

## Individual fluctuations in efficacy of febantel against *Muellerius capillaris* in goats

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**Summary** — One hundred and eighty-seven dairy goats originating from 7 farms in western France were treated individually with febantel (probenzimidazole drug) at a dose rate of 5 mg/kg in spring 1991. Individual faecal samples were collected on d 0, 7 and 21 post-treatment and processed for counting first stage larvae of *Muellerius capillaris* (LPG: larvae per gram of faeces). Eggs of digestive tract strongyles were also counted on d 0 and 7 (EPG: eggs per gram of faeces). Blood samples were taken on d 0 to assess pepsinogen concentration related to abomasal damage caused by strongyle infection. The individual characteristics of the goats were recorded. The procedure was repeated on the same animals in autumn 1991. The faecal larval count reduction (FLCR) was mainly related to farm and season: farm 1 in the spring and farm 6 in the autumn showed a higher proportion of high responder (HR) goats (FLCR > 80%), whereas farm 3 exhibited a lower proportion of HR goats in the autumn. On the other hand, the characteristics of the goats (breed, physiological status, age, weight, presence or absence of wattles and horns) as well as the initial level of parasitism (LPG, EPG and pepsinogen concentration) all had a role which was limited or zero on the variability of response to treatment. Goats could not be individually categorized according to their response level because the FLCR values obtained in the spring were not repeated in the autumn, suggesting that other environmental parameters could be involved.

**goat / *Muellerius capillaris* / febantel / anthelmintic efficacy / individual variation**

**Résumé** — Fluctuations individuelles d'efficacité du fébantel vis-à-vis de *Muellerius capillaris* chez les Caprins. Cent quatre-vingt-sept chèvres laitières provenant de 7 fermes dans l'Ouest de la France ont été traitées individuellement au fébantel (probenzimidazole) à la posologie de 5 mg/kg au printemps 1991. Des prélèvements individuels de fèces ont été réalisés à 0, 7 et 21 j après le traitement pour déterminer le nombre de larves L1 de *Muellerius capillaris* (LPG). Les œufs de strongles gastro-intestinaux ont également été dénombrés à J0 et J7 (OPG). Des prélèvements de sang ont été effectués à J0 pour la mesure du pepsinogène sanguin en relation avec les lésions abomasales dues aux trichostrongles. Les caractéristiques individuelles des chèvres ont été enregistrées. Cette procédure a été répétée sur les mêmes animaux à l'automne 1991. La réduction d'excrétion fécale de larves

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(REFL) a été principalement liée aux facteurs ferme et saison : la ferme 1 au printemps et la ferme 6 en automne ont montré une plus forte proportion d'animaux bons répondeurs (REFL > 80%) tandis que la ferme 3 présentait une plus faible proportion de ces bons répondeurs en automne. À l'opposé, les caractéristiques des chèvres (race, statut physiologique, âge, poids, présence ou absence de pendeloques et de cornes) ainsi que le parasitisme initial (LPG, OPG, pepsinogène) ont eu une influence limitée ou pas d'influence sur la variabilité de la réponse des chèvres au traitement. Les chèvres n'ont pas pu être catégorisées de manière individuelle sur leur niveau de réponse puisque les valeurs de réduction d'excrétion larvaire obtenues au printemps n'étaient pas répétables en automne, suggérant ainsi l'intervention d'autres paramètres environnementaux.

### **chèvre / *Muellerius capillaris* / fébantel / efficacité des anthelminthiques / variation individuelle**

## **INTRODUCTION**

Host physiological and pathological factors may influence anthelmintic efficacy by decreasing drug concentrations (Prichard, 1985). This phenomenon is of concern where helminths show a moderate susceptibility at routine dosages of benzimidazoles such as *Muellerius capillaris* in goats (Bankov, 1981; Cabaret *et al*, 1984). The efficacy of benzimidazoles against *M capillaris* infection can be reliably assessed by measuring the post-treatment reduction of first-stage larvae output, and larval excretion has been positively correlated with adult and immature numbers in treated and control animal groups (Dakkak *et al*, 1979; Cabaret *et al*, 1980b). A dose response has been demonstrated both for larval output and worm population with fenbendazole in sheep (Dakkak *et al*, 1979).

In a previous field study (Richard and Cabaret, 1992), it was shown that individual variation in efficacy of fenbendazole against *M capillaris* in goats was mainly attributable to the actual dose rate received by the animals. Clear treatment differences between low and high responders were found, but characterization of these animals was difficult. On the other hand, the possible influence of season or farm was not determined in this work.

The aim of this paper was to assess the individual fluctuations in efficacy of febantel, a pro-benzimidazole compound, against *M*

*capillaris* in goats at a dose rate of 5 mg/kg. This dose rate is not fully effective against *M capillaris* in goats (Denev *et al*, 1986) and was specifically used to produce observable changes in anthelmintic efficacy between individual goats. An attempt was made to relate the individual level of response to farm and seasons.

## **MATERIALS AND METHODS**

### ***Experimental design***

The study was conducted on 7 dairy goat farms in spring (March to June) and autumn (September to December) 1991. The farms were located in the western part of France (Deux-Sèvres) and had a flock size ranging from 40 to 200 adult goats. The farms were characterized by having industrial dairy production (average annual milk yield of 410–800 l per goat) and permanent grazing throughout the year.

At the beginning of the experiment in the spring, about 25 goats in each farm were randomly selected, weighed and were given febantel orally (Rintal®, Bayer) at a dose rate of 5 mg/kg. Faecal samples were collected per individual on d 0, 7 and 21 post-treatment and blood samples on d 0. The individual characteristics of the goats were recorded (Richard *et al*, 1990): breed, age, presence or absence of horns or wattles, pregnancy or lactation and months of lactation (table 1). A similar procedure was repeated in the autumn on the same farms. A total of 141 animals were surveyed in both spring and autumn.

### **Faecal and serological examinations**

Faecal nematode egg counts (d 0 and 7) were performed by a modified McMaster technique (MAFF, 1986) using magnesium sulphate as flotation liquid, and first stage larvae of *M capillaris* extracted and counted (d 0, 7 and 21) according to a modified Baermann technique (Cabaret *et al*, 1980a). Results were expressed respectively as eggs per gram of faeces (EPG) and larvae per gram of faeces (LPG). In addition, farm faecal samples were cultured for 10 d at 22°C for the spring survey. Identification (MAFF, 1986) showed that *Teladorsagia* and *Trichostrongylus* were predominant (55–91%). The frequencies of the other genera were less than 18% except for *Haemonchus* on farm 7 (39%). Serum pepsinogen concentrations for each sample were determined as previously described (Kerboeuf, 1979) in order to assess the degree of abomasal damage caused by strongyle infection.

### **Data analysis**

The individual faecal larval count reduction (FLCR) on d 7 or 21 post-treatment was calculated by:

$$\frac{\text{LPG on d 0} - \text{LPG on d 7 or 21}}{\text{LPG on d 0}} \times 100$$

when LPG was  $\geq 5$  on d 0. The term high responder (HR) to the treatment was used for goats showing an FLCR  $> 80\%$ . In contrast, animals with an FLCR  $< 20\%$  were categorized as low responders (LR). The faecal strongyle egg count reduction (FECR) on d 7 was calculated in a similar way.

Data were analyzed using the computer package Stat-Itcf (1988). The relationships between FLCR distributions and goat characteristics, initial parasitism or season were assessed with chi-square test. Simple comparisons may lead to a restricted interpretation if 2 or more of the parameters are not independent. As a result, multiple regression fitted by least squares was required to assess and quantify the relationship between FLCR and all suitable (numerical) variables. The statistical significance of the variables was tested using the 0.05 level of confidence. Lastly, multiple correspondence analysis was performed to obtain a synthetic description of the main features of the animals related to the FLCR. Numerical variables were split into 3 classes of approximately

the same number of goats: age, AG; weight, WE; LPG; EPG; and pepsinogen, PP. The FECR and FLCR were split into the following 3 classes: 0–19; 20–79; and 80–100%. The other variables were categorical: breed, BR, lactation, LA; season, SE; and farm, FA.

## **RESULTS**

### **Existence of low and high responders to treatment**

Mean faecal egg and larval counts are reported in tables I and II, respectively. General patterns obtained from spring and autumn surveys are presented in table III. The proportion of LR goats formed the largest proportion irrespective of the day (d 7 or 21) or the season and ranged from 39.6 to 51.3%. Conversely HR goats represented 10.5 to 23% of the animals. Distributions of goats according to their responses on d 7 and 21 post-treatment were highly dependent both in spring and autumn ( $P < 0.0001$ ).

### **Repeatability of faecal larval count reduction (FLCR) between spring and autumn surveys**

The comparison of FLCR split into 3 classes (0–19; 20–59; and 60–100%) for the 141 animals surveyed in both spring and autumn showed that the 2 responses according to the season of sampling were independent (chi-square test,  $P > 0.05$ ). Only 44.6 and 36.2% of the goats remained in the same FLCR class on d 7 and 21 respectively during the 2 surveys.

### **FLCR and factors of variation**

A preliminary parameter-to-parameter comparison by chi-square test was made to assess possible monofactorial relationships

Table I. Goat characteristics and parasitological data (mean  $\pm$  SD) of the 7 surveyed farms.

|                                                     | Farm                               |                                        |                                          |                                    |                                          |                                      |                                      |
|-----------------------------------------------------|------------------------------------|----------------------------------------|------------------------------------------|------------------------------------|------------------------------------------|--------------------------------------|--------------------------------------|
|                                                     | 1                                  | 2                                      | 3                                        | 4                                  | 5                                        | 6                                    | 7                                    |
| Number of goats <sup>a</sup>                        | 30 (30)                            | 30 (31)                                | 28 (33)                                  | 21 (31)                            | 25 (25)                                  | 28 (27)                              | 25 (30)                              |
| <b>Goat characteristics</b>                         |                                    |                                        |                                          |                                    |                                          |                                      |                                      |
| French Alpine breed (%)                             | 100                                | 17                                     | 96                                       | 19                                 | 4                                        | 7                                    | 4                                    |
| Saanen breed (%)                                    | 0                                  | 77                                     | 4                                        | 62                                 | 96                                       | 75                                   | 88                                   |
| Polled (%)                                          | 17                                 | 20                                     | 25                                       | 33                                 | 32                                       | 39                                   | 8                                    |
| No wattles (%)                                      | 57                                 | 40                                     | 39                                       | 52                                 | 36                                       | 64                                   | 72                                   |
| Mean age (year)                                     | 3.0                                | 2.8                                    | 4.7                                      | 5.8                                | 3.6                                      | 3.8                                  | 4.4                                  |
| Mean weight (kg) <sup>a</sup>                       | 63.6 (49.4)                        | 59.9 (66.9)                            | 47.4 (53.8)                              | 57.9 (60.1)                        | 50.9 (53.7)                              | 50.9 (48.6)                          | 61.7 (63.9)                          |
| Lactating (%) <sup>a</sup>                          | 0 (100)                            | 73 (100)                               | 100 (94)                                 | 100 (54)                           | 88 (24)                                  | 93 (96)                              | 100 (0)                              |
| <b>Parasitological data</b>                         |                                    |                                        |                                          |                                    |                                          |                                      |                                      |
| Mean EPG d 0 <sup>a</sup>                           | 455 $\pm$ 714<br>(733 $\pm$ 766)   | 1 085 $\pm$ 901<br>(2 517 $\pm$ 1 722) | 4 876 $\pm$ 2 778<br>(2 674 $\pm$ 1 507) | 276 $\pm$ 419<br>(1 177 $\pm$ 857) | 3 263 $\pm$ 2 359<br>(1 975 $\pm$ 1 866) | 763 $\pm$ 522<br>(3 223 $\pm$ 1 724) | 664 $\pm$ 592<br>(3 294 $\pm$ 1 895) |
| Mean FECR d 7 (%) <sup>a</sup>                      | 46.2 $\pm$ 37<br>(75.9 $\pm$ 22)   | 22.2 $\pm$ 29<br>(46.7 $\pm$ 24)       | 27.3 $\pm$ 34<br>(33.9 $\pm$ 33)         | 49.1 $\pm$ 34<br>(40.5 $\pm$ 30)   | 37.6 $\pm$ 23<br>(40.7 $\pm$ 28)         | 38.2 $\pm$ 31<br>(24.4 $\pm$ 25)     | 54.7 $\pm$ 26<br>(39.2 $\pm$ 24)     |
| Mean pepsinogen d 0 (mU TYR)                        | 933 $\pm$ 418<br>(1 107 $\pm$ 479) | 1 347 $\pm$ 522<br>(1 296 $\pm$ 545)   | 536 $\pm$ 273<br>(548 $\pm$ 286)         | 174 $\pm$ 112<br>(1 073 $\pm$ 379) | 255 $\pm$ 158<br>(968 $\pm$ 771)         | 1 475 $\pm$ 645<br>(706 $\pm$ 512)   | 969 $\pm$ 516<br>(1 605 $\pm$ 746)   |
| No of anthelmintic treatments per year <sup>b</sup> | 3(0)                               | 5(5)                                   | 5(5)                                     | 3(2)                               | 2(2)                                     | 6(4)                                 | 2(2)                                 |

<sup>a</sup> Autumn data in parentheses; <sup>b</sup> benzimidazole compounds in parentheses.

**Table II.** Mean *Muellerius* first stage larval outputs (LPG) before (d 0) and after (d 7 and 21) febantel treatment according to the farm (mean  $\pm$  SD), and related mean of individual FLCR (mean  $\pm$  SD)

| Farm          | LPG           |               |               | FLCR (%)        |                 |
|---------------|---------------|---------------|---------------|-----------------|-----------------|
|               | d 0           | d 7           | d 21          | d 7             | d 21            |
| <i>Spring</i> |               |               |               |                 |                 |
| 1             | 219 $\pm$ 188 | 112 $\pm$ 136 | 68 $\pm$ 100  | 51.4 $\pm$ 31.2 | 68.8 $\pm$ 25.3 |
| 2             | 175 $\pm$ 325 | 181 $\pm$ 292 | 136 $\pm$ 215 | 21.4 $\pm$ 31.1 | 31.6 $\pm$ 37.4 |
| 3             | 222 $\pm$ 273 | 210 $\pm$ 243 | 252 $\pm$ 250 | 32.4 $\pm$ 37.6 | 22.7 $\pm$ 35.1 |
| 4             | 161 $\pm$ 150 | 143 $\pm$ 172 | 169 $\pm$ 178 | 35.7 $\pm$ 34.1 | 29.7 $\pm$ 34.1 |
| 5             | 252 $\pm$ 276 | 198 $\pm$ 209 | 130 $\pm$ 186 | 34.7 $\pm$ 40.2 | 51.4 $\pm$ 41.4 |
| 6             | 167 $\pm$ 174 | 187 $\pm$ 199 | 155 $\pm$ 245 | 16.5 $\pm$ 26.8 | 33.8 $\pm$ 39.3 |
| 7             | 203 $\pm$ 339 | 193 $\pm$ 271 | 127 $\pm$ 248 | 27.1 $\pm$ 33.9 | 54.2 $\pm$ 35.9 |
| <i>Autumn</i> |               |               |               |                 |                 |
| 1             | 97 $\pm$ 116  | 59 $\pm$ 66   | 77 $\pm$ 96   | 29.3 $\pm$ 26.1 | 28.4 $\pm$ 30.1 |
| 2             | 119 $\pm$ 143 | 116 $\pm$ 99  | 111 $\pm$ 138 | 20.5 $\pm$ 26.8 | 24.8 $\pm$ 29.4 |
| 3             | 168 $\pm$ 202 | 165 $\pm$ 159 | 200 $\pm$ 205 | 20.9 $\pm$ 26.9 | 12.3 $\pm$ 21.4 |
| 4             | 287 $\pm$ 249 | 222 $\pm$ 278 | 122 $\pm$ 103 | 34.1 $\pm$ 29.4 | 47.3 $\pm$ 33.7 |
| 5             | 194 $\pm$ 334 | 122 $\pm$ 181 | 197 $\pm$ 273 | 30.8 $\pm$ 34.7 | 25.7 $\pm$ 28.5 |
| 6             | 143 $\pm$ 211 | 103 $\pm$ 168 | 63 $\pm$ 80   | 38.1 $\pm$ 37.6 | 51.2 $\pm$ 35.6 |
| 7             | 233 $\pm$ 391 | 132 $\pm$ 169 | 120 $\pm$ 225 | 40.2 $\pm$ 37.1 | 47.4 $\pm$ 38.6 |

**Table III.** Distribution of FLCR in dairy goats 7 and 21 d post-treatment with febantel

| FLCR (%)      | % goats |      |
|---------------|---------|------|
|               | d7      | d21  |
| <i>Spring</i> |         |      |
| 0-19          | 51.3    | 39.6 |
| 20-39         | 11.8    | 11.2 |
| 40-59         | 13.3    | 8.6  |
| 60-79         | 7.0     | 17.6 |
| 80-100        | 16.6    | 23.0 |
| <i>Autumn</i> |         |      |
| 0-19          | 49.3    | 45.0 |
| 20-39         | 13.9    | 15.3 |
| 40-59         | 14.3    | 13.4 |
| 60-79         | 12.0    | 12.9 |
| 80-100        | 10.5    | 13.4 |

with the FLCR (table IV). No significant relationship was seen between FLCR and the following factors: age; presence of horns or wattles; LPG d 0; pepsinogen d 0; and FECR d 7. Some other parameters seemed

to play a limited role on FLCR since their influence was only established for 1 season (spring or autumn) or for 1 post-treatment day (d 7 or d 21): lactation; weight; breed, and EPG d 0 (table IV). Moreover, the effect of season was significant on d 21; higher FLCR was seen in spring ( $P = 0.05$ ). The most important and constant factor influencing FLCR was the farm: in spring (d 7 and 21) FLCR was significantly higher in farm 1 ( $P < 0.004$  and  $P < 0.0003$  respectively); in autumn (d 21) farm 3 exhibited a lower FLCR and farm 6 a greater FLCR ( $P < 0.0009$ ). In order to assess the possible relationship between FLCR at d 21 in spring and autumn and the number of benzimidazole treatments given per year, a Friedman 2-way analysis of variance by ranks was performed using the 7 farms and the 3 above-mentioned criteria. The result ( $P = 0.84$ ) indicated that the distribution of ranks in each criterion was a matter of chance and that no agreement was obtained between record of benzimidazole treatments and FLCR in spring and autumn.

**Table IV.** Relations between FLCR at d 7 and 21 post-treatment and goat characteristics (chi-square tests).

| Goat characteristic       | FLCR at d 7 |        | FLCR at d 21 |              |
|---------------------------|-------------|--------|--------------|--------------|
|                           | Spring      | Autumn | Spring       | Autumn       |
| Lactating/pregnancy       | $P < 0.003$ | NS     | $P < 0.0003$ | NS           |
| Weight                    | NS          | NS     | $P < 0.02$   | NS           |
| Alpine/Saanen/mixed breed | $P < 0.004$ | NS     | NS           | $P < 0.02$   |
| Farm                      | $P < 0.004$ | NS     | $P < 0.0003$ | $P < 0.0009$ |

Multiple regressions performed on the FLCR at d 7 and 21 with all the numerical variables in spring and autumn confirm the results obtained above. The part of variability of FLCR explained by the variables was very low with the coefficient of determination ( $r^2$ ) ranging from 10 to 17% according to the season (table V).

#### **Characterization of the low and high responder goats at d 21**

In the correspondence analysis, the farm variable was introduced as a supplementary variable. The first 3 axes accounted for 34% of the variance. On the principal plane (axes 1 and 2), it can be seen that the high

response variable (FLCR 3) was strongly isolated (fig 1). On the other hand, the poor response to treatment was related to lactating and mixed breed goats, moderately infected with gastrointestinal strongyles and also to the autumn period. Animals from farm 3 were associated with low responses to treatment.

#### **DISCUSSION**

At 5 mg/kg BW of febantel, the mean faecal larval count reduction on d 7 or 21 post-treatment for *M capillaris* was moderate in dairy goats and allowed the allocation of the animals into high (FLCR > 80%) medium and low (FLCR < 20%) responders. Numer-

**Table V.** Components of best regression models for the FLCR on d 7 and 21 in spring and autumn.

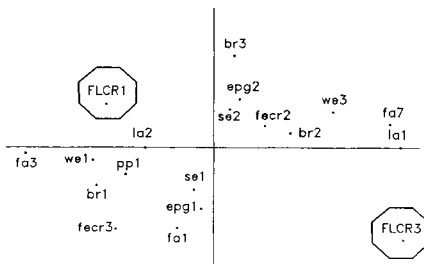
| Equation of regression                                                                                                        | Probability | $r^2$ |
|-------------------------------------------------------------------------------------------------------------------------------|-------------|-------|
| <i>Spring</i>                                                                                                                 |             |       |
| $\text{LOG (FLCR7)} = 1.45 - 0.12 \text{ AGE} + 0.30 \text{ LOG (LPGo)}$<br>$+ 0.01 \text{ WEIGHT} - 0.36 \text{ LOG (PEPo)}$ | 0.0001      | 0.17  |
| $\text{LOG (FLCR21)} = 1.07 - 0.13 \text{ AGE} + 0.02 \text{ WEIGHT} + 0.29 \text{ LOG (LPGo)}$                               | 0.0006      | 0.14  |
| <i>Autumn</i>                                                                                                                 |             |       |
| $\text{LOG (FLCR7)} = 0.28 + 0.36 \text{ LOG (LPGo)} + 0.19 \text{ LOG (FECR7)}$                                              | 0.003       | 0.10  |
| $\text{LOG (FLCR21)} = -1.4 + 0.32 \text{ LOG (LPGo)} + 0.44 \text{ LOG (PEPo)}$                                              | 0.0012      | 0.11  |

ous factors are known to affect the pharmacokinetics and efficacy of antiparasitic drugs in animals resulting in large individual variations (Prichard, 1985; Galtier, 1990). They are related to the absorption, the transport, the metabolism and excretion of the drug and include age, breed, reproductive status, disease and nutritional conditions. In a previous global field survey (Richard and Cabaret, 1992), the main factor affecting the faecal larval count reduction of *M capillaris* was the dose of fenbendazole in the range 3.4 to 9.6 mg/kg. The poor responders in autumn belonged to the Alpine breed, were in late pregnancy and had low levels of strongyle and lungworm infection. Our study, which was conducted with a single dose rate and repeated twice in spring and autumn, gave somewhat different results. The parameters related to goat characteristics and initial levels of parasitism did not have inconstant effects on FLCR from 1 season to another suggesting that there is an additional seasonal influence. The characteristics of goats, as recorded in this study, had a limited influence on the variability of

response to febantel treatment (10–17% in multiple regression). Furthermore, the goats could not be categorized reliably according to their response level as the FLCR was not repeatable a few months later, indicating that other environmental parameters play an important role in the response. Further factors related to the individual physiology of goats or to the variability of *M capillaris* susceptibility might be involved. The efficacy of benzimidazoles depends partly on the extent of oesophageal groove closure (Prichard and Hennessy, 1981). Partial or complete rumen bypass is a very frequent phenomenon in goats (Rickard, 1992) and may thus account for the variability in efficacy. The availability of anthelmintics also depends on the rate of transit of digesta (Taylor *et al*, 1992). Febantel is extensively metabolized in the liver (Beretta *et al*, 1987) and hepatic injury might account for variation in efficacy (Galtier *et al*, 1991).

Response patterns were significantly different according to the farm and the season suggesting that the susceptibility of *M capillaris* populations to febantel may exhibit variations.

The hypothesis of an anthelmintic resistance, which exists for gastrointestinal strongyles, cannot be categorically ruled out in these farms because of the low dosage of febantel used (5 mg/kg), which is known to be only partially effective against *M capillaris* in goats (Denev *et al*, 1986). However, 2 facts could indicate that such a resistance does not occur in the surveyed farms. Firstly, it is well recognized that the frequency of animal drenching is one of the most important factors affecting the development of resistance (Sykes *et al*, 1992). In our study, the farms having low FLCR in spring and autumn had a drench plan varying from 2 to 5 benzimidazole treatments per year and no relationship was seen between FLCR and benzimidazole treatments. Secondly, FLCR patterns in each farm (except for farm 3) were different from 1 season to another sug-



**Fig 1.** Goat response to treatment with febantel in relation to the season, initial parasitic infection level and goats characteristics: multiple correspondence analysis. Only the significant classes are indicated. FLCR: faecal larval count reduction on d 21, 1: < 20%, 3:  $\geq$  80%; FECR: faecal egg count reduction on d 7, 2: 20–79%, 3:  $\geq$  80%; EPG1 (15–719), EPG2 (720–2159); PP1 (44–611); BR1 (French Alpine), BR2 (Saanen), BR3 (mixed breed); LA1 (non-lactating), LA2 (lactating); WE1 (31–49), WE3 (60–93); SE1 (spring), SE2 (autumn); FA1, FA3, FA7 (farms).

gesting that anthelmintic resistance was not a consistent hypothesis.

On the other hand, a recent survey, conducted in the same 7 farms, has shown that the motility of the first-stage larvae, when in contact with thiabendazole, pyrantel or ivermectin, was different from 1 farm to another (Kulo *et al*, 1994). The situation, however, is not clearly understood since it is probable that motility of L1 expresses genetic diversity in *M capillaris* rather than susceptibility of adult population to anthelmintics (Kulo *et al*, 1994).

Investigations are still required to delineate the respective roles of genetic and environmental factors in the ability of goats to respond to febantel treatment as well as the possible occurrence of *M capillaris* anthelmintic resistance in dairy-goat farms.

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