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Research paper

Economic modelling of grazing management against gastrointestinal nematodes in dairy cattle

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ABSTRACT

Grazing management (GM) interventions, such as reducing the grazing time or mowing pasture before grazing, have been proposed to limit the exposure to gastrointestinal (GI) nematode infections in grazed livestock. However, the farm-level economic effects of these interventions have not yet been assessed so far. In this paper, the economic effects of three GM interventions in adult dairy cattle were modelled for a set of Flemish farms for which data were available: later turnout on pasture (GM1), earlier housing near the end of the grazing season (GM2), and reducing the daily grazing time (GM3). Farm accountancy data were linked to *Ostertagia ostertagi* bulk tank milk ELISA results and GM data for 137 farms. The economic effects of the GM interventions were investigated through a combination of efficiency analysis and a whole-farm simulation model. Modelling of GM1, GM2 and GM3 resulted in a marginal economic effect [5th; 95th percentiles] of € 8.36 [−222; 88], € −9.05 [−143; 38] and € −53.37 [−301; 87] per cow per year, respectively. The results suggest that the dairy farms modelled can improve their economic performance by postponing the turnout date, but that advancing the housing date or reducing daily grazing time mostly leads to a lower net economic farm performance. Overall, the GM interventions resulted in a higher technical efficiency and milk production but these benefits were offset by increased feed costs as a result of higher maintenance and cultivation costs. However, results highly differ between farms, indicating the need to evaluate GM interventions at the individual farm level for appropriate decision support.

1. Introduction

The control of gastrointestinal (GI) nematode infections in cattle strongly depends on anthelmintic usage (Charlier et al., 2014). However, anthelmintic resistance is emerging and approaches to reduce dependence on the traditional chemotherapeutics are required (Sutherland and Leathwick, 2011; Geurden et al., 2015). Grazing management (GM) interventions have since long been proposed to reduce exposure to GI nematode infections and remain the only alternative to anthelmintic treatment in cattle as long as no effective anthelmintic vaccines are commercially available (Stromberg and Averbeck, 1999; Vercruysse et al., 2007). Among the most consistent and effective GM interventions to reduce GI nematode exposure levels are interventions such as shortening the length of the grazing season (which can be achieved to postpone the date of turnout on pasture or advance the housing date near the end of the grazing season) and mowing pasture before grazing (Charlier et al., 2005b; Forbes et al., 2008; Bennema et al., 2010; Vanderstichel et al., 2012; Morgan et al., 2013).

However, the farm-level economic effects of such interventions have not yet been assessed. Previous studies have focussed on the difference in the economic performances between grazing and non-grazing farms (Ford, 1996; White et al., 2002; van den Pol-van Dasselaar et al., 2013; Hardie et al., 2014). Other studies have studied the economic effects of helminth exposure (van der Voort et al., 2014) or anthelmintic treatment interventions with-

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out considering GM options (Charlier et al., 2012). Analysing the economic effect of feeding management changes in dairy farming is not straightforward, because they can cause a chain of effects in the whole-farm management (Ward, 2006; Schils et al., 2007; Baudracco et al., 2013; Gregorini et al., 2014). To address this problem, whole-farm simulation models are typically used to simulate typical farms and to link altered outcomes to farm profitability (Dijkhuizen and Morris, 1997).

The aim of this study was to model the effect of GM interventions to control exposure to GI nematodes in dairy cattle on the farm-level economic performances. We combined farm-specific accountancy data with a previously published inefficiency effect model on the effects of GI nematode infection (van der Voort et al., 2014) and a whole-farm simulation model.

2. Materials and methods

2.1. Methodological framework

To analyse the economic effects of GM interventions, a methodological framework was used that combined multiple information sources and methods. Fig. 1 presents the methodological framework and shows the different steps and methods applied in this study. The framework relied on information of sampled farms of which data was collected on the GI nematode infection status, GM information and economic farm performance. This information is the baseline information for each farm for which GM interventions were simulated. Simulations take place on individual farm level. For each modelled farm, first, an efficiency analysis was performed to assess the economic improvement potential of the dairy farm before introducing GM interventions. Second, an inefficiency effect model was used to estimate the effect of the GM interventions on milk production (output) of each modelled farm (van der Voort et al., 2014). Third, a whole-farm simulation model, "DairyWise", was used to model the effect of the GM interventions on the input use of the modelled farm (Schils et al., 2007). Fourth, based on the changes in input use and output production of the farm, efficiency analysis assessed the technical and cost efficiency effects of the different GM interventions. Finally, a partial budget model was used to calculate the economic marginal effect of each GM intervention for each modelled farm. The following sections describe each step in more detail.

2.1.1. Efficiency analysis

Efficiency analysis, a method first described by Farrell (1957), was applied at two stages in the framework (Fig. 1). First, it was used to study the production efficiency of each modelled dairy farm without and with the introduction of the modelled GM intervention. Secondly, efficiency analysis was also used to determine the effect of a change in infection due to a change in GM on the milk production (inefficiency effect model).

The method of efficiency analysis allows to identify the farmís inefficiency in transforming input(s) in output(s) by comparing the current transformation of input(s) into output(s) with the potential optimal performance level. In dairy farming, examples of inputs are feed and labour, while milk is the main output. The optimal technical performance is the optimal input-output transformation that can be reached by using a given technology. This optimal observed level is also called the frontier. When farms are situated on or close to this frontier they achieve the best technical performance level and are called technically efficient. There are two ways to estimate this efficiency: Output-oriented technical efficiency (TE) reflects the ability of a farm to produce maximal amount of output(s) with a given amount of input(s). Input-oriented TE reflects the ability of a farm to use minimal amounts of input(s) to obtain (a) given amount of output(s). Cost allocative efficiency (CAE) reflects the ability to use inputs in cost minimising proportions, given their respective prices and the production technology. Input-oriented TE and CAE can be combined to provide a measure for cost efficiency. Efficiencies are scores measured between 0 and 1, where 0 indicates fully inefficient and 1 fully efficient (Kumbhakar and Lovel, 2000; Coelli et al., 2005).

In this study, input-oriented TE and CAE were estimated. To establish the benchmark from the data set and to derive the efficiency estimates, Data Envelopment Analysis (DEA) was applied. To estimate TE and CAE an input distance function approach was used and constant returns to scale were assumed (Coelli et al., 2005).

To calculate TE and CAE scores, milk production in litres of energy-corrected milk was used as the output variable. Inputs were (1) concentrates' intake (i.e. representing concentrates and by-products, defined as kilograms used), (2) roughage intake (i.e. home-grown maize and purchased roughage like straw and hay, defined as kilograms used), (3) pasture (i.e. all hectares of pasture which were used for grazing and for the production of hay and grass silage, defined in hectares), (4) number of dairy cattle in the herd, and (5) other variable costs, which were the remaining variable costs of the farm (i.e. animal health, manure, energy etc.). The TE and CAE scores for each modelled farm were estimated before and after introducing GM interventions to study possible changes.

2.1.2. Inefficiency effect model

To estimate the effect on milk production due to a lower level of infection resulting from changing GM, an inefficiency effect model was used. In this study, we used the inefficiency effect model described by van der Voort et al. (2013). The inefficiency effect model allows for the simultaneous estimation of the production frontier and effect of an explanatory variable (i.e. the level of exposure to GI nematodes) on TE (Kumbhakar et al., 1991; Battese and Coelli, 1995; Wang and Schmidt, 2002).

When the change in TE was known, regressive calculation could be performed on the inefficiency effect model to calculate the change in milk production. The applied model allows the estimation of the direct effect of lower exposure to infection without taking into account the change in milk production due to e.g. an increase in feed intake as a result of a lower level of infection. The change in milk production was estimated for each modelled individual farm and for each GM interventions.

2.1.3. Whole-farm simulation model

To determine changes in input use, a whole-farm simulation model called "DairyWise" was used. DairyWise was developed by Wageningen UR Livestock Research and is a static model that simulates the technical, environmental and financial processes on Dutch dairy farms (Schils et al., 2007; van den Pol-van Dasselaar et al., 2013; Zijlstra and Holshof, 2013; Eekeren et al., 2016).

The DairyWise model is based on the most up-to-date knowledge with respect to animal nutrition, crop production and fertilization. By including alternatives for the farm's operational management, performance changes can be estimated. Central to DairyWise is the FeedSupply model, which balances the herd requirements, generated by the DairyHerd model, with the supply of home-grown and purchased feed. The minimum input requirements of DairyWise include livestock and feed management data (i.e. the number of animals, the grazing system and feeding strategy) and land and crop management data (i.e. soil type, number of hectares and the use of fertilizers). If the user has more detailed input information, it is possible to introduce additional data and to overwrite the default values of the model parameters. The default values are based on dairy farm data from the most recent publication of KWIN-veehouderij (KWIN, 2013–2014).