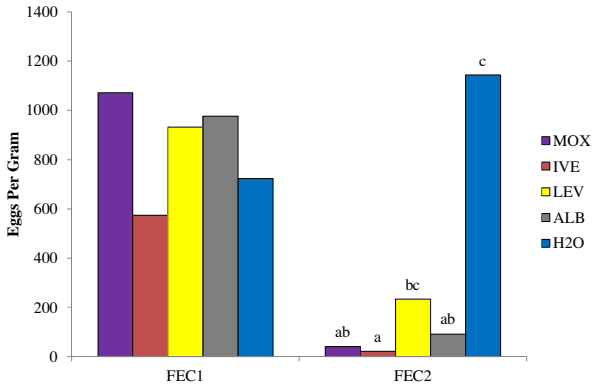

Fig. 2. Effect of treatment on geometric mean fecal egg counts (FEC). FEC1 = Pretreatment FEC; FEC2 = Post-treatment FEC. IVE, ivermectin; MOX, moxidectin; LEV, levamizole; ALB, albendazole; H2O, water. [a,b,c]Means without a common superscript differ (P < 0.05).

3. Results

Sire breed of doe affected (P < 0.01) FEC1, but did not affect (P = 0.12) FEC2 (Fig. 1). Savanna-sired does had higher FEC1 than does sired by Kiko or Myotonic. Age of doe did not affect FEC1 or FEC2 (data not shown). Treatment did not affect (P = 0.21) FEC1, but was an important source of variation (P < 0.001) for FEC2. Water control group had higher FEC2 means than MOX, IVE, and ALB (Fig. 2). The IVE group had a significantly lower FEC2 mean than LEV.

Treatment affected (P < 0.001) reduction values for log transformed FEC, but age and breed had no effect (P > 0.2). The water control group had lower (P < 0.01) FEC reduction value (−9.5%; [FEC increased by 9.5%]) than MOX (45.85%), IVE (50.54%), and ALB (32.48%). No other groups differed (P > 0.1) from each other (LEV = 20.49%) for FEC reduction.

Resistance was evident to the four anthelmintics tested (Table 1). The minimum reduction threshold for Eq. (1) and Eq. (3) was 90% to show susceptibility to a test drug. For Eq. (2), the threshold was 80%. None of the anthelmintics tested met the threshold for any of the equations. For Eq. (1), water significantly differed from the other treatment groups for FEC change post-treatment; FEC increased for the water control group post-treatment (Table 1). Eq. (2) showed no differences (P = 0.28) among the treatment groups. Eq. (3) showed LEV had a lower (P < 0.05) FEC reduction than the other treatments (Table 1).

Anthelmintic product influenced (P < 0.05) the percentage of does that met the threshold values for effective treatment response