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Financial analysis of brucellosis control for small-scale goat farming in the Bajío region, Mexico

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ABSTRACT

Brucellosis is an endemic disease in small-scale goat husbandry systems in Mexico. It is a zoonosis and the economic consequences can be large, although estimates are not available for the Mexican goat sector. Our objective was to conduct a financial analysis of brucellosis control in a prominent dairy goat production area of the Bajío region, Mexico. We used three models: (1) a brucellosis transmission model at village flock level (n = 1000 head), (2) a flock growth model at smallholder flock level (n = 23 head) using output of model 1 and (3) cost–benefit analysis of several brucellosis control scenarios based on output of model 2. Scenarios consisted of test-and-slaughter or vaccination or a combination of both compared to the base situation (no control). The average net present values (NPV) of using vaccination over a 5-year period was 3.8 US$ (90% CI: 1.3–6.6) and 20 US$ (90% CI: 11.3–28.6) over a 10-year period per goat. The average benefit-cost ratios over a 5-year period and 10-year period were 4.3 US$ (90% CI: 2.2–6.9) and 12.3 US$ (90% CI: 7.5–17.3) per goat, respectively. For the total dairy goat population (38,462 head) of the study area (the Bajío of Jalisco and Michoacán) the NPV's over a 5-year and 10-year period were 0.15 million US$ and 0.8 million US$. However, brucellosis prevalence was predicted to remain relatively high at about 12%. Control scenarios with test-and-slaughter predicted to reduce brucellosis prevalence to less than 3%, but this produced a negative NPV over a 5-year period ranging from −31.6 to −11.1 US$ and from −31.1 to 7.5 US$ over a 10-year period. A brucellosis control campaign based on vaccination with full coverage is economically profitable for the goat dairy sector of the region although smallholders would need financial support in case test-and-slaughter is applied to reduce the prevalence more quickly.

1. Introduction

Caprine brucellosis is a ubiquitous disease caused by bacteria genus *Brucella* spp. which may reduce fertility through abortion, stillbirths and cause orchitis in males goats (Chand et al., 2002; Corbel, 2006). *Brucella melitensis* transmitted by goats is also the most virulent and important cause of human brucellosis. Humans with brucellosis suffer from fever, chills, sweats, aches; complications

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involving cardiac, ostearticular and neurological systems have also been reported (Corbel, 2006). Diagnosis of human brucellosis is not straightforward because the typical symptoms are not specific. Therapy consists of at least 6 weeks of antibiotic treatment. Despite these severe consequences in both goats and humans, brucellosis in livestock is still uncontrolled in many countries of the global South (OIE, 2005). In the Bajío region of Mexico for example, where small-scale goat husbandry is common, the average seroprevalence of caprine brucellosis was estimated to be 20% (Oseguera Montiel et al., 2013).

The core components of the brucellosis control and eradication campaign in Mexico are vaccination, and a test-and-slaughter of seropositive animals. Mexican directives state that caprine brucellosis is a notifiable disease and its control and prevention are compulsory. Therefore, all goat farmers should take part in the campaign, and costs should be shared between the government and farmers (SAGARPA, 1996). Reality is different, however, because local governments' and farmers' efforts and participation in brucellosis control is variable between municipalities, states and villages, resulting in a heterogeneous brucellosis prevalence across the country and within regions, e.g. a prevalence of 38% was reported for the state of Jalisco while it was 11% in the neighbouring state of Michoacán (Oseguera Montiel et al., 2013).

A possible reason for not fully implementing control measures could be the lack of knowledge on the costs. Pioneer studies of cost–benefit analysis of brucellosis control in cattle were done in the UK and in Spain (Hugh-Jones et al., 1976; Bernués et al., 1997). More recently Coelho et al. (2011) reported a cost–benefit analysis of brucellosis control in small ruminants in the North of Portugal. Roth et al. (2003) provided the most comprehensive study on the economics of brucellosis control by estimating the benefits for the livestock sector and for public health in Mongolia. In Mexico economic analyses of brucellosis are available at farm level for intensive dairy cattle farms (Montaño et al., 2007), but not for the Mexican goat sector. Mexico has a diversity of agroecosystems resulting in different goat husbandry systems and population densities across the country. A regional approach of controlling and preventing brucellosis is needed because goats from several flocks are herded together and trading promotes *B. melitensis* transmission between goat populations from different jurisdictions. The aim of this paper is to investigate the costs and benefits to farmers of several brucellosis control strategies and therefore to understand whether brucellosis control is economically profitable for small-scale goat husbandry in a dairy goat area of the Bajío region, Mexico. The main question is whether or not control of brucellosis in goat farming systems in this area is economically profitable for farmers.

2. Materials and methods

2.1. Study site

The study site is a basin area around the Chapala lake and the Lerma river in central west Mexico, which is part of the Bajío region. The study area is shared by two administrative jurisdictions (states): Michoacán and Jalisco; goats are moved back and forth between the two states for trading and grazing. The region has valleys where crop production is important. The altitude of the area ranges from 1500 to 2000 m above sea level. Prominent activities are grain production, (e.g. sorghum, maize, wheat), agro-industry of tinned fruits and vegetables, pork, and caprine and bovine dairy production. Fig. 1 shows municipalities of two states of the Bajío region where goat husbandry is relatively prominent.

Goat husbandry is mostly carried out by smallholders, based on extensive grazing systems with small flocks (median = 19, interquartile range 6–54).[1] Total goat milk production of these relatively small flocks is over 12 million litres per year.[2] This milk is key input for the production of '*cajeta*' a sweet similar in taste to English caramel, a commodity for the domestic and US export market.

2.2. Brucellosis transmission model

Brucellosis transmission within a large village flock ($n = 1000$) was simulated with a compartmental deterministic model for a 5-year and 10-year periods. With this model five control scenarios coded as b, i, ii, iii and iv were evaluated. A village flock was chosen rather than an individual flock because the bulk of the goat farmers apply extensive grazing, where goats from different flocks often come into contact with each other in grazing areas. We assumed that flocks consisted of female goats only because the female:male goat ratio is 27:1 in Michoacán and 44:1 in Jalisco.

Scenario b is a baseline scenario, with brucellosis control measures; in scenario i mass vaccination (whole flock) with a standard dose of Rev 1 ($1–2 \times 10^9$ colony-forming units) in year 1 was conducted. A life-long protection (5-years) by the vaccine was assumed (Díaz-Aparicio et al., 2004). Therefore, vaccination was applied only to replacement goats from year 2 on. Scenario ii consisted of mass vaccination and test-and-slaughter at year 1 and at year 6. Replacements vaccinated from year 2 on. The goat population was assumed to be of a fixed size and culled goats were immediately replaced by brucellosis free replacements. In iii all goats were vaccinated at year 1 and continuous vaccination of replacements from year 2 on. In addition test-and-slaughter was included at year 4 and at year 9. Scenario iv consisted of test-and-slaughter at year 1 and at year 6 while no vaccination was applied at all. The goat population was assumed to be of a fixed size and culled goats were immediately replaced by brucellosis free replacements. In scenarios where testing is being applied, all goats were assumed to be tested. The four scenarios were chosen because they represent the core of the brucellosis control and eradication campaign in Mexico (SAGARPA, 1996).

[1] Census by a NGO Subcomité de Productores de Ovicaprinos del estado de Michoacán.

[2] Milk processed in 2010 by one renowned company, (personal communication and records from the company).