



Bovine paramphistomosis in Galicia (Spain): Prevalence, intensity, aetiology and geospatial distribution of the infection

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ABSTRACT

The present study explored various basic aspects of the epidemiology of paramphistomosis in Galicia, the main cattle producing region in Spain. In total, 589 cows from different farms located across the region were selected at random in the slaughterhouse for examination of the rumens and reticula for the presence of Paramphistomidae flukes. Paramphistomes were found in 111 of 589 necropsied cows (18.8%; 95% CI: 15.7–21.9%), with higher prevalences of infection in beef cows than in dairy cows (29.2% vs 13.9%). Although the number of flukes per animal was generally low (median = 266 flukes), some cows harboured large parasite burdens (up to 11,895 flukes), which may have harmful effects on their health or productivity. Cows with higher parasite burdens also excreted greater numbers of fluke eggs in their faeces, which suggests that heavily parasitized mature cows play an important role in the transmission of paramphistomosis. This role may be particularly important in Galicia, where the roe deer, which is the only wild ruminant in the study area, was found not to be a reservoir for the infection. The use of morpho-anatomical and molecular techniques applied to a large number of fluke specimens provided reliable confirmation that *Calicophoron daubneyi* is the only species of the family Paramphistomidae that parasitizes cattle in Galicia. The environmental data from the farms of origin of the necropsied cows were used in Bayesian geostatistical models to predict the probability of infection by *C. daubneyi* throughout the region. The results revealed the role of environmental risk factors in explaining the geographical heterogeneity in the probability of infection in beef and dairy cattle. These explanatory factors were used to construct predictive maps showing the areas with the highest predicted risk of infection as well as the uncertainty associated with the predictions.

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1. Introduction

Paramphistomosis is a parasitic infection caused by digenetic trematodes belonging to the family Paramphistomidae Fischoeder, 1901, which includes many genera

and species (e.g. *Paramphistomum* spp., *Calicophoron* spp., *Cotylophoron* spp., *Gigantocotyle* spp., etc.) that inhabit the gastrointestinal tract of wild and domestic ruminants throughout the world (Jones, 2005). Paramphistomes have a heteroxenous life cycle that involves freshwater snails (intermediate hosts). The parasite larvae develop until reaching a stage (cercaria) that emerges from the mollusc and typically encysts on vegetation, hard surfaces or water, and then develops into a stage (metacercaria) that is

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ingested by grazing ruminants (final host). In the ruminant host, juvenile parasites first locate in the small intestine and feed on the intestinal mucosa. As they grow, the parasites migrate upwards to the reticulum and rumen where they spend the remainder of their adult lives, shedding eggs that contaminate snail habitats.

As regards the pathology caused by paramphistomes in domestic ruminants, experimental infections of goats, with *Paramphistomum cervi* (Singh et al., 1984), and cattle, with *Calicophoron microbothrium* (Mavenyengwa et al., 2005), have revealed that the immature worms migrating in the small intestine cause more severe damage than the adult worms established in the rumen and reticulum. Moreover, Dorchies et al. (2002) associated the presence of paramphistome larvae in calves with several clinical symptoms, including death. Nevertheless, ruminal lesions have also been associated with heavy infections by adult worms of *Paramphistomum ichikawai* (Rolfe et al., 1994) and *C. microbothrium* (Mavenyengwa et al., 2005), which may have affected digestion and absorption, resulting in diarrhoea, anorexia, anaemia and weakness (Rolfe et al., 1991; Mavenyengwa et al., 2010; Dorny et al., 2011). The effect of the infection on animal production remains controversial (Spence et al., 1992, 1996), partly because detrimental effects of paramphistomes can be masked by concurrent infections with other helminths (e.g. *Fasciola hepatica* and gastrointestinal nematodes) that usually infect grazing ruminants. Moreover, as with other parasitic infections, the pathology of paramphistomosis also depends on the immune status of infected animals, the size of parasite burdens and the species of parasite involved in the infections (Mavenyengwa et al., 2005, 2008).

Paramphistomosis is highly prevalent in tropical and subtropical countries (Singh et al., 1984; Rangel-Ruiz et al., 2003; Phiri et al., 2007; Dorny et al., 2011) where it causes high morbidity, mainly in animals raised by use of traditional husbandry systems, in which periods of nutritional stress occur. Hematophagous flukes, which are considered to be highly pathogenic, occur in these countries, but not in Europe, where paramphistomes in cattle had been considered virtually harmless (Rieu et al., 2007). However, Dorchies et al. (2002) have described some cases of serious illness caused by paramphistomes. Furthermore, epidemiological studies conducted in central France (Mage et al., 2002) have shown that the prevalence of infection with *Calicophoron daubneyi* (Dinnik, 1962) in cattle increased significantly, from 5.2% to 44.7%, between 1990 and 1999. Paramphistomosis has also been detected on farms in UK and Wales (Foster et al., 2008) and Ireland (Murphy et al., 2008), indicating that this pathology should be considered in the differential diagnosis of other enteric processes in cattle. In Spain, infections by *P. cervi* have been reported in cows and deer (Cordero et al., 1994; Ramajo-Martín et al., 2007). Díaz et al. (2007a,b) detected, by coprological techniques, infections by paramphistomes in 26–36% cattle farms in Galicia, which appears to indicate a high prevalence of bovine paramphistomosis in the region. However, documentation of the presence of infection and/or the raw data on its prevalence, without any assessment of the spatial variability existing in such a wide region, is of limited interest and does not indicate the real risk of infection

in areas with different climatic and environmental conditions, which may affect the life cycle of the parasite. Moreover, other circumstances such as the existence of wild reservoirs for paramphistomes have not been evaluated.

All of the above led us to carry out a comprehensive epidemiological study on cattle paramphistomosis in Galicia, which included the following steps: (1) at bovine host level, we determined the parasite burdens in rumens and reticula as well as the distribution of the parasites within these organs. We also identified, by morphoanatomical and molecular analysis, the species of Paramphistomidae worms found at necropsy, and we determined the association between the numbers of flukes in the rumen and reticulum and the numbers of parasite eggs in faecal samples; (2) at the host level, i.e. in roe deer (*Capreolus capreolus*), which is the only wild ruminant found in the vicinity of cattle farms, we performed necropsies to detect the presence of paramphistomes; and (3) at geospatial level, we investigated the distribution of the cattle paramphistomosis, exploring the linkages between the spatial patterns and some climatic and environmental factors that are thought to affect different phases of the parasite life cycle (e.g. survival and distribution of the intermediate host and its probability of infection, the development of the intra-mollusc larval stages and the infection risk of cattle, among other factors). Moreover, we constructed predictive maps to help decision-makers spatially target the monitoring and control of paramphistomosis in dairy and beef cattle. All statistical analyses were performed in a Bayesian framework to incorporate uncertainty about model parameters.

2. Materials and methods

2.1. Study area

The present study was carried out in Galicia (NW Spain), which is located between latitudes 41° 49' to 43° 47'N and longitudes 6° 42' to 9° 18'W, and surrounded by the Cantabria Sea to the north and the Atlantic Ocean to the west. The climate in the region is temperate maritime, with an annual average temperature of 11.6 °C and annual average rainfall of 1065 mm. The altitude ranges between 0 and 2129 m. The soil mainly consists of metamorphic and igneous rocks, which in hydrological terms represents a very heterogeneous and anisotropic environment.

Galicia occupies a surface area of 29,575 km², administratively divided into 315 municipalities with very different cattle farming activity and stocking rate per surface unit. According to the 2008 livestock census, there were 339,530 dairy cows (99% on farms in the northern half of the region), and 221,917 beef cows (on farms spread over a larger area extending to the south-east of the region). Grasslands occupy approximately 60% of the useful agricultural land and cows usually graze throughout the year, mainly on beef cattle farms. The type of livestock husbandry and the climatic characteristics of the region favour grazing-linked transmission of helminthosis.

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