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Anthelmintic treatments against digestive-tract nematodes in grazing dairy goats with high or low levels of milk production

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Summary — The effect of a regular anthelmintic treatment during the grazing period on milk production and milk composition was measured in a dairy goat farm. One month before turnout, 92 goats were given 10 mg·kg⁻¹ febantel and then allocated to 2 equivalent groups according to their levels of milk production. The first group was given febantel monthly, the second group was kept as an untreated control. Parasitological, haematological and serological data were collected monthly from March to September. Milk production data were recorded from March to August, goats being dried up in September.

Results of strongyle egg counts, serum inorganic phosphate concentrations and 4 necropsic examinations indicated a low level of nematode infection composed almost exclusively with Trichostrongylus colubriformis in untreated goats. No significant changes in milk yield, fat and protein content were detected between treated and untreated groups. Moreover, the impact of monthly anthelmintic treatment on milk production was different depending on the initial level of milk yield. Anthelmintic treatment induced a 4–8% increase in milk production for goats with the highest milk yield at the start of the experiment, whereas no beneficial effects were recorded for goats with the lowest milk yield.

Résumé — Traitements anthelminthiques contre les nématodes du tube digestif chez les chèvres au pâturage ayant un niveau faible ou élevé de production laitière. L’effet d’un traitement anthelminthique régulier durant la saison de pâturage sur la production laitière et les taux butyres et protéiques du lait a été mesuré dans une exploitation caprine. Un mois avant la mise au pâturage, 92 chèvres ont été traitées au febantel à 10 mg·kg⁻¹ et divisées en 2 groupes équivalents au plan de leur production laitière. Le premier groupe a été traité mensuellement au febantel tandis que le second, non traité, était gardé comme groupe témoin. Les données parasitologiques, hémato logiques et sérologiques ont été mesurées mensuellement de mars à septembre. Les données de production laitière ont été enregistrées de mars à août, les chèvres étant taries en septembre. Les résultats des coproscopies, des concentrations en phosphore sérique et de 4 examens nécropsiques ont indiqué un faible niveau d’infestation par les nématodes représentés quasi exclusivement par Trichostrongylus colubriformis.

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The effect of anthelmintic treatment of lactating ruminants on milk production has been studied by many authors, especially in dairy cattle, with conflicting results (Herd, 1982). Studies on the importance of economic losses associated with parasitism, the burdens of parasites required for such losses as well as the specific control measures needed do not lead to an unequivocal conclusion (Hawkins, 1993). For dairy goats, information in this area is very limited. Farizy (1970) recorded a 17.6% increase in milk yield over a 3-week period after a thiabendazole treatment whereas Cabaret et al. (1989) did not observe any correlation between milk production and egg output of digestive tract strongyles in a sample of 25 dairy-goat farms of northwest France. In a recent study, we have demonstrated that infection with *Haemonchus contortus* and *Trichostrongylus colubriformis* induced a decrease in milk yield which was more pronounced in goats with the highest lactation performance (Hoste and Chartier, 1993). Nevertheless these results were obtained in experimental conditions and did not allow us to draw parasite control recommendations in dairy goat farms.

The aim of the present field study was to assess the beneficial effect of a regular anthelmintic treatment on milk production and composition (fat and protein content) during the grazing period of dairy goats. A second objective was to relate in field conditions the milk-production response to antiparasitic treatment with the initial level of milk yield in goats.

**MATERIALS AND METHODS**

**Location of the study and climatic data**

The goat farm was located in western France and used an Alpine herd of 130 milking goats grazing alternately on 2 plots of 1.5 and 3 hectares from April to early October. The average milk production per goat per lactation was 703 l. The usual drenching plan included 4 drenches per year: 3 with benzimidazoles at kidding time in November, at turnout and at mating time in June, and one with ivermectin in September when goats were dried up.

The level of milk yield, grazing management and flock size can all be regarded as representative of dairy goat farms in the area (Chartier and Reche, 1992; Kulo, 1993).

Over the period of experimentation, the pattern of rainfall was characterized by an important shift from winter to summer and autumn compared with the normal values: 100, 120 and 125 mm in June, August and October, respectively, versus 50, 50 and 80 for the normal precipitation (National Meteorology Department, Lezay, 2 km from the goat farm). In a similar way, the mean monthly minimum temperature data showed that winter 1991-1992 had very low values (−1°C versus + 1.1°C in January).

**Experimental design**

Ninety-two dairy goats were included in the study. Except for 11 animals, the goats were in their
second or higher lactation. All goats kidded between November and December. In March, one month before turnout, 2 equivalent groups of 46 goats were defined according to their levels of milk production for the first months of lactation. At this time, all the animals were given 10 mg kg⁻¹ body weight febantel (Rintal®, Bayer Pharma, France) as a divided dose with a 24 h interval. This dosage was twice the dose rate recommended for sheep for digestive-tract strongyles and was chosen to take into account differences in bioavailability and efficacy of benzimidazole and probenzimidazole compounds in the 2 species (Bogan et al, 1987; Delatour et al, 1988; Benchouali et al, 1993; Hennessy et al, 1993). At turnout, one group of goats was given febantel monthly while the other was kept as a control untreated group, all goats being kept on the same pasture. This procedure may underestimate the beneficial effect of the anthelmintic since treated goats experience a continuous intake of larvae which could have a depressive effect on production (Thomas et al, 1984). Nevertheless, overcoming such a limitation with the management of 2 separated groups of goats was not possible. In both treated and control groups, subgroups of goats were defined according to the level of production. Twenty percent of the goats with the highest milk yield in the first months of lactation made up the high-producer subgroups (high-producer treated (HPT) and high-producer control (HPC)). The same categorization was applied for the 20% of the goats with the lowest milk yield at the beginning of the study (low producer treated (LPT) and low producer control (LPC)). The different groups and subgroups of goats with their respective initial level of milk production are presented in table I.

<table>
<thead>
<tr>
<th>Subgroups (4 x 10 goats)</th>
<th>Groups (2 x 46 goats)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treated monthly</td>
<td>Untreated</td>
</tr>
<tr>
<td>2.03 ± 0.56</td>
<td>2.17 ± 0.65</td>
</tr>
<tr>
<td>High producer</td>
<td>2.77 ± 0.21</td>
</tr>
<tr>
<td>Low producer</td>
<td>1.56 ± 0.17</td>
</tr>
</tbody>
</table>

Laboratory procedures

Individual faecal and blood samples were taken monthly from March to September. An additional faecal sampling was carried out in October when the goats were removed from pasture. Individual faecal egg counts using magnesium sulphate as flotation liquid and group faecal cultures were performed by standard procedures (MAFF, 1986). The packed cell volume (PCV) was measured by use of the microhematocrit method. Serum pepsinogen concentration was determined as described by Kerboeuf (1975) and serum inorganic phosphate concentration was determined by use of an autoanalyzer (Technicon, Bayer Diagnostics) following Robinson et al (1971). The 2 latter parameters were assessed as they are related to abomasal (increase in pepsinogen) and intestinal (decrease in inorganic phosphate) nematode infection (Anderson et al, 1966; Coop et al, 1976). In addition, 4 culled untreated goats were necropsied during the survey: 1 in May; 3 in September. Worm recovery, count and identification were performed according to MAFF (1986).

Milk production data

The milk production data including milk fat and protein content were collected in March, April, May, June and August at the local milk registration organisation. Determinations of fat and protein contents (Biggs et al, 1987) were made with a mid-infrared spectrometer (Milko-Scan 380, Fosselectric, Germany) at 5.73 μm for fat content and 6.46 μm for protein content. All goats were dried up in September.

Statistical analysis

Statistical analysis included 1-way or 2-way analysis of variance and comparisons of means (t-test) with egg counts being transformed to log (x + 1) to stabilize variance. To compare the response to anthelmintic treatment in the HPT and LPT subgroups, relative indices were calculated as follows for each sampling date:
These indices reflected the difference in response to anthelmintic treatment in the HP and LP subgroups. These differences were statistically tested by means of t-test.

RESULTS

Effect of the anthelmintic treatment

Parasitological data

At the start of experiment the mean strongylo egg counts were low (340 epg) in both groups. From 3 months after turnout, the egg counts were significantly different (t-test, \( P < 0.01 \)) between the treated and the untreated goats. The former had moderate egg outputs whereas the latter showed a peak count (1,600 epg) in September (fig 1). The egg outputs for other helminths were very low, ie below 50 eggs per g (Strongyloides papillosus, Skrjabinea sp, Trichuris sp) and no Moniezia eggs were seen. Faecal larval culture indicated that only Teladorsagia/Trichostrongylus larvae were recovered in both groups for the whole duration of study. This was confirmed by the results of necropsic examinations performed on 4 culled untreated goats. Low numbers of parasites were found in May and September and the worm populations were composed almost exclusively with T colubriformis (table II).

Haematological and serological data

No significant differences in PCV and pepsinogen concentrations were seen between treated and untreated groups until the end of the study (data not shown). The mean values ranged from 25 to 28% for PCV and from 246 to 350 mU tyrosine for pepsinogen concentrations. In contrast, serum inorganic phosphate concentrations decreased significantly (Anova, \( P < 0.001 \)) from June onwards (fig 1). The consequences of anthelmintic treatments were prominent at the end of the grazing period in August and September with significantly higher values in the treated than in the untreated goats (t-test, \( P < 0.05 \)).

Milk yield and composition data

No significant differences were assessed (Anova and t-test) for milk yield between the treated and the untreated goats (table...
Milk fat content strongly increased in both groups at the end of lactation in August (ANOVA, \( P < 0.001 \)) and were higher in the untreated than in the treated goat group (ANOVA, \( P < 0.05 \)). Nevertheless, the untreated group showed a higher fat content at the start of the experiment (t-test, \( P < 0.05 \)) and a covariance analysis using the initial fat content as a covariate indicated that no significant difference occurred between the 2 groups of animals. The milk protein content followed a similar pattern as fat content with a significant increase (ANOVA, \( P < 0.01 \)) in August but there was no statistical difference between treated and untreated goats (table III).

### Table II. Worm burdens for digestive-tract nematodes in 4 necropsied culled untreated dairy goats.

<table>
<thead>
<tr>
<th>Tag number of goats (date of slaughter)</th>
<th>Teladorsagia circumcincta</th>
<th>Trichostrongylus colubriformis</th>
<th>Trichostrongylus vitrinus</th>
<th>Skrjabine.sp</th>
</tr>
</thead>
<tbody>
<tr>
<td>901 (April)</td>
<td>20</td>
<td>4,540</td>
<td>-</td>
<td>1,290</td>
</tr>
<tr>
<td>107 (September)</td>
<td>20</td>
<td>1,730</td>
<td>-</td>
<td>70</td>
</tr>
<tr>
<td>738 (September)</td>
<td>20</td>
<td>4,860</td>
<td>50</td>
<td>210</td>
</tr>
<tr>
<td>946 (September)</td>
<td>40</td>
<td>2,670</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### Table III. Milk data (mean ± SD) in monthly treated (T) and control (C) goats. No statistical difference was detected between groups.

<table>
<thead>
<tr>
<th>Month</th>
<th>Milk yield (l)</th>
<th>Fat content (g/l)</th>
<th>Protein content (g/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>March</td>
<td>T: 2.03 ± 0.56</td>
<td>28.8 ± 4.6</td>
<td>29.3 ± 2.5</td>
</tr>
<tr>
<td></td>
<td>C: 2.17 ± 0.65</td>
<td>31.2 ± 4.2</td>
<td>29.5 ± 2.5</td>
</tr>
<tr>
<td>April</td>
<td>T: 1.90 ± 0.51</td>
<td>31.0 ± 5.2</td>
<td>29.7 ± 2.4</td>
</tr>
<tr>
<td></td>
<td>C: 1.97 ± 0.63</td>
<td>33.3 ± 5.3</td>
<td>30.6 ± 3.3</td>
</tr>
<tr>
<td>May</td>
<td>T: 2.00 ± 0.60</td>
<td>29.4 ± 4.4</td>
<td>28.5 ± 2.1</td>
</tr>
<tr>
<td></td>
<td>C: 2.17 ± 0.56</td>
<td>31.4 ± 5.0</td>
<td>29.8 ± 2.6</td>
</tr>
<tr>
<td>June</td>
<td>T: 1.86 ± 0.56</td>
<td>30.7 ± 3.6</td>
<td>27.6 ± 2.5</td>
</tr>
<tr>
<td></td>
<td>C: 1.94 ± 0.58</td>
<td>31.3 ± 5.8</td>
<td>27.9 ± 2.9</td>
</tr>
<tr>
<td>August</td>
<td>T: 1.14 ± 0.40</td>
<td>39.5 ± 6.4</td>
<td>31.1 ± 3.7</td>
</tr>
<tr>
<td></td>
<td>C: 1.16 ± 0.42</td>
<td>40.4 ± 6.0</td>
<td>31.0 ± 3.9</td>
</tr>
</tbody>
</table>

### Comparison between high-producer and low-producer goats

The patterns in faecal egg counts, PCV, serum pepsinogen and inorganic phosphate concentrations were similar in the HPT and LPT groups (data not shown). In contrast, the impact of regular anthelmintic treatment on milk yield was different, depending on the initial level of milk production (table IV). In the LP subgroup, drenching led to a paradoxical slight decrease in milk yield in May and June (relative indices < 1) compared with control goats. Conversely, in HPT goats, anthelmintic treatment induced a
4–8% increase in milk production for the same period (t-test, P = 0.06 in June). No difference was observed in the fat and protein content between HP and LP subgroups.

DISCUSSION

No significant effect of anthelmintic treatment on lactation performance (milk yield and composition) was seen in grazing dairy goats when comparing animals drenched at 4 week intervals and the control animals. These results are in contrast with a previous study where a single mixed nematode infection led to a decrease in milk yield ranging from 2.5 to 10% reduction from control values in dairy goats (Hoste and Chartier, 1993). However, both studies have quite different experimental designs. One investigated the effects of anthelmintic treatment of naturally infected goats (mainly Trichostrongylus) and the other was performed on naive animals in experimental conditions (Haemonchus and Trichostrongylus). Beyond the nematode species involved, several factors could explain such discrepancies between the 2 studies. Firstly, the pattern of strongyle infection during the grazing period in untreated goats in this study was characterized by a low egg output rising to a moderate level 1 month before the animals were dried up. This low level of infection was confirmed by the limited average worm burden recovered from the 3 necropsic examinations in untreated goats at the end of the grazing season (3 087) when compared to mean data obtained in 31 necropsied dairy goats in the same area (15 065) according to Chartier and Reche (1992). Climatic factors, especially a cold winter, may have partly induced such a situation by reducing the available overwintered infective larvae and thus the subsequent pasture infection (Gruner, 1979). Secondly, a striking feature was the dominance of *T. colubriformis* and the impossibility of obtaining a zero egg count in the treated animals despite a monthly drenching with febantel. A faecal egg count reduction test conducted on 30 goats in October with thiabendazole has demonstrated that resistance to benzimidazoles occurred (Chartier and Pors, 1994). This lack of complete effectiveness of anthelmintic in the treated goats combined with the low level of nematode infection may be partly responsible for the absence of beneficial effects of anthelmintic treatment on milk production. Thirdly, the previous experimental study was carried out on naive animals bred indoors which had therefore no previous exposure or acquired immunity to strongyle infection. These goats were probably more susceptible than the ones from the present study, which had been pastured before, although data on the development of resistance to nematode infection are equivocal for goats (Pomroy and Charleston, 1989a, b; Hosking and Watson, 1993). Fourthly, the timing of anthelmintic control with respect to stage of lactation may be important to consider. The greater economical benefit of treatment seems to be achieved early in lactation in dairy cows (Ploeger *et al*, 1989). In the present study, the differences in strongyle egg counts between treated and control goats occurred at a very late stage of lactation, ie 1 month before drying up. It may be assumed that the effect of existing worms on milk production is moderate at this stage when animals show a decreasing milk yield.

<table>
<thead>
<tr>
<th>Month</th>
<th>High producer treated</th>
<th>Low producer treated</th>
</tr>
</thead>
<tbody>
<tr>
<td>March</td>
<td>1.00 ± 0.08</td>
<td>1.05 ± 0.11</td>
</tr>
<tr>
<td>April</td>
<td>1.00 ± 0.11</td>
<td>1.04 ± 0.21</td>
</tr>
<tr>
<td>May</td>
<td>1.04 ± 0.15</td>
<td>0.93 ± 0.26</td>
</tr>
<tr>
<td>June</td>
<td>1.08 ± 0.22</td>
<td>0.97 ± 0.20</td>
</tr>
<tr>
<td>August</td>
<td>1.05 ± 0.37</td>
<td>1.10 ± 0.33</td>
</tr>
</tbody>
</table>
Bliss and Todd, 1977). In this regard, the present situation was quite different from our previous study in which goats were infected at the second month of lactation (Hoste and Chartier, 1993). The impact of anthelmintic treatment on lactation performance of the goats was different for animals of HPT and LPT subgroups. In goats producing a large amount of milk at the beginning of the experiment, the drenching led to an increase of 4-8% in milk yield in May and June. This result did not reach the generally accepted level of significance ($P = 0.06$) probably because of the small number of goats in each subgroup ($n = 10$). At this time, goats were about at the sixth month of lactation and the control goats did not yet show significant increase in strongyle egg outputs. These apparently conflicting results may be explained by a detrimental effect of parasitism from the early stage of infection as recorded in experimental conditions (Hoste and Chartier, 1993).

Notwithstanding the apparent relationship between productive traits and susceptibility to parasite infection (McEwan et al., 1992; Hoste and Chartier, 1993), it seems difficult to adopt control measures for parasitism at an individual basis in dairy goats in French conditions. Conversely, there is a need to formulate control programs at a farm level in which the anthelmintic regime is related to the expected levels of parasitism, the plane of nutrition and the performance of dairy goats (Plouger et al., 1989; Blackburn et al., 1992). Predictions of the impact of anthelmintic treatment will probably then be feasible.

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