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EFFICACY OF IVERMECTIN AGAINST *PARELAPHOSTRONGYLUS ANDERSONI* (NEMATODA, METASTRONGYLOIDEA) IN WHITE-TAILED DEER (*ODOCOILEUS VIRGINIANUS*)

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ABSTRACT: Ivermectin was injected subcutaneously at 200 and 400 $\mu\text{g}/\text{kg}$ of body weight into seven white-tailed deer (*Odocoileus virginianus*) in an attempt to control the muscle nematode *Parelaphostrongylus andersoni*. Counts of first-stage larvae in feces dropped to zero at 17 to 18 days posttreatment. Larvae reappeared in feces 1.5 to 6 wk later in six deer. Four deer were treated again approximately 9 wk after the first treatment; larval counts dropped to zero in 12 to 18 days. Larvae reappeared in low numbers 45 to 55 days after the second treatment. Because deer were held indoors on cement and the prepatent period of these worms is approximately 2 mo, the reappearance of larvae was not due to reinfection by accidental ingestion of gastropod intermediate hosts. Results suggest that ivermectin at dosages of 200 or 400 $\mu\text{g}/\text{kg}$ of body weight suppressed larval production by adult female nematodes for several weeks or destroyed first-stage larvae in the lungs.

Key words: Ivermectin, muscle nematodes, *Parelaphostrongylus andersoni*, white-tailed deer, *Odocoileus virginianus*, experimental study.

INTRODUCTION

Ivermectin (22,23-dehydroavermectin B₁), because of its proven efficacy against many species of nematodes and arthropods of domestic animals (Campbell, 1985), has stimulated interest in its application against parasites of wildlife (Kinzer et al., 1983). To date, the parasites chosen for study are those of known or potential pathogenicity for their hosts. These include: *Psoroptes ovis*, a mite of desert bighorn sheep (*Ovis canadensis mexicana*) (Kinzer et al., 1983); *Protostrongylus* sp., a lung nematode of Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*) (Miller et al., 1987); *Parelaphostrongylus tenuis*, the meningeal nematode of white-tailed deer (*Odocoileus virginianus*) (Kocan, 1985); *Elaphostrongylus cervi*, a nematode of red deer (*Cervus elaphus*) (Watson, 1986); and *Dictyocaulus viviparus*, a lungworm of red deer (Mackintosh et al., 1985).

A muscle-inhabiting nematode, *Parelaphostrongylus andersoni*, of white-tailed deer may not be as pathogenic as the parasites listed above, but lesions are severe in several species of hosts and natural mor-

tality probably occurs (Nettles and Prestwood, 1976; Pybus, 1983). In the present study, seven white-tailed deer were infected with *P. andersoni*, treated with ivermectin, and their feces monitored over time for first-stage larvae. Counts of larvae in feces dropped to zero several days post-treatment, but reappeared several weeks later in most deer.

MATERIALS AND METHODS

Orphaned, neonatal fawns were reared and maintained as described by Pybus (1983). Deer (four males, three females) were inoculated per os with 300 infective larvae of *P. andersoni* (Pybus, 1983) on 8 February or 3 May 1983, and treated with ivermectin as outlined in Table 1. Fawns were injected subcutaneously in the neck with ivermectin (Ivomec® for cattle, Merck Frosst Canada Inc., P.O. Box 1005, Pointe Claire, Dorval, Quebec, Canada H9R 4P8) at 200 or 400 $\mu\text{g}/\text{kg}$ given once or twice. One female deer was infected with *P. andersoni* on 8 February 1983, but not treated. Feces of all deer were examined from 2 to 14 times for larvae prior to inoculation. Postinoculation fecal samples were collected approximately four times/wk and examined for first-stage larvae of *P. andersoni* according to a modified Baermann technique (Samuel and Gray, 1982). Results were ex-

TABLE 1. White-tailed deer inoculated with 300 infective larvae of *Parelaphostrongylus andersoni* and treated with ivermectin.

| Deer | | | | | | |
|-------------|-----------------------------------|-----|--------------------------------|----------------------------|--|-----------------------------|
| Deer number | Age (months) at inoculation | Sex | Pre-patent period (days) | Treatment DPI ^a | Dosage of ivermectin ($\mu\text{g}/\text{kg}$) | End of experiment DPI |
| WT 1 | 11 | F | 57 | 87 | 400 | 169 |
| WT 2 | 7 | M | 61 | 110, 171 | 200/200 | 253 |
| WT 3 | 7 | M | 57 | 93, 171 | 200/200 | 197 |
| WT 4 | 7 | F | 62 | 110, 171 | 200/200 | 253 |
| WT 5 | 7 | F | 55 | 110, 171 | 200/200 | 253 |
| WT 6 | 7 | M | 57 | 171 | 200 | 253 |
| WT 7 | 7 | M | 49 | 93 | 200 | 253 |
| WT 8 | 7 | F | 56 | — ^b | — | 209 |

^a Days postinoculation.

^b Control.

pressed as larvae per gram (LPG) of feces wet weight. From 75 to 145 postinoculation fecal samples were collected from each deer. There were no overt signs of clinical illness in the deer during the study. Deer were held indoors on cement at animal facilities of the University of Alberta (Edmonton, Alberta, Canada T6G 2E9) throughout the study with no access to terrestrial gastropods, the intermediate hosts of *P. andersoni*.

RESULTS

Although the number of first-stage larvae shed in the feces varied among white-tailed deer, patterns were consistent following treatment with ivermectin (Fig. 1). Counts of first-stage larvae in feces dropped to zero at 17.6 days (range 17 to 18 days) following the first treatment with ivermectin. Counts remained at zero following treatment for an average of 4 wk (range 1.5 to 6.0 wk for six of the seven white-tailed deer). Larvae were not recovered from one white-tailed deer (WT 7) for at least 14 wk (when the experiment was terminated). Larvae reappeared in feces of six deer from 27 to 60 days after treatment (\bar{x} = 42 days).

Larval counts decreased to zero at 12 to 18 days after the second treatment with ivermectin (Fig. 1); they remained at zero for as few as 14 days (WT 3—experiment ended) to 49 days (WT 2). Larvae reappeared in feces of three deer from 45 to 55 days after the second treatment (\bar{x} = 52

days). Counts of larvae from the untreated control deer also were low at this time.

DISCUSSION

Although it would have been advantageous to determine survival of adult worms, our only measure of efficacy of treatment with ivermectin was the reduction in numbers of first-stage larvae in the feces of deer. Fortunately, we examined feces for as long as 12 to 20 wk after the first injection of ivermectin and documented reappearance of larvae after 9 of 11 treatments. Blair and Klei (1986) question results of short-term studies; "L1 larvae may reappear after prolonged periods suggesting efficacy of the drug against L1 or reproductive efficacy of female worms rather than adult worms." If we had only monitored feces for 4 wk after treatment, such as was done by Miller et al. (1987), we would have listed five of the seven positive deer as negative for first-stage larvae (8 of 11 treatments).

Ishii et al. (1985) report a 4 to 5 wk inhibition of larval output by the metastrongyloid *Angiostrongylus cantonensis* after treatment of rats with ivermectin. They suggest that cessation of larval production is due to the paralyzing action of ivermectin against the adult female worm and temporary damage to her reproductive system. McCraw and Menzies (1986)

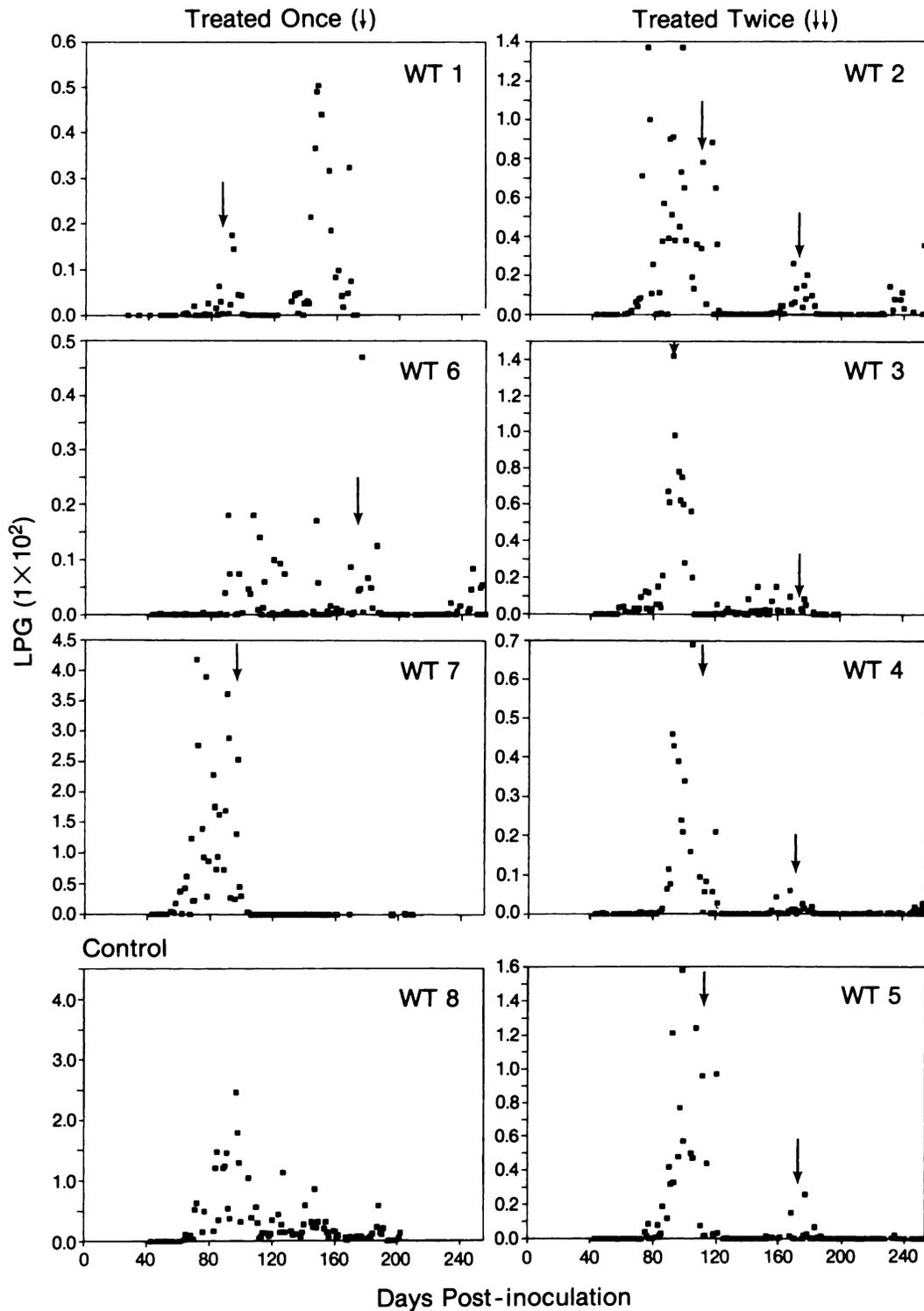


FIGURE 1. Numbers of first-stage larvae of *Parelaphostrongylus andersoni* in feces of white-tailed deer following treatment with ivermectin.

report an inhibition of larval output by the metastrongyloid *Muellerius capillaris* in domestic goats 11 to 20 days after treatment and a reappearance of larvae in feces 34 to 59 days after treatment. They present strong evidence that ivermectin kills adult worms and suggest that reappearance of first-stage larvae in feces might be the result of maturation of immature worms that were not affected by the anthelmintic.

Frequent handling of free-ranging or captive wildlife, particularly the large ruminants, is not desirable or always possible; thus, it would be convenient if a single dose of ivermectin eliminated infection by *P. andersoni*. That did not happen in this study or in two previous studies on related nematodes. Kocan (1985) and Watson (1986) recovered live adult *Parelaphostrongylus tenuis* and the closely related *Elaphostrongylus cervi*, respectively, from white-tailed deer and red deer following treatment with ivermectin. Counts of larvae in feces were reduced following treatment in both studies; counts from treated red deer remained below untreated controls for 4 mo (Watson, 1986). Kocan (1985) suggested that ivermectin destroyed first-stage larvae of *P. tenuis* in the lung and, perhaps, affected "egg production and/or viability."

In a field test of ivermectin against another metastrongyloid nematode, *Protostrongylus* sp. of wild free-ranging bighorn sheep, Miller et al. (1987) report average pre- and posttreatment larval counts of >100 and 0 or <5/g of feces, respectively. However, evaluation of the efficacy of ivermectin in this study is difficult because posttreatment samples were collected in July and September when numbers of larvae in feces are seasonally low (Uhazy et al., 1971).

Results of the present study, along with others published recently, suggest only limited efficacy of ivermectin against metastrongyloid nematodes living outside the tracheobronchial tree. For *P. andersoni* in white-tailed deer, one dosage of 400 µg/kg body weight or one to two doses

of 200 µg/kg suppressed shedding of first-stage larvae in feces for several weeks, but only eliminated infection following 2 of 11 treatments.

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