Veterinary Parasitology 214 (2015) 80–88

Contents lists available at ScienceDirect

Veterinary Parasitology

journal homepage: www.elsevier.com/locate/vetpar

Mixed methods evaluation of targeted selective anthelmintic treatment by resource-poor smallholder goat farmers in Botswana

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ARTICLE INFO

Article history:
Received 9 June 2015
Received in revised form
30 September 2015
Accepted 4 October 2015

Keywords:
FAMACHA©
Participatory epidemiology
Livestock management
Goats
Targeted selective treatment
Nematodes

ABSTRACT

Due to the threat of anthelmintic resistance, livestock farmers worldwide are encouraged to selectively apply treatments against gastrointestinal nematodes (GINs). Targeted selective treatment (TST) of individual animals would be especially useful for smallholder farmers in low-income economies, where cost-effective and sustainable intervention strategies will improve livestock productivity and food security. Supporting research has focused mainly on refining technical indicators for treatment, and much less on factors influencing uptake and effectiveness. We used a mixed method approach, whereby qualitative and quantitative approaches are combined, to develop, implement and validate a TST system for GINs in small ruminants, most commonly goats, among smallholder farmers in the Makgadikgadi Pans region of Botswana, and to seek better understanding of system performance within a cultural context. After the first six months of the study, 42 out of 47 enrolled farmers were followed up; 52% had monitored their animals using the taught inspection criteria and 26% applied TST during this phase. Uptake level showed little correlation with farmer characteristics, such as literacy and size of farm. Herd health significantly improved in those herds where anthelmintic treatment was applied: anaemia, as assessed using the five-point FAMACHA© scale, was 0.44–0.69 points better (95% confidence interval) and body condition score was 0.18–0.36 points better (95% C.I., five-point scale) in treated compared with untreated herds. Only targeting individuals in greatest need led to similar health improvements compared to treating the entire herd, leading to dose savings ranging from 36% to 97%. This study demonstrates that TST against nematodes can be implemented effectively by resource-poor farmers using a community-led approach. The use of mixed methods provides a promising system to integrate technical and social aspects of TST programmes for maximum uptake and effect.

1. Introduction

Gastrointestinal nematodes (GINs) affect health and production in livestock worldwide by reducing the productive value of animals through declines in milk production, growth rate, fertility, and increased susceptibility to other diseases (Cobon and O'Sullivan, 1992; Perry and Randolph, 1999; Thumbi et al., 2013). In South-East Asia and sub-Saharan Africa, helminth infection is ranked as the animal health constraint with the highest impact on resource-poor livestock keepers (Perry et al., 2002).

Globally, the acute threat of anthelmintic resistance makes whole-group treatments unsustainable and has led to adoption of targeted treatment strategies in intensive livestock production systems (Van Wyk, 2001; Kenyon et al., 2009; Charlier et al., 2014). Targeted selective treatment (TST) is based on the premise that most animals are able to cope unaided even in the face of severe

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http://dx.doi.org/10.1016/j.vetpar.2015.10.006
0304-4017/

parasite challenge (Malan et al., 2001), so it is possible to avoid losses to the whole flock or herd by only treating the subset that are clinically affected by heavy parasite infection (Van Wyk, 2008; Molento et al., 2009; Leask et al., 2013). At the same time, parasites that are not exposed to the drug (i.e. in *refugia*) will maintain non-resistant alleles in the population, diluting the genetic contribution of any anthelmintic resistant worms which survive in the treated animals (Van Wyk, 2001). However, uptake of the selective treatment approach is limited by the reluctance of farmers to risk sacrificing short term productivity in the interests of long term sustainability (Charlier et al., 2014).

In resource-poor regions, GINs affect the livelihoods of individual subsistence farmers rather than the profit margin of large production systems. Despite small average herd sizes, subsistence farmers are unlikely to have the resources for regular whole-group treatments and face high costs of anthelmintic drugs relative to animal value. In addition, those grazing on communal pastures, as is the norm in Botswana, are not able to practise other recommended strategies to control GINs such as pasture management and rotation, and selective breeding (Krecek and Waller, 2006; Van Wyk et al., 2006; Riley and Van Wyk, 2009). TST would enable rapid gains in animal health and production for relatively small investments in chemotherapy, and an inherently sustainable approach from the outset. However, limited access to education for farmers and sparse animal health support systems could challenge the implementation of TST.

The blood-sucking nematode *Haemonchus contortus* is the number one helminth infection impacting resource-poor livestock keepers (Perry et al., 2002). TST for *H. contortus* infection can be implemented using simple indicators, and primarily the FAMACHA© system, which uses ocular mucous membrane colour as an indication of anaemia caused by haemonchosis (Malan et al., 2001). This system has been implemented and validated around the world as a method for TST in both sheep and goats (Bath et al., 2001; Vatta et al., 2002, 2001; Kaplan et al., 2004; Mahieu et al., 2007; Di Loria et al., 2009; Scheuerle et al., 2010; Sotomaior et al., 2012; Maia et al., 2014, 2015; Nabukenya et al., 2014). Both the FAMACHA© system and the Five Point Check© system, which includes FAMACHA© and additional checks for clinical signs caused by non-haematophagic internal parasites, are designed for easy use by farmers without veterinary skills (Bath and Van Wyk, 2009; Maia et al., 2014). However, the use of these systems has been primarily studied in commercial flocks, with few studies on its application in resource-poor settings, and no investigations of the constraints or opportunities associated with the social context in which it is implemented (Nabukenya et al., 2014; Maia et al., 2015).

In this study we used a novel mixed method approach to determine the feasibility of introducing TST for sustainable and cost-effective management of GINs in small ruminants by smallholder subsistence farmers, the majority of whom had not previously used anthelmintics. Mixed methods research, where qualitative and quantitative approaches are combined to address the same aim, provides the potential to better understand how TST can be implemented within existing technical, social, and educational contexts in a way that is valuable to resource-poor farmers and sustainable (Ozawa and Pongpirul, 2014). Previous research has neglected this area, focusing instead on technical improvements in TST and validating its effectiveness for anthelmintic resistance and economics. We aimed to empower the farmers to assess and manage the health of their own livestock, thereby increasing resilience and food security. At the same time, we were able to assess the performance and benefits of TST in this setting, and understand the social context of implementation, such that we are better placed to embed TST into livestock management programmes elsewhere.

2. Materials and methods

2.1. Mixed methods framework

We used a multiphase research design where qualitative focus group and individual interview data were collected at the beginning and end of the study, respectively, and quantitative questionnaire data and clinical data were gathered concurrently during the main part of the study. An overview of the research framework used is presented in Fig. 1, and additional information on each phase is described in Supplementary Methods in the online Supplementary materials.

Ethical approval for this study was received from the University of Bristol Faculty of Medical and Veterinary Science Research Ethics Committee (Reference 3481), the University of Bristol Home Office Liaison Team and Animal Welfare and Ethical Review Board (University Investigation Number UIN/13/043). Research approval was obtained from the Government of Botswana through the Ministry of Environment, Wildlife and Tourism and the Ministry of Agriculture, permit reference EWT 8/36/4 XXI (44).

2.2. Study area

The study area consisted of four villages which border Makgadikgadi and Nxai Pans National Park (MPNP) in northeast-central Botswana. The villages, Gweta (population 5304), Khumaga (758), Moreomaoto (518), and Phuduhudu (564) (Statistics Botswana, 2011), each consist of a central area and houses with yards where small numbers of domestic animals may be kept. On the outskirts of the villages, larger numbers of livestock are kept at cattle posts, which are generally made up of simple accommodation for livestock keepers, and animal folds surrounded by wooden palisade fences or thickets of thorn branches (kraals) where livestock are secured at night. Livestock, including cattle, goats, sheep, donkeys, and horses, are released in the morning to graze and return to their kraals in the evening. Total livestock ownership in these districts is approximately 65%, with 39–45% of households owning goats and 7–8% owning sheep (Statistics Botswana, 2014).

2.3. Enrolment, training, and data collection

The first objective of this research project was to identify parasite-related challenges to livestock production by subsistence farmers in a marginal mixed land use area shared with wildlife. We used a participatory approach to narrow the research focus to specific livestock diseases that are considered relevant to the communities. In November and December 2012 we conducted focus group discussions in Moreomaoto and Khumaga village using participatory epidemiology methods (Catley, 2006; Ameri et al., 2009; Bett et al., 2009). The two focus groups were made up of individual livestock owners who volunteered to participate after the opportunity was announced by the *Kgosi* (chief) at a village-wide meeting. The information gathered in the initial focus group discussions in both villages was then used to create an enrolment questionnaire to identify farmers to participate in the study and gather baseline information about livestock owners in the community. Participating farmers completed the questionnaire in Setswana after verbal informed consent was given; eligibility was limited to livestock owners.

During enrolment of each herd, the trainers worked with the farmers to record baseline characteristics of each animal, including species (sheep or goat), ear tag number, colour, age, sex, reproductive status, and measurement of heart girth as a proxy for weight (De Villiers et al., 2009). A composite faecal sample was collected from each enrolled herd and strongyle eggs were counted using a modified McMaster technique (Morgan et al., 2005). The farm-