Using copper oxide wire particles or sericea lespedeza to prevent peri-parturient gastrointestinal nematode infection in sheep and goats

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ABSTRACT

Gastrointestinal nematodes (GIN) continue to plague the small ruminant industry, especially in parts of the world with warm, humid climates. Alternatives to chemicals are needed for GIN control because ofanthelmintic resistance and a desire to reduce chemical residues in meat products. Three experiments using peri-parturient does or ewes addressed the objective: 1) in Arkansas, meat goats were untreated (n = 20) or fed copper oxide wire particles (COWP; 2 g each) in pelleted sericea lespedeza (Lespedeza cuneata; n = 22) before kidding while consuming sericea lespedeza hay, 2) in Arkansas, 42 Katahdin ewes were randomly assigned to remain untreated or were fed COWP (2 g each) before lambing within groups fed bermudagrass (Cynodon dactylon) or sericea lespedeza hay in a 2×2 factorial design, 3) in Louisiana, Gulf Coast Native ewes were randomly assigned to remain untreated or were fed COWP (4 g each) in a pelleted ration (n = 10 each) after lambing began. Fecal egg counts (FEC) and blood packed cell volume (PCV) were determined weekly in all experiments, and coproculture to examine GIN species was conducted in the first two experiments. *Haemonchus contortus* is typically the predominant GIN in the southeastern U.S., even during cooler months. However, *Trichostrongylus* spp. was the predominant GIN in Arkansas during these experiments. In all of the experiments, feeding COWP led to a reduction in FEC, but no change in PCV. The sericea lespedeza hay fed to ewes in Experiment 2 was associated with a reduction in FEC compared with ewes fed bermudagrass hay. Kids and lambs from COWP-treated dams in two experiments were lighter than those from untreated dams. Sericea lespedeza aided in the control of GIN infection, and while feeding COWP to peri-parturient ewes and does offered some reduction in GIN infection, body weight of offspring at birth and 60 or 90 days of age may be reduced.

1. Introduction

During the peri-parturient period, the immune system relaxes and the ewe and doe become more susceptible to gastrointestinal nematodes (GIN; *Connan*, 1968, 1976; *Rahman and Collins*, 1992; *Baker et al.*, 1998; *Beasley et al.*, 2010). Because of this phenomenon, pasture contamination by dams is significant and leads to exposure of offspring to GIN (*Barger*, 1993, 1996). Control of GIN during the peri-parturient period could reduce exposure to offspring. However, the prevalence of multi-anthelmintic resistance (*Kaplan et al.*, 2005; *Howell et al.*, 2008) and a need for alternatives to chemical dewormers in organic production systems have led to the use of other approaches.

Integrated tools for GIN control were described by *Waller* (1999) and included grazing strategies, the FAMACHA system, use of copper oxide wire particles (COWP), improved
nutrition, genetic resistance, and condensed tannin-rich forages. Two of these tools that can be easily incorporated during shed lambing/kidding include COWP and feeding sericea lespedeza (Lespedeza cuneata), a condensed tannin-rich forage. COWP have been used to control GIN in sheep and goats (Burke et al., 2004, 2005, 2007; Burke and Miller, 2006; Vatta et al., 2009). However, the current literature is lacking on a means to control GIN infection during the peri-parturient period and a more convenient method of administering the COWP rather than in a bolus to individual animals. It was determined that COWP were effective in reducing H. contortus, but not intestinal nematodes (Bang et al., 1990; Chartier et al., 2000; Knox, 2002). Similarly, fresh or dried sericea lespedeza has been shown to reduce fecal egg counts (FEC) of H. contortus in sheep and goats (Min and Hart, 2003; Lange et al., 2006; Shaik et al., 2006; Terrill et al., 2007). A reduction of adult abomasal (Terrill et al., 2007, 2009) and intestinal (Shaik et al., 2006) worms was apparent in goats fed sericea lespedeza hay in Georgia. The objective of the current study was to determine the effectiveness of COWP incorporated into a pellet alone or in combination with sericea lespedeza in controlling GIN infection during the peri-parturient period in sheep and goats.

2. Materials and methods

2.1. Experiment 1: COWP in pregnant does

Naturally GIN-infected goats grazed grass pastures at USDA, Agricultural Research Service, Dale Bumpers Small Farms Research Center in Booneville, AR before the experiment began. Animals used were mature peri-parturient does (n = 42) of Spanish (n = 25) or Spanish × Boer breeding (n = 17). In early January 2009, does were blocked by breed type and randomly assigned to remain untreated (n = 20) or fed 2 g COWP (Burke et al., 2004, 2007) in a sericea lespedeza pellet at one feeding (n = 22). The pellet was processed at Fort Valley State University, Fort Valley, GA with a small pellet machine (Model CL, Type 3; California Pellet Mill, Crawfordsville, IN) using ‘AU Grazer’ sericea lespedeza leaf meal, 2.2 mg COWP/g sericea lespedeza, and a small amount of water at a temperature of less than 50 °C. After feeding the COWP pellets, all does were managed as a single group. Mature does started kidding 10 days later and all kidded within 32 days after the experiment began. Goats were supplemented with 450 g/head of 16% crude protein corn/soybean meal daily and all goats had access to free choice ‘AU Grazer’ sericea lespedeza hay and trace mineralized salt (Land O’ Lakes Sheep and Goat Mineral, Shoreview, MN) in an outdoor pen with limited vegetation. Goats returned to 2 ha of grass pasture 7 days after kidding or as early as 14 days after COWP feeding. Ewes started lambing 7 days later and all lambed within 32 days after the experiment began. One ewe did not lamb and one ewe died from pregnancy toxemia during lambing. Ewes were supplemented with 450 g/head of 16% CP corn/soybean meal daily and had access to free choice trace mineralized salt (Land O’ Lakes Sheep and Goat Mineral) in an outdoor pen with limited vegetation. Ewes returned to grass pasture 7 days after lambing or as early as 14 days after COWP feeding and continued to receive free choice bermudagrass or sericea lespedeza hay until approximately 60 days postpartum each on approximately 2 ha pasture. Body weight of lambs was recorded at birth and approximately 60 days of age.

2.2. Experiment 2: COWP and sericea lespedeza in pregnant ewes

Peri-parturient mature Katahdin ewes (n = 42) grazed bermudagrass (Cynodon dactylon) overseeded with cereal rye (Secale cereale) pasture at USDA, ARS, in Booneville, AR before the experiment began. In early January 2009, in a 2 × 2 factorial design, ewes were randomly assigned to 1) no COWP and bermudagrass hay (n = 11), 2) COWP pellet (described above) and bermudagrass hay (n = 12), 3) no COWP and sericea lespedeza (‘AU Grazer’) hay (n = 9), or 4) COWP pellet and sericea lespedeza hay (n = 10). The COWP pellets were fed in one feeding. Ewes started lambing 7 days later and all lambed within 32 days after the experiment began. One ewe did not lamb and one ewe died from pregnancy toxemia during lambing. Ewes were supplemented with 450 g/head of 16% CP corn/soybean meal and had access to free choice trace mineralized salt (Land O’ Lakes Sheep and Goat Mineral) in an outdoor pen with limited vegetation. Ewes returned to grass pasture 7 days after lambing or as early as 14 days after COWP feeding and continued to receive free choice bermudagrass or sericea lespedeza hay until approximately 60 days postpartum each on approximately 2 ha pasture. Body weight of lambs was recorded at birth and approximately 60 days of age.

2.3. Sample collection for Experiments 1 and 2

A pooled fecal sample was collected for coproculture (Peña et al., 2002) on day 0 (day of COWP feeding) in Experiments 1 and 2. Before weaning of kids, goats were re-randomized to be used for another experiment; another pooled sample was collected from two sub-groups of does at approximately 90 days postpartum for coproculture to examine potential trend in population of GIN. Feces and blood were collected from individual animals every 7 days between days 0 and 21 (Experiment 1) or 28 (Experiment 2) for FEC and blood packed cell volume (PCV) analyses. Feces were collected from all does at 90 days postpartum to examine any residual effect of COWP treatment. The FEC analyses for this and subsequent experiments were completed using a modified McMaster technique (Whitlock, 1948), and the PCV analyses were completed using a micro-hematocrit centrifuge and reader.

2.4. Experiment 3: COWP in pregnant ewes

Twenty Suffolk × Gulf Coast Native crossbred ewes grazed ryegrass (Lolium multiflorum) pasture at Louisiana State University in Baton Rouge at the beginning of lambing in mid-February 2008. All ewes lambed by mid-March except one ewe that did not lamb. Ewes were randomly allocated to untreated and COWP groups (n = 10 each). Fecal and blood samples were collected for FEC and PCV analysis as described above every 7 days for 12 weeks (days − 49 to 35; day 0 = day of COWP feeding). At the start of the study, FEC for untreated and COWP groups were 333 and 335 eggs/g, respectively. Infection steadily increased and COWP (4 g/ewe) in 2.6 kg of pellets was administered at one feeding to the COWP group in
week 7 (day 0; 50 to 79 days postpartum) when FEC of both groups exceeded 1000 eggs/g. The pellets contained 16% crude protein and were processed at a commercial feed mill (Mid-GA Farm Supply, Inc., Montezuma, GA) with or without (control group) COWP (1.5 mg/g of feed). Other than during feeding, the ewes were maintained as one group. Body weight of lambs was determined at birth and weaning. Lambs were weaned in mid-May.

2.5. Statistical analysis

Data were analyzed as repeated measures (Littell et al., 1996) using mixed models and included COWP (all Experiments) and hay (Experiment 2) treatment, breed type (Experiment 1), the repeated effect of day of experiment, and interactions in the model (SAS/STAT® Software, 1996). Random effects were breed and residual error. Animal was the experimental unit. An autoregressive covariance structure was used for all models. Means were separated using pre-planned pairwise comparisons using the t-test when treatment effect was $P<0.05$. The FEC data were log transformed: $\ln(\text{FEC} + 1)$. Statistical inferences were made on transformed data and untransformed least squares means were presented. Body weight determined on offspring from dams at birth and weaning (Louisiana sheep) or 60 days of age (Arkansas sheep and goats) was analyzed using General Linear Models of SAS. COWP and hay treatment of dam, birth type (single or multiple), gender, breed (goats only), sire (four used for Arkansas lambs and two used for Arkansas kids; unknown sires for Louisiana sheep), and interactions were included in the model. Order of birth of offspring and age of dam were used as covariates. If not significant ($P<0.05$), then the covariate was removed from the model. There were 2 kids from untreated does and 6 kids from COWP-treated does that were not included in the statistical analysis because sire was unknown (multiple sires were used during last week of breeding). The main effects and interactions were considered to be significant at $P \leq 0.05$ and tended to be significant at $P \leq 0.10$. Only significant interactions or main effects are presented. If an interaction or main effect is not presented, it was not significant ($P \geq 0.05$) or did not tend to be significant ($P > 0.10$).

3. Results

3.1. Experiment 1: COWP in pregnant does

Coproculture of a pooled fecal sample from all does at the start of the trial revealed that Trichostrongylus spp. was the predominant nematode species (51%) followed by H. contortus (44%), Teladorsagia spp. (4%) and Oesphogastomum spp. (1%). Subsequent culture conducted on two sub-groups of does 90 days postpartum indicated that the percentage of Trichostrongylus spp. was even higher (88 to 100%). Feeding COWP to peri-parturient does led to a reduction in FEC by day 14 ($P < 0.02$), but FEC of untreated does decreased and was similar to that of COWP-treated does by day 21 (COWP×day, $P < 0.008$; Fig. 1A). The FEC of the crossbred does tended to be greater than that of Spanish does (1729±1188 eggs/g, $P < 0.07$). In Spanish does, PCV of the untreated group was less than that of the COWP-treated group, but the opposite occurred in the crossbred does (COWP×breed×day, $P < 0.004$; Fig. 1B). The PCV of Spanish does was greater than that of the crossbred does ($P < 0.001$). In May, when kids were weaned, FEC were similar between untreated (2032 eggs/g) and COWP-treated (1109 eggs/g) does.

Birth weight (3.31±0.07±0.09 kg, $P < 0.02$) and body weight at 60 days of age (12.8±11.8±0.4 kg, $P < 0.03$) of kids from untreated does were heavier than those from COWP-treated does. At birth and 60 days of age, males were heavier than females ($P < 0.03$; $P < 0.05$) and single born were heavier than multiple born kids ($P < 0.002$; $P < 0.04$; data not shown). There was no effect of breed or sire.

3.2. Experiment 2: COWP and sericea lespedeza in pregnant ewes

The predominant nematode species in peri-parturient ewes was Trichostrongylus spp. (68%), followed by Cooperia spp. (44%); Teladorsagia spp. (13%), Oesphogastomum spp. (13%), and H. contortus (1%). Subsequent culture conducted on two sub-groups of does exceeded 1000 eggs/g. The pellets contained 16% crude protein and were processed at a commercial feed mill (Mid-GA Farm Supply, Inc., Montezuma, GA) with or without (control group) COWP (1.5 mg/g of feed). Other than during feeding, the ewes were maintained as one group. Body weight of lambs was determined at birth and weaning. Lambs were weaned in mid-May.
3.3. Experiment 3: COWP in pregnant ewes

Subsequent to COWP feeding, FEC in the untreated group remained greater than 1000 eggs/g and the FEC of COWP-treated ewes was reduced by 82.9% relative to untreated ewes (COWP×day, P<0.001; Fig. 3). The PCV remained high (>31%) throughout the experiment and was similar between groups. Lamb birth weights were similar between treatments (4.88±0.18 kg) and influenced by gender (P<0.003; data not shown). Weaning weights at approximately 90 days of age were reduced in lambs from COWP-treated ewes (20.0±23.6±0.9 kg, P<0.01) and was influenced by gender (P<0.05).

4. Discussion

There was a reduction in FEC in groups of ewes or does fed the pelleted COWP. Burke et al. (2010) also reported a reduction in goats fed pelleted COWP. Incorporating COWP in a pelleted ration ensures a more even distribution of the COWP, reducing the risk of some animals not receiving enough to impact GIN or others receiving too much, leading to a susceptibility to copper toxicity. The reduction in FEC in the goats and the ewes in Experiment 2 was not as great as in previous reports (Burke et al., 2004; Vatta et al., 2009) because of the low to moderate percentage of *H. contortus*. Previous studies in sheep and goats have indicated that COWP is ineffective against intestinal GIN species (Bang et al., 1990; Chartier et al., 2000; Knox, 2002). There must have been an effect of *H. contortus* in at least some of the goats that led to haemonchosis because two goats that were not on study required deworming because of low PCV (<15%) before the experiment began and a Boer type doe fed COWP required deworming by day 21 because of a low PCV. Although speciation of GIN was not examined in the Louisiana ewes, it was likely that the population of *H. contortus* was high because of the greater reduction in FEC in COWP-treated dams relative to the *Trichostrongylus* predominant Arkansas experiments.

The sericea lespedeza hay fed to peri-parturient ewes led to some reduction of FEC. Again, because the population of GIN was mixed with a high percentage of *Trichostrongylus* spp., it is not surprising that there was not a further reduction in FEC. Terrill et al. (2007, 2009) reported a reduction in adult *H. contortus*, but not *Trichostrongylus colubriformis*, an intestinal species. In addition, because both untreated and COWP-treated groups of does were fed sericea lespedeza hay, FEC may have been lower than previous years in which bermudagrass hay was fed to all does (Burke et al., 2010).

There was no interaction between COWP and sericea lespedeza in Experiment 2. Perhaps because both of these treatments target abomasal GIN, which were relatively low, an interaction was not detected. Further research is needed on a more sensitive population of animals, such as early weaned lambs or kids, to examine the combination treatments.

There is some indication in the literature that COWP administered to pregnant ewes has been associated with reduced body weight of offspring (Burke et al., 2005). In that study, twin born lambs from ewes administered 2 or 4 g
COWP during late pregnancy were lighter at 30 and 60 days of age than lambs from untreated ewes and single born lambs regardless of treatment of their dam. In the current study, in Louisiana, lambs from COWP-treated ewes were lighter than lambs from untreated ewes at weaning. This did not occur in Experiment 2 in Arkansas, but these ewes were administered 2 g rather than the 4 g used in ewes in Experiment 3. There could be some reduction in milk production or quality in COWP-treated ewes, but further studies are necessary.

There was also a reduction in birth weight and 60 day body weights of kids from COWP-treated does. Weaned kids tended to experience reduced weight gains when fed copper sulfate in an earlier study (Burke and Miller, 2008). Metabolism of copper may be different between sheep and goats, which may explain differences in changes in birth weight and subsequent body weight in untreated and COWP-treated females in Experiments 1 and 2.

It is not clear why birth weights of lambs from ewes fed sericea lespedeza hay, high in condensed tannins, would be lighter than those fed bermudagrass hay. There could have been differences in intake of hay initially, which was not measured. However, by approximately 60 days postpartum, body weight of lambs was similar between hay groups.

Whenever dietary copper is used in sheep, and perhaps goats, caution must be exercised to avoid copper toxicity. An earlier study conducted at the Arkansas location indicated a copper deficiency in untreated lambs (Burke and Miller, 2006). Therefore, risk of administering COWP in this environment is relatively safe. However, if producers are unsure of copper status, specialists should be consulted before use of COWP for GIN control. Further discussion on safety of COWP in sheep can be found in Burke et al. (2004).

In previous studies in which Boer or Boer crossbred and Spanish goats were used at the Arkansas location, Spanish goats were more resistant to GIN infection than the Boer type goats (Burke et al., 2007, 2010). This is a limited population of Boers, and additional Boer populations should be used to examine resistance among goat breeds. There is little reported on GIN resistance in goat breeds in the U.S., but others have noted breed differences to H. contortus infection (Preston and Allonby, 1978; Baker et al., 1998; Costa et al., 2000). More studies are needed on within and between breed selection of resistant goats in the U.S. to add breeding for resistance to the integrated tools for GIN control for goat producers.

There has been greater effort on determining breed or within breed differences to GIN infection in sheep (Miller et al., 1998, 2006; Notter et al., 2003; Vanimisetti et al., 2004), including a current project in the U.S. on identifying GIN resistant Katabhdin sires by using FEC (http://www.nsip.org/breed-groups/katabhdin/sire-summary). Mature Katabhdin ewes tolerate (low incidence of anemia) GIN well, but are not completely resistant (FEC can be relatively high) to these parasites (Burke and Miller, 2002).

5. Conclusion

These studies demonstrated the potential control of GIN infection during the peri-parturient period using COWP and sericea lespedeza. These tools are not magic bullets designed to eradicate GIN altogether, but should be used in a program in which small ruminant producers have some means of controlling acute cases. A reduction in GIN infection of dams on farms without effective anthelmintics will benefit control of GIN in offspring. No interaction of COWP and sericea lespedeza was detected in Experiment 2, but should be revisited in a more sensitive H. contortus predominant model.

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References


