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Evaluation of the utility of subjective clinical parameters for estimating fecal egg counts and packed cell volume in Canadian sheep flocks

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ABSTRACT

A study was conducted in sheep on Canadian farms to describe the relationship between packed cell volume (PCV) or fecal egg counts (FEC) and subjective clinical parameters that may indicate the severity of parasitic gastroenteritis. Twenty-one farms in Ontario (ON) and 8 farms in Quebec (QC) were purposively selected and visited during April–May (spring) and August (summer) 2007. At each farm visit, blood and fecal samples were collected from 10 ewes and 10 female lambs; body condition score (BCS), dag score (DS), fecal consistency score (FCS) and FAMACHA score were recorded for all sampled sheep. Packed cell volume was determined for all blood samples, and FEC were performed for all fecal samples. Summary statistics and simple correlations were performed for the parameters recorded. Two mixed models with random effects at the farm level were developed; one using PCV as the response variable and another using the natural log of eggs per gram of feces (lnEPG). Finally, the residuals from both models were correlated to the covariates in the models. The mean PCV values during the spring were 29.7% and 36.7% for lambs, and 28.8% and 31.1% for ewes, in ON and QC, respectively. During the summer, the mean PCV was 32.0% and 32.8% for lambs, and 30.1% and 29.9% for ewes, in ON and QC, respectively. The arithmetic mean FEC per gram of feces (EPG) during the spring was 3 and 2 for lambs, and 1266 and 789 for ewes, in ON and QC, respectively, whereas during summer the arithmetic mean EPG was 907 and 237 for lambs, and 458 and 246 for ewes, in ON and QC, respectively. Results from simple correlations indicated that PCV was negatively correlated with lnEPG ($r = -0.255$; $r^2 = 6.5\%$) and FAMACHA ($r = -0.312$; $r^2 = 9.7\%$), and positively correlated with BCS ($r = 0.317$; $r^2 = 10\%$). LnEPG was negatively correlated with BCS ($r = -0.232$; $r^2 = 5.4\%$) and PCV ($r = -0.255$; $r^2 = 6.5\%$), but positively correlated with FAMACHA ($r = 0.178$; $r^2 = 3.2\%$)

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and DS ($r = 0.086$; $r^2 = 0.7\%$). Results from the models indicated that PCV and lnEPG residuals were negatively correlated with FAMACHA, FCS and almost all categories of BCS and DS, although the correlations were very low. The main results from this study suggested that none of the subjective clinical parameters evaluated were highly correlated with PCV or lnEPG and therefore were not good predictors of lnEPG or PCV on the studied farms in Ontario and Quebec.

1. Introduction

Reliance on anthelmintic drugs as the only measure to control gastrointestinal nematodes (GIN) in sheep has lead to the development of anthelmintic resistance (AR) (Prichard et al., 1980; Coles et al., 1994; Waller, 1997; Jackson and Coop, 2000; Falzon et al., 2013). Studies on the prevalence of AR, and risk factors associated with the development of AR, suggest that factors such as increased frequency of treatments and the use of clean pastures are likely the main contributors to the development of AR (Suter et al., 2004). Moving sheep to a "clean" pasture immediately after treatment of the flock with an anthelmintic drug increases the risk of selection for resistance as this markedly reduces the population of susceptible parasites in refugia. The term refugia refers to the parasite population that escapes exposure to the anthelmintic being applied, thus escaping selection for resistance (van Wyk, 2001; Silvestre et al., 2002), and refers primarily to the nematode population that is free-living on pasture as well as those residing in untreated animals (van Wyk, 2001). The risk of development of AR and its link to the need to preserve nematode populations in "refugia" underscores the necessity to validate targeted selective strategies to control GIN with reduced use of chemical drugs.

Exploiting the concept of "overdispersion", where only a few animals carry the highest parasite burdens, has resulted in the development of several methods that target control toward this minority of highly infected sheep. Furthermore, decreasing the total number of annual treatments would theoretically help maintain a susceptible nematode population in refugia. Some studies have been carried out to identify clinical or production parameters which are strongly correlated with sheep GIN burden, and thus help focus treatments on heavily parasitized sheep with abnormal clinical parameters and/or lower production traits. To date, the main parameters studied as potential indicators of clinical GIN parasitism in sheep and goats are fecal soiling or dag score (DS) (Larsen et al., 1994; Osoro et al., 2007), fecal consistency score (FCS) (Larsen and Anderson, 2000), body condition score (BCS) (Osoro et al., 2007), and the more recently developed FAMACHA system that detects anemia caused primarily by *Haemonchus contortus* (Malan et al., 2001; van Wyk and Bath, 2002).

Studies conducted in Australia and the United Kingdom in lambs found poor correlations between DS and other markers for the presence of GIN such as fecal egg counts (FEC) or plasma pepsinogen concentrations (Larsen et al., 1994; Larsen and Anderson, 2000). However, a study conducted in 2003 in southwest England, in two to five month-old lambs exposed to natural parasite challenge, demonstrated a significant positive association between DS and FEC, where lambs with higher DS had higher FEC (Broughan and Wall, 2007).

The use of the color of the palpebral conjunctivae of sheep for clinical evaluation of the level of anemia was explored by Malan et al. (2001) in South Africa. The aim was to identify individual sheep severely infected with *H. contortus* and selectively treat only those with clinical infections, i.e. anemic. This was to reduce the frequency of treatments, a risk factor for development of AR (Malan et al., 2001). In this study, ewes were primarily used to evaluate the FAMACHA concept: the authors reported that the Pearson correlation coefficients between hematocrit (packed cell volume, PCV) and mucous membrane anemia classifications varied between −0.3 and −0.6 ($r^2 = 0.09$ and 0.36 respectively). Another study, conducted between 1998 and 2000 in South Africa, was carried out to validate the FAMACHA system in goats. This work, which used a hematocrit less than or equal to 19% to define anemia in goats, revealed that the sensitivity of the system to detect anemic goats improved from 31.1% when FAMACHA categories 4 and 5 were used to classify animals as anemic, to 80.0% when FAMACHA scores 3–5 were used, however, the specificity decreased from 91.2% to 54.3%, respectively (Vatta et al., 2001).

The FAMACHA system has been validated in sheep and goats in other regions of the world such as the southeastern United States where anthelmintic resistance in *H. contortus* is a severe problem (Kaplan et al., 2004; Molento et al., 2009). The correlation between PCV and FAMACHA reported by Kaplan et al. (2004) for sheep was 0.52 ($r^2 = 27.0\%$), but the correlation between FEC and FAMACHA was 0.21 ($r^2 = 4.4\%$).

The objective of this study was to determine the relationship between PCV and eggs per gram of feces (EPG) with FAMACHA score, BCS, DS and FCS in sheep raised under cold continental climatic conditions in the provinces of Ontario (ON) and Quebec (QC) where parasite populations may be different from those described in warmer regions. The results will potentially allow for identification of clinical parameters that could be used as indirect markers of parasitic gastroenteritis in sheep.

2. Materials and methods

2.1. Study population and sampling protocols

This study was part of a 3-year longitudinal study (2006–2008) that has been described in detail elsewhere (Mederos et al., 2010). In short, the work reported here was conducted between April and August 2007 (second year