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End-season daily weight gains as rationale for targeted selective treatment against gastrointestinal nematodes in highly exposed first-grazing season cattle

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ABSTRACT

A two-year study was carried out to assess the feasibility of a targeted selective treatment to control gastrointestinal nematodes (GIN) in 24 groups of first grazing season (FGS) cattle. A two-step procedure aiming at defining exposure risk at group level and at identifying the most infected individuals within groups through measurement of the average daily weight gain (ADWG) at housing was used. The first step was to define retrospectively, by grazing management practices (GMP) indicators, two levels of groups' exposure to GIN determined by anti *O. ostertagi* antibody ODR level (cut-off 0.7). For the low level of exposure, no relationship between parasitological parameters and heifer growth was seen, whereas for the high level ADWG was negatively correlated with increasing *Ostertagia* ODR values. The best classification was obtained with an expert system modelling the number of *Ostertagia* L3 generations on plots. GMP input for the expert system included standard data (turnout/housing data and supplementary feeding amount) combined with paddock rotation planning and monthly temperatures. The threshold of 3 successive generations of L3 or more on plots allowed identifying the groups according to low or high infection exposure level, except two groups that were misidentified as being highly exposed. In the second step, individual ADWG was found to be negatively associated with *Ostertagia* ODR in heifers from groups classified as highly exposed (≥3 generations of L3). In these groups, sensitivity and specificity of ADWG thresholds were calculated for several individual *Ostertagia* ODR thresholds. The best compromise between sensitivity (i.e., correctly treating the heifers that need to be treated) and specificity (i.e., not treating animals that should not be treated) was equivalent respectively to 76% and 56% (AUC ≈ 0.7) and was reached using an end-season ADWG threshold of 683 g/day to detect animals exhibiting an *Ostertagia* ODR cut-off at 0.93. Other ADWG thresholds were proposed taking into account the farmers' or the veterinarians' objectives: either maximizing the production through both an increase of the ADWG threshold and the sensitivity or keeping a significant nematode population *in refugia* with a corresponding limitation of anthelmintic treatments through a decrease of ADWG threshold and an increase of the specificity. Finally, a targeted selective treatment for FGS cattle based on GMP and flexible ADWG thresholds seems feasible at housing without laboratory analysis, accepting that some resilient animals with high *Ostertagia* ODR will not be treated due to their ability to perform under parasitic challenge.
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Abbreviations: ADWG, average daily weight gain; BSS, Breech soiling score; DISCO, diarrhea score; EXP, exposure; FEC, faecal egg count; FGS, first grazing season; FGSC, first grazing season cattle; GIN, gastrointestinal nematodes; GMP, grazing management practices; ILP, infective larval pressure; ODR, optical density ratio; ROC, receiver operating characteristic; TEC, time of effective contact; TST, targeted selective treatment.

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1. Introduction

Infections by gastrointestinal nematodes (GIN) are very common in grazing cattle in temperate regions. Among GIN species, *Ostertagia ostertagi* is the most pathogenic and is responsible for production losses, or even diarrhea in naïve first grazing season cattle (FGSC) (Ploeger and Kloosterman, 1993).

The use of broad spectrum anthelmintics (AH) has been the cornerstone of GIN control since the introduction of highly efficient anthelminthics in 1981. The control of GIN in heifers is often based on repeated whole systematic treatments performed at standard periods without evaluation and adaptation to the specific risk in each herd (Ploeger et al., 2000). Unfortunately, the highly repeated use reported since 1990 (Ploeger et al., 1990a) has led to increased selection of GIN resistant populations across Europe especially regarding macrocyclic lactones (Demeler et al., 2009; Geurden et al., 2015). In the last survey of Geurden et al. (2015), low faecal egg count reductions following ivermectin or moxidectin treatment were seen in 10–60% of dairy cattle farms varying by country (Germany, Italy, UK and France). The measures to limit or to delay the risk of development of anthelmintic resistance in ruminants mainly involve rationalizing (decreasing) anthelmintic use, keeping a nematode population *in refugia* (i.e., population not exposed to the drug) and controlling the introduction of resistance alleles into the farms (Van Wyk, 2001; Leathwick and Besier, 2014).

As GIN infection level may vary among FGSC within groups, as a result of the overdispersed distribution of parasites (Gasbarre et al., 2001), targeted selective treatment (TST), defined as the treatment of individuals that are the most infected or suffer most of the infection within a given group, has been proposed to limit the selection pressure by preserving alleles of susceptibility in the nematode population in the non-treated animals (Kenyon and Jackson, 2012).

To select FGSC to be treated, several individual indicators related to GIN infection (i.e., average daily weight gain (ADWG), serum pepsinogen, faecal egg count, among others) have been explored (Greer et al., 2010; Höglund et al., 2009, 2013; Charlier et al., 2014; O'shaughnessy et al., 2015). Among these indicators, ADWG is promising in young dairy cattle because it could be easily assessed by any farmer.

At group level, a minimum exposure with GIN is needed to induce mean growth retardation (Ploeger et al., 1994; Shaw et al., 1998; Merlin et al., 2016). The level of exposure to GIN infections between FGSC groups is influenced by grazing management practices (GMP), such as turn-out and housing dates, grazing duration, paddock rotation, supplementary feeding and meteorology (Ploeger et al., 1990b; Bennema et al., 2010; Charlier et al., 2010a). This information is the rationale for the whole group anthelmintic treatment approach defined as the targeted treatment (TT) strategy (Charlier et al., 2014).

The level of exposure/infection of FGSC groups with *Ostertagia* sp. at the end of the grazing season can be routinely assessed by the measurement of average serum pepsinogen value from several animals (Dorny et al., 1999; Eysker and Ploeger, 2000). However, this technique suffers from a lack of standardization and reproducibility (Charlier et al., 2011). Alternatively, the level of anti-*Ostertagia* antibodies in serum by in-house ELISA has been shown to be related with the contact with the parasite during the first grazing season (Ploeger et al., 1994; Dorny et al., 1999; Eysker and Ploeger, 2000). A commercial ELISA assay for *Ostertagia* antibodies determination was developed later on and within- and between-laboratory repeatability tests were found to be satisfactory (Charlier et al., 2009).

In a previous study, Merlin et al. (2016) showed that categorization of heifer groups based on 3 simple GMP indicators related to parasite exposure was consistent with average *Ostertagia* ODR level at the end of the season. They also showed that weight losses were only correlated to GIN infection at housing in those groups having higher parasite exposure. These first promising results suggested that integrating GIN exposure indicators at group level could be an important preliminary step for TST implementation.

The objectives of our study were two-fold. The first objective was to further investigate GMP indicators including additional information related to paddock rotation and meteorological data, in order to better categorize GIN exposure at group level. The second objective was to evaluate the performances of TST approach based on the end-season weight gain to detect the most infected/exposed FGSC. Housing was selected because this period allows the collection of GMP data and animals can be easily restrained, weighed and possibly treated by the farmer.

2. Materials and methods

2.1. Site and animals

Experiments were conducted during two consecutive grazing seasons (2013–2014) on 6 different field stations located in Pays-de-la-Loire, Brittany and Normandy regions, i.e., in the western part of France. The number of groups was 24 and the number of animals per group varied from 9 to 52, and in overall 577 animals (79% Holstein, 20% Normande, 1% cross-bred) were studied. FGSC remained untreated against GIN during their whole grazing period which lasted on average 6 months (range: 2–9 months). According to the group, turnout was from mid-March to mid-August and housing from mid-October to mid-December. At turnout, the mean age of heifers was 8 months (range: 4–17 months) and they weighed between 98 and 378 kg.

2.2. Grazing management practices (GMP) indicators

Data on GMP were collected from the field station's managers (e.g., number/surface area of paddocks, amount of supplementary feeding and age at turnout). The amount of supplementary feeding was scored from 1 (grass represents the largest part of daily intake on average) to 2 (50% grass/50% supplementary feeding), or 3 (supplementary feeding represents the largest part). Then, two indicators combining several GMP were built: the average time of effective contact (TEC) with GIN larvae during the FGS, and the infective larval pressure on paddocks (ILP). As turnout could be spread over time within a group, TEC (expressed in months) was calculated, for each group, as the duration of the grazing season minus the duration animals mainly received supplementary feeding (score 3) (Ravinet et al., 2014).

ILP was calculated with an expert system (Parasit'sim[1]), which models the number of *Ostertagia* sp. infective larval generations met by heifer groups during their FGS (Chauvin et al., 2009). This model incorporates a combination of GMP (date of turnout, one *versus* several paddocks and rotations planning, grazing time on each paddock, date of housing, yes/no supplementary feeding equals to score 3 during grazing) as they can broadly influence the rate of increase of the pasture infectivity. The increasing pasture infectivity is modeled by calculating the numbers of parasitic cycles realized since turnout. At the beginning of the grazing season, residual infective larvae (L3G0) are ingested by the animals; at the end of the prepatent period, infected animals shed the first generation of eggs of the year (EG1). The development time from eggs to infective larvae (dteil) on pastures depends on temperature and the calculation of this is based on a previous model using daily average temperatures published by Grenfell et al. (1987). Daily

[1] An Excel sheet for the use of Parasit'Sim is available on request to Alain Chauvin alain.chauvin@oniris-nantes.fr

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