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A survey of farm management practices and their associations with anthelmintic resistance in sheep flocks in Ontario, Canada

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ABSTRACT

To describe parasite control and farm management practices commonly used by Ontario sheep farmers, and to determine whether any of these practices were associated with the level of anthelmintic resistance (AR) to ivermectin, fenbendazole or levamisole, we conducted fecal egg count reduction (FECR) tests in Ontario sheep flocks, and administered a questionnaire pertaining to farm practices that were considered putative risk factors for AR. In the previous 5 years, most of the producers had used ivermectin and fenbendazole drenches (95% and 68%, respectively), while only 11% had used levamisole drench. Producers treated their animals a mean of 2.6 times per year. Routine treatment was practiced by 82% of the producers; most ewes were treated either at lambing (55%) and/or at the beginning of winter housing (48%). The majority of the producers (82%) also used targeted or targeted selective treatment; however, it was often in addition to, rather than in lieu of, routine treatment. Twenty-five producers (66%) brought in new animals in the previous year. Many producers (45%) did not calibrate the drench gun before use. The mean FECR percentages following treatment with ivermectin, fenbendazole, and levamisole were 23.7%, 28.6% and 99.1%, respectively. Although univariable analyses identified several marginally significant risk factors ($0.10 > p > 0.05$), none were significant in the final model for ivermectin FECR percentage. In contrast, use of benzimidazoles in the previous 5 years was associated ($p = 0.01$) with increased resistance (lower mean FECR percentage) to fenbendazole. Levamisole resistance could not be modeled due to the very low levels of resistance on the farms surveyed. This study: (1) provided a picture of management practices employed by Ontario sheep producers who were experiencing AR to one or more anthelmintic drugs on their farms; and (2) allowed us to identify areas for further AR risk factor research.

1. Introduction

Gastrointestinal nematodes (GINs) cause significant disease in grazing sheep worldwide (Scott, 2007). For many years, anthelmintic drugs have represented the cornerstone of GIN control, since they were efficacious and relatively inexpensive and easy to use (Kenyon and Jackson, 2012). However, reports of anthelmintic resistance (AR)

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have become increasingly common over the past 20 years, and AR now represents the status quo in numerous sheep-rearing countries (Kaplan and Vidyashankar, 2012). A recent study in Canadian sheep flocks demonstrated that ivermectin drench failure was a common occurrence, and that resistance to both ivermectin and fenbendazole was present on most farms (Falzon et al., 2013).

Several management practices, such as increased frequency of anthelmintic treatment (Calvete et al., 2012), and inadequate quarantine strategies for new animal introductions (Sargison, 2011), have been described as risk factors for AR. However, the association of AR with these practices is based on complex theoretical principles (Sargison, 2011) or simulation studies (Leathwick et al., 1995). So far, few observational studies on risk factors associated with AR have been conducted on commercial sheep farms (Suter et al., 2004; Calvete et al., 2012), and there is a lack of empirical evidence regarding which management practices should be recommended to sheep producers to lower the risk of AR on their farms. Moreover, a recent survey on sheep farms in the United Kingdom (Morgan and Coles, 2010) showed that, despite the widespread dissemination in 2005/2006 of theoretically plausible practical guidelines on how to counter AR (Abbott et al., 2009), very few changes in management practices ensued in the following 2 years. Therefore, it is important to improve our knowledge of the management practices that are commonly used on farms, and to understand producers' perceptions of AR risk on their farms, so that extension programs to stakeholders can be improved (Woodgate and Love, 2012).

In Ontario, Canada, the ewe flock has been increasing steadily over the past few years (Statistics Canada, 2012), yet information on farm management practices commonly practiced on Ontario sheep flocks is currently lacking. The objectives of this study were: (a) to describe parasite control and farm management practices commonly used by Ontario sheep farmers who were interested in AR and whose sheep attained mean GIN fecal egg counts (FECs) that reached a set threshold of 200 eggs per gram (epg) of feces; and (b) to determine whether any of these practices were associated with the level of AR to ivermectin, fenbendazole or levamisole.

2. Materials and methods

A description of the farm selection, ivermectin drench check, and the Fecal Egg Count Reduction Test (FECRT) can be found in Falzon et al. (2013); the farms involved in the present study were the same 47 sheep farms that were followed over two consecutive grazing seasons in 2010 and 2011, to determine the frequency of AR in Ontario sheep flocks. Among these 47 farms, animals on 39 farms attained mean GIN FECs that reached the set threshold of 200 epg of feces. As a result, an ivermectin drench check was carried out by producers on these farms. On the basis of FECs before treatment and 14 days later, "drench failure" was defined as a reduction in mean FECs of <95%. FECRTs were then conducted in flocks with ivermectin drench failure. The percentage reduction in mean FECs following treatment with ivermectin, fenbendazole and levamisole was calculated using the method endorsed by the World Association for the Advancement of Veterinary Parasitology (Coles et al., 1992).

A questionnaire on management practices and putative risk factors for AR was administered by one of the co-authors (LCF) in a face-to-face interview with the farm manager on the farms that performed an ivermectin drench check. Questionnaires took approximately 30–40 min each to complete and were carried out during the grazing seasons of 2010 or 2011.

The questionnaire contained 29 questions about management in the preceding 5 years, and was divided into six main sections: (i) current demographics of the farm; (ii) use of anthelmintics; (iii) quarantine strategies for new animal introductions (animals of interest included sheep, goats, llamas and/or alpacas, but not cattle or other livestock); (iv) pasture management and alternative strategies for parasite control; (v) manure disposal; and (vi) perceived anthelmintic resistance. The majority of the questions were closed-ended, with a few semi-open (i.e. a close-ended question with the addition of a category "other – please specify") and open-ended questions. Routine treatment was defined as treatment of the whole flock at fixed times during the year and not based on fecal egg count results or evidence of clinical parasitism. Targeted treatment and targeted selective treatment were defined as treatment of the whole flock or individual animals, respectively, when GIN parasitism was suspected. A copy of the questionnaire can be obtained from the authors upon request.

The questionnaire data were entered into an Excel spreadsheet (Microsoft Office Excel©, 2007) and analyzed using SAS® 9.3 (SAS Institute Inc., Cary, NC, USA). Summary descriptive statistics of all variables were generated, and the statistical unit of analysis was at the farm-level. Fecal Egg Count Reduction (FECR) percentages were calculated at the farm-level, and are presented in full elsewhere (Falzon et al., 2013). The FECR percentages following ivermectin ($n = 29$), fenbendazole ($n = 20$) or levamisole ($n = 17$) treatment were used for three separate anthelmintic-based outcomes and model-building processes to determine predictors of the FECR percentages. For each of the three models, univariable associations between the predictor variables and the outcome were screened using linear regressions (for continuous predictor variables) or *t*-tests (for categorical predictor variables). Predictor variables that were significantly associated with outcomes at a liberal alpha value of ≤ 0.20 were offered to a general linear model, with all predictor variables considered as fixed effects. Predictor variables that were significant at an alpha value ≤ 0.05 were retained in the final model.

3. Results

The questionnaire was administered on 38/39 farms that performed the ivermectin drench check; 20 questionnaires were administered in the first year of the study (2010), and 18 administered in the second (2011).

Of the 38 farms surveyed, 29%, 26%, 34%, and 11% had flock sizes of <50 sheep, 50–99 sheep, 100–300 sheep, and >300 sheep, respectively. Most of the producers kept sheep for meat purposes (31/38; 82%). None of the farms included in the study were organic or working toward organic status. Twenty-five (66%) flocks lambed once a year; another 10 flocks (26%) lambed in multiple seasons, while the remaining 3 flocks (8%) lambed year-round. Farms that lambed in multiple seasons or year round, used accelerated lambing (an intensive management scheme), except on one farm where the ram was left with the ewes all year round. Ewes and lambs were grazed together on 89% of the farms, for a mean of 3.8 months (range from 1 to 7 months). Potential for manure run-off spreading into grazed pastures was reported on 15 (39%) of the 38 farms, and 23 (61%) of the 38 farmers reported that sheep had access to the manure pile.

Of the producers surveyed, 95% (36/38) reported using ivermectin drench, 68% (26/38) used fenbendazole drench, and 11% (4/38) had used levamisole, in the past 5 years. In the preceding 12 months, producers had treated their flock or a portion of the flock with an anthelmintic drug a mean of 2.6 times (range from 0 to 5).

Most producers (31/38; 82%) treated their sheep routinely, i.e. at a specific time or management procedure. Ewes were treated routinely a mean of 2.1 times/year (range from 1 to 4), rams were treated routinely a mean