Efficacy of Diclazuril in Comparison with Chemical and Ionophorous Anticoccidials Against Eimeria spp. in Broiler Chickens in Floor Pens

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ABSTRACT

Two 42-d floor pen studies were conducted with commercial broiler chickens to measure the efficacy of 1 ppm diclazuril in the starter or grower diet in shuttle programs with 66 ppm salinomycin. Study 1 compared a salinomycin to diclazuril (starter to grower diet) shuttle treatment with salinomycin to salinomycin, salinomycin to 100 ppm monensin, salinomycin to 99.8 ppm lasalocid, and unmedicated treatments. Study 2 compared a diclazuril to salinomycin (starter to grower) shuttle treatment with 125 ppm nicarbazin to salinomycin, 79.2 ppm narasin + nicarbazin to salinomycin, 125 ppm zoalene to salinomycin, and unmedicated treatments. Fifty 1-d-old chicks were randomly allotted to each of 10 pens per treatment in each study using a randomized complete block design. Starter (Days 0 to 21) and grower (Days 22 to 37) diets in each study contained 55 ppm bacitracin methylene disalicylate. The finisher diet (Days 38 to 42) in each study was unmedicated. Birds were inoculated via their feed on Day 22 (Study 1) or Day 15 (Study 2) with a mixed inoculum of Eimeria acervulina, Eimeria maxima, and Eimeria tenella. Four birds per pen (two male and two female) were randomly selected in each study for coccidial lesion scores on Day 6 postinoculation. These studies demonstrated that the use of 1 ppm diclazuril in shuttle programs was highly efficacious against a mixed inoculum of Eimeria spp. in comparison with nicarbazin, narasin + nicarbazin, and zoalene in starter diets and salinomycin, monensin, and lasalocid in grower diets.

(Key words: diclazuril, anticoccidial, chicken, Eimeria spp.)

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INTRODUCTION

The anticoccidial efficacy of diclazuril against Eimeria spp. in broiler chickens in floor pen studies was first reported by Vanparijs et al. (1989). These workers found that 1 ppm diclazuril in the diet from Days 1 to 42 of study was highly efficacious against mixed infections of E. tenella and E. acervulina or E. necatrix and E. brunetti. This work was subsequently expanded to three additional floor pen studies including one with a single species infection of E. mitis and two studies involving a mixture of E. acervulina, E. maxima, and E. tenella or E. brunetti and E. necatrix (Vanparijs et al., 1990). These studies provided further confirmation of the high, broad-spectrum efficacy of 1 ppm diclazuril when fed in the diet of broiler chickens from Days 1 to 42.

The efficacy of diclazuril was compared with 110 ppm monensin (five studies), 3 ppm halofuginone (two studies), 66 ppm salinomycin (three studies), and 100 ppm lasalocid (two studies) by McDougald et al. (1990). In each study, birds were inoculated via the feed on Day 17 with a different set of E. acervulina, E. maxima, E. necatrix, E. brunetti, and E. tenella isolates. The results indicated that 1 ppm diclazuril was comparable to or more efficacious than the other anticoccidials based on bird performance and on the control of coccidiosis mortality and coccidial lesions.

The above studies involved the use of diclazuril in starter and grower diets. In practice, anticoccidials are frequently used in shuttle programs in which one product is fed in the starter diet and a different one in the grower diet (Eckman et al., 1974; McDougald, 1982, 1990). Two floor pen studies were conducted to compare 1 ppm diclazuril with different chemical and ionophorous anticoccidials in shuttle programs.

MATERIALS AND METHODS

Two 42-d studies were conducted in floor pen facilities located at Southern Poultry Research, Athens, Georgia, to compare different variations of anticoccidial shuttle programs. Study 1 compared in the grower diet: 1 ppm diclazuril (Clinacox), 66 ppm salinomycin (three studies), and 100 ppm lasalocid (two studies) by McDougald et al. (1990). In each study, birds were inoculated via the feed on Day 17 with a different set of E. acervulina, E. maxima, E. necatrix, E. brunetti, and E. tenella isolates. The results indicated that 1 ppm diclazuril was comparable to or more efficacious than the other anticoccidials based on bird performance and on the control of coccidiosis mortality and coccidial lesions.

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100 ppm monensin (Coban®60),7 99.8 ppm lasalocid (Ava-tec®),8 and unmedicated (starter and grower diets) treatments. The starter diet in each of the preceding anticoccidial treatments contained 66 ppm salinomycin.

Study 2 compared in the starter diet: 1 ppm diclazuril, 125 ppm narasin (Nicarb 25%),7 79.2 ppm narasin + nicarbazin (Maxiban®72),5 125 ppm zoalene (Zoamix),6 and unmedicated (starter and grower diets) treatments. The grower diet in each of the preceding anticoccidial treatments contained 66 ppm salinomycin.

In each study, the floor pen unit was divided into 10 blocks of five pens each. The five treatments in each study were assigned at random to one pen in each block in a randomized complete block design. Fifty (25 male and 25 female) 1-d-old Ross × Ross (Study 1) or Ross × Cobb (Study 2) broiler chickens were randomly allotted to each pen. Initial bird density in each study was 14.89 birds/m². Standard corn-soybean diets formulated at or above 10% of the feed on Day 15. The coccidial isolates were purified from litter samples by Southern Poultry Research. All isolates were obtained during 1998 from broiler farms using a shuttle program of zoalene-salinomycin (E. acervu- lina, FS 19), narasin-salinomycin (E. maxima, FS 12), or narasin-narasin (E. tenella, FS 16).

A group of five male and five female birds were randomly selected in each pen and wing-banded at the beginning of each study (Day 0). Four birds (two male and two female) were randomly selected from this group in each pen for coccidial lesion scoring (Johnson and Reid, 1970) on Day 28 in Study 1 or Day 21 in Study 2. Based on this procedure, lesion scores ranged from normal (0) to severe (4). During the first 7 d of each study, birds that died or were culled were replaced with a bird of the same sex from a reserve of birds from the same hatch. Dead or culled birds were not replaced after Day 7.

Means and analysis of variance for weight gain, feed consumption, feed conversion (feed:gain), coccidial lesion scores per pen, and pen mortality were calculated using the general linear models procedure of SAS® (SAS Institute, 1989). Pen mortality percentages were analyzed after arc sine square root transformation (Snedecor and Coch- ran, 1980). All significant differences were based upon \( P < 0.05 \).

### RESULTS

#### Study 1

Means for weight gain, feed consumed, and feed conversion were improved for birds in the diclazuril treatment in comparison with all other treatments (Table 1). Means for weight gain and feed conversion for birds on the salinomycin, monensin, and lasalocid treatments were improved in comparison with the unmedicated treatment. Birds on the lasalocid treatment also had greater feed consumption in comparison with the unmedicated treatment.

| Treatments | Weight gain (kg) | Feed per bird (kg) | Feed:gain | Mortality percentage
<table>
<thead>
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</thead>
<tbody>
<tr>
<td>Unmedicated</td>
<td>1.921c</td>
<td>3.679c</td>
<td>1.994a</td>
<td>12.0b</td>
</tr>
<tr>
<td>1 ppm diclazuril</td>
<td>2.156a</td>
<td>3.956a</td>
<td>1.856c</td>
<td>1.0c</td>
</tr>
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<td>66 ppm salinomycin</td>
<td>2.023b</td>
<td>3.728a</td>
<td>1.913b</td>
<td>9.6b</td>
</tr>
<tr>
<td>100 ppm monensin</td>
<td>2.012b</td>
<td>3.699b</td>
<td>1.914b</td>
<td>10.2b</td>
</tr>
<tr>
<td>99.8 ppm lasalocid</td>
<td>2.037b</td>
<td>3.836b</td>
<td>1.936b</td>
<td>6.2a</td>
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<tr>
<td>SEM</td>
<td>0.0172</td>
<td>0.0375</td>
<td>0.0152</td>
<td>0.095</td>
</tr>
</tbody>
</table>

1. Elanco Animal Health, Indianapolis, IN 46285.
Mean percentage mortality for all causes was lower in the diclazuril treatment in comparison with all other treatments (Table 1). Coccidiosis-related mortality did not occur with the diclazuril treatment. Means for coccidiosis-related and total mortality with the lasalocid treatment were reduced in comparison with the respective means from the unmedicated treatment.

Mean coccidial lesion scores in the upper zone of the intestine and in the ceca for birds on the diclazuril treatment were lower in comparison with all other treatments (Table 2). Mean coccidial lesion score in the middle zone of the intestine with the diclazuril treatment was reduced in comparison with the salinomycin, monensin, and unmedicated treatments. Lesion score means in all three zones (upper, middle, and ceca) of birds on the lasalocid treatment were lower than the respective means from birds on the unmedicated treatment. Mean total lesion score across all three zones of the intestinal tract was lower in the diclazuril treatment in comparison with all other treatments. Mean total lesion score in the lasalocid treatment was lower than the salinomycin, monensin, and unmedicated treatments.

**Study 2**

Mean weight gain per bird at 42 d of study was greater in the diclazuril treatment in comparison with all other treatments (Table 3). Weight gain means in the nicarbazin and narasin + nicarbazin treatments were improved in comparison with the zoalene and unmedicated treatments. Mean weight gain in the zoalene treatment was greater than the mean gain in the unmedicated treatment. Mean feed conversion was improved in the diclazuril treatment in comparison with all other treatments except nicarbazin. Mean feed conversion in the nicarbazin treatment was improved in comparison with the zoalene and unmedicated treatments. Feed conversion means in the narasin + nicarbazin and zoalene treatments were improved in comparison with the unmedicated treatment. Coccidiosis-related mortality occurred only in the unmedicated treatment.

Mean coccidial lesion score in the upper zone of the intestine in the diclazuril treatment was lower in comparison with all other treatments (Table 4). Mean coccidial lesion score in the upper zone for the nicarbazin and narasin + nicarbazin treatment were lower in comparison with the zoalene and unmedicated treatments. In the middle zone of the intestine, mean lesion score in the nicarbazin treatment was lower in comparison with the means for the diclazuril, zoalene, and unmedicated treatments. Middle zone mean lesion score in the diclazuril treatment was reduced in comparison with the zoalene and unmedicated treatments. Lesion score means in the ceca were lower in the diclazuril and nicarbazin treatments in com-
parison with all other treatments. Means for total lesion score across all three zones were lower in the diclazuril and nicarbazin treatments in comparison with the narasin + nicarbazin, zoalene, and unmedicated treatments. Mean total lesion score in the narasin + nicarbazin treatment was lower than in the zoalene or unmedicated treatment.

**DISCUSSION**

The coccidial inoculum in Study 1 was moderately severe as indicated by the 8% coccidiosis mortality and mean lesion scores in the range of three to four in the unmedicated treatment. Because birds in Study 2 were exposed to the coccidial inoculum during the starter phase on Day 15, the challenge was reduced to more closely simulate natural conditions. This reduction was largely achieved by reducing the number of E. tenella oocysts in the inoculum from $5 \times 10^4$ to $1.5 \times 10^4$ sporulated oocysts per bird.

In Study 1, the mean total lesion score was lower, and bird performance improved with the salinomycin-diclazuril shuttle treatment in comparison with each of the other treatments. The improved efficacy of diclazuril in this study in comparison with monensin, salinomycin, and lasalocid was consistent with results reported previously by McDougald et al. (1990) in floor pen studies involving six different groups of field isolates. However, total lesion score means in each treatment were appreciably lower in the earlier work than in the current study.

In Study 2, the diclazuril-salinomycin and nicarbazin-salinomycin treatments were comparable in terms of total lesion control, but weight gain at Day 42 was superior in the diclazuril-salinomycin treatment. The diclazuril-salinomycin treatment was more efficacious than either of the other two treatments based upon total lesion control and bird performance.

The improved efficacy of diclazuril in comparison with the ionophore and chemical anticoccidials used in these studies was most likely due to two factors. First, the mode of action of diclazuril is different in contrast to the ionophore and chemical anticoccidials used in Studies 1 and 2. Work by Maes et al. (1988) demonstrated that 1 ppm diclazuril was lethal against both asexual and sexual stages of E. tenella and that oocyst shedding was completely prevented. Verheyen et al. (1989) demonstrated 1 ppm diclazuril had no effect against the various schizont stages of E. maxima, but oocyst wall formation in all fertilized macrogamonts was completely disturbed and resulted in necrosis of the developing oocyst. The fact that diclazuril acts primarily against the late stages of E. maxima probably explains the greater lesion score means observed in the mid-zone of the intestine with this treatment in both studies. Work with E. acervulina has demonstrated that diclazuril acts primarily against the asexual stages and especially the late schizont generations (Maes et al., 1989).

Second, the results also indicated that the coccidial isolates used in these studies were less sensitive to the ionophores, narasin + nicarbazin, and zoalene. This lack of sensitivity was especially evident in the high lesion score means in the upper zone of the intestine and the ceca with the ionophore treatments in Study 1 and with the narasin + nicarbazin and zoalene treatments in Study 2.

In conclusion, the use of 1 ppm diclazuril in a shuttle program demonstrated improved performance and greater efficacy against a mixed inoculum of E. acervulina, E. maxima, and E. tenella in comparison with nicarbazin, narasin + nicarbazin, and zoalene in starter diets and salinomycin, monensin, and lasalocid in grower diets.

**REFERENCES**


