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# Persistence of the efficacy of copper oxide wire particles against *Haemonchus contortus* in grazing South African goats

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ABSTRACT

A study was conducted to examine the duration of anthelmintic effect of copper oxide wire particles (COWP) in grazing goats, as data for the persistence of efficacy of COWP in this host species is limited. Forty-eight indigenous male goats were infected naturally by grazing them on *Haemonchus contortus*-infected pasture. When the faecal egg count (FEC) in the goats was 3179 ± 540 eggs per gram of faeces (mean ± standard error), half the animals were treated with 4 g COWP (day 0; mean live weight = 25.5 ± 0.8 kg). Eight treated (COWP) and eight non-treated (CONTROL) goats were removed from the pasture on each of days 7, 28 and 56, maintained for 27 or 29 days in concrete pens and then humanely slaughtered for nematode recovery. Mean liver copper levels were in the high range in the goats removed from pasture at day 7 (treated: 191 ± 19.7 ppm; untreated: 120 ± 19.7 ppm; $P = 0.022$), but had dropped to normal levels at days 28 and 56. The mean *H. contortus* burdens of the treated versus the non-treated goats were, respectively, 184 ± 48 and 645 ± 152 for the goats removed from pasture at day 7 (71% reduction; $P = 0.004$), 207 ± 42 and 331 ± 156 at day 28 (37% reduction; $P = 0.945$) and 336 ± 89 and 225 ± 53 at day 56 (−49% reduction; $P = 0.665$). Weekly monitoring of FECs after treatment until slaughter indicated that the COWP-treated goats had lower FECs than the controls, the treatment main effect being significant at days 7, 28 and 56 ($P < 0.01$). The day main effect and the treatment × day interaction were only significant for the goats removed from pasture at day 28 ($P \leq 0.001$). Packed cell volumes increased during the course of the experiment (day, $P < 0.001$), but the treatment main effect was significant only for the goats removed from pasture at day 28 (CONTROL 28 d, 28.65 ± 0.52% < COWP 28 d, 31.31 ± 0.52%; $P < 0.001$). No differences in live weight between groups were considered to be of any practical significance. The study indicated that persistence of efficacy of COWP is limited in goats, extending at most to 28 days after treatment. However, repeated COWP administration at three-month intervals may be safe, given that liver copper levels return to normal two to three months after COWP treatment.



## 1. Introduction

Disease caused by *Haemonchus contortus* is one of the major constraints to the production of sheep and goats in the tropics and subtropics, and causes substantial losses to farmers worldwide. The anthelmintic properties

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of copper-containing compounds have been known for a long time (Wright and Bozicevich, 1931), but the worldwide increase in anthelmintic resistance has prompted more recent investigations into the renewed use of copper as an anthelmintic (Burke et al., 2007). Specifically, investigations have focused on copper oxide wire particles (COWP) which have been shown to have an anthelmintic effect against abomasal nematodes, particularly *H. contortus* (Bang et al., 1990). They represent a potentially cheap alternative to anthelmintics for small-scale farmers in the developing world, if the use of COWP can be successfully integrated into worm control programmes.

Only one study (Galindo-Barboza et al., 2011) has specifically examined the persistence of efficacy of COWP based on worm counts in sheep. Recent data from goats managed under communal farming conditions suggest that egg counts are reduced two weeks, but not six weeks, after treatment with COWP (Spickett et al., 2012). However, no worm count data are available on the duration of efficacy of COWP in groups of goats subjected to similar levels of parasite exposure, nutrition and management. The present study therefore sought to examine the effect of COWP treatment in goats treated and removed from infective pasture at three different stages, namely at 7, 28 and 56 days post treatment.

## 2. Materials and methods

The use of animals for this experiment met the requirements of the Onderstepoort Veterinary Institute Animal Ethics Committee.

### 2.1. Preparation of infected pasture

A 0.67 ha pasture of star grass (*Cynodon incompletus* Nees) at Onderstepoort Veterinary Institute, Pretoria was utilized for the study in 2006–2007. In the spring of 2006, six months prior to the start of the actual experiment, the grass was cut and fertilized. The pasture was irrigated through the spring and summer until the conclusion of the experiment in the following autumn if less than 25 mm rain fell during the previous week. Rainfall data were collected at Onderstepoort Veterinary Institute while temperature data were obtained from the South African Weather Service for central Pretoria, which is approximately 16 km south of the Institute.

Since the pasture had not been used for animal grazing for several years prior to the experiment, it was seeded with *H. contortus* larvae by grazing infected sheep on it. Initially, twenty indigenous sheep were purchased from a commercial vendor, transported to Onderstepoort Veterinary Institute and maintained in concrete pens which were swept clean daily to preclude accidental nematode infection. The animals were fed a commercial pelleted feed and lucerne (*Medicago sativa*) hay and the animals had free access to water. The sheep were dewormed with 10 mg/kg fenbendazole (Panacur BS®, Intervet South Africa) and 7.5 mg/kg levamisole (Tramisol®, Coopers, Afrivet Business Management, South Africa) daily for 5 days, followed by 0.3–0.5 mg/kg ivermectin (Ivomec Injection®, Merial South Africa) administered 6 days and 13 days after the combination treatment with fenbendazole and levamisole. Thirty-three days later, the animals were infected with 5000 third-stage larvae of a susceptible strain of *H. contortus* given as 1000 larvae per day for five days, as low-level, trickle dosing has been shown to be the optimal method for achieving establishment of parasites (Barger et al., 1985; Dobson et al., 1990). When the infections were patent in the late spring period (on day −82 relative to the start of the experiment), the sheep were transferred to the pasture where they were grazed from Monday to Friday from 8.00 am to 3.00 pm. For security reasons, the sheep were maintained in their pens overnight and on the weekends, where they received hay and pellets and free access to water.

### 2.2. Experimental goats

Forty-eight indigenous intact ($n = 20$) and castrated ($n = 28$) male goats were purchased from an experimental farm near Pietermaritzburg, South Africa, the same farm from which resistance to anthelmintics had been reported in Van Wyk et al. (1989) and Vatta et al. (2009), and transported to Onderstepoort Veterinary Institute where they were maintained and fed in a similar manner to the sheep. The goats were dewormed with a combination of 7.5 mg/kg levamisole and 7.5 mg/kg rafoxanide (Nem-a-rid®, Intervet South Africa) on day −114 relative to the start of the experiment. When faecal egg counts (FECs) were carried out on the goats 9 days after treatment, the reduction in egg count was 40% (Table 1). Third-stage larvae recovered following culture of the faeces were identified using the key of Van Wyk et al. (2004) and proportionally belonged to the following genera: 61% *Haemonchus*, 24% *Teladorsagia*/*Trichostrongylus* and 15% *Oesophagostomum* ($n = 100$). The goats were treated with 0.4 mg/kg moxidectin (Cydectin Injectable®, Fort Dodge Animal Health) 5 days later and the FECs were reduced by 85% when determined 14 days after this treatment. Only two larvae were recovered on faecal culture following the second treatment and both were *Haemonchus* spp.

The goats were maintained in pens until day −51 when they were moved to the pasture seeded with *H. contortus* larvae by the sheep. The goats were grazed together with the sheep until day −2 of the experiment, when the sheep were removed from the pasture. The FECs of the goats were checked weekly until day −2 when their mean FEC was 3179 ± 540 epg. Two days later, on day 0 (28 February 2007), the 48 goats were allocated to six experimental groups for treatment/non-treatment and date of removal from pasture. The goats were paired for average live weight and FECs for the two sampling dates (days −9 and −2) preceding the date of treatment. Eight clusters were formed consisting of three pairs of goats with similar live weight and FEC. A pair of goats was randomly selected from a cluster and allocated to one of three dates of removal from pasture (7 d, 28 d or 56 d), one goat was allocated to treatment (COWP) and the other to non-treatment (CONTROL). This process was repeated for the remaining pairs within a cluster so that a goat from each cluster was ultimately allocated to each of the six experimental groups, and repeated for the remaining seven clusters.