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Impact of "Grain to Green" Programme on echinococcosis infection in Ningxia Hui Autonomous Region of China

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ABSTRACT

Cystic echinococcosis (CE) is endemic among the human population of Xiji County, Ningxia Hui Autonomous Region, China, where the prevalence is estimated to be between 2.2% and 3.6%. Government-run sheep abattoirs in Xiji County have closed in recent years and, as a consequence, slaughter is carried out mostly at rural market places. The market place in Xinglong Township, Xiji County, is home to an increasing number of stray dogs and the lack of government control over slaughter practices potentially favours *Echinococcus granulosus* transmission. A survey of sheep, goats and cattle reared in Xiji County was conducted in Xinglong Market and Xinglong Township to determine prevalence and transmission dynamics of *E. granulosus* infection. The liver and lungs of all livestock aged one year and older were examined macroscopically post mortem; visual examination and palpation of organs determined overall prevalence of *E. granulosus*. Cysts consistent in appearance with *E. granulosus* were observed in 2/184 sheep (prevalence 1.0%) and 1/55 of the cattle examined (prevalence 1.8%); 0/13 goats were found to be infected. However, microscopic examination of these suspected cysts failed to confirm these samples as *E. granulosus*, giving a prevalence of confirmed infection of zero percent in all three species. The prevalence of liver fluke was 61.3% in sheep and 12.7% in cattle with a significant difference between males and females ($p \leq 0.001$). Considering the high prevalence of echinococcosis in the local human population, the absence of CE observed among commercially slaughtered livestock was surprising. Several explanations for this discrepancy and their implications are proposed.

1. Introduction

Species in the genus *Echinococcus* are actively transmitted in diverse ecosystems from the arctic tundra to sub-tropical regions making echinococcosis among the most geographically widespread of the zoonotic parasitic diseases (Craig et al., 2007). The global burden of CE has

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been estimated at 1,009,662 disability-adjusted life years (DALYs) for the years 1996–2003 (Budke et al., 2006) and 144,000 DALYs in 2010 (Murray et al., 2013). In addition to the impact on human health, the disease is associated with considerable economic loss to agriculture and worker productivity (Torgerson et al., 2000; Torgerson, 2003; Budke et al., 2004, 2005; Majorowski et al., 2005) as the intermediate hosts of CE are generally food-producing animals (Eckert et al., 2001). Transmission is generally facilitated where local slaughter practices are poorly regulated, stray dog populations are high and knowledge of transmission factors is poor (Yang et al., 2006a).

China is the largest producer of sheep meat in the world (FAOSTAT, 2014). With rural pastoral communities at an increased risk due to the synanthropic host–parasite transmission cycle of *Echinococcus* (Craig et al., 2007), the population at risk is 60 million people in 22 provinces (Ito et al., 2003). The number of people infected with CE is estimated to be between 600,000 and 1.3 million (Ito et al., 2003) with an associated US$ 146,129,587 income loss based on per capita gross national income (Budke et al., 2006).

Ningxia Hui Autonomous Region (NHAR) is located in north-western China bordering Inner Mongolia to the north and Gansu Province to the west. *Echinococcus granulosus* is endemic in NHAR, highly endemic in Xiji County (Yang et al., 2006b), and transmission occurs via a sheep–dog cycle. Lack of control over slaughter practices and movement and trade of sheep, goats and cattle in the region may facilitate transmission of CE in the region, the prevalence of which has been estimated at 2.2–3.6% in the rural population of Xiji (Yang et al., 2009). Rural poverty and a deteriorating environment due to the rapid development of the Chinese economy have prompted policy change with respect to rehabilitating forest resources. This 'Grain to Green Programme' implemented across 25 provinces of China in 2002 aims to address ecological protection in agricultural regions by incentivising farmers to stall feed grazing animals, thus encouraging growth of forested land (Zhiyongm, 2003). The aim of this study was to survey CE among livestock slaughtered at an outdoor market in this county, the prevalence of which may have been impacted by ten years of implemented change in agricultural policy. A survey of agricultural and trade practices, domestic dog ownership, and the level of local knowledge and understanding of CE was also conducted among farmers in five rural villages in Xiji in an attempt to elucidate dynamics of *E. granulosus* transmission in the region. Previous studies in the Middle East, Africa and Asia have investigated co-infections of *E. granulosus* and *Fasciolia hepatica* (Ghazaei, 2007; Berhe, 2009; Kabir et al., 2009; Berhe et al., 2011; Şakru et al., 2011) and, given that the two parasites are often co-endemic and have important economic consequences in terms of condemnation of livers, the prevalence of both species in sheep, goats and cattle were surveyed.

2. Methods

2.1. Study sites

The study was conducted in Xiji County, Ningxia Hui Autonomous Region. Xiji County is a rural area in NHAR heavily reliant on subsistence agriculture with cultivation of cereal crops and domestic livestock the main focus of local agriculture (Yang et al., 2006a; Dai, 2010). Local residents have a low average income and the public health system is poorly resourced and funded. The majority of the local population is educated only to junior high school level, and more than half do not have access to potable water (Yang et al., 2008; Luo and Wang, 2009; Anand, 2010). Approximately 50% of the population of Xiji County are of the Hui Islamic ethnic minority, with distinctive religious and cultural practices which may influence livestock slaughter practices in the region (Yang et al., 2006a; Xu et al., 2012). Information on the trade and slaughter of livestock was obtained from the local Animal Centre for Disease Control (ACDC) and is summarised in Table 1. The market at Xinglong Township (Xinglongzhen, Fig. 1) was chosen for the examination of sheep and goats as sheep sold there were, on average, heavier and therefore more likely to be older compared to those sold at most other markets. The market was also the sixth largest in Xiji in terms of sheep sold during 2011. Examination of slaughtered cattle was undertaken at a home slaughter in Shanjiaji Village (Zhangjiez, Fig. 1).

2.2. Data collection and carcass inspection

Demographic information including age, village of origin, and feeding practices for each animal was collected at the time of slaughter. Tracing of animals to the home village relied on interview with animal owners or vendors at the time of slaughter. Interviews and completion of survey forms was aided by a bilingual native Chinese speaker. Because *E. granulosus* infection in livestock is highly age-dependent (Cabrera et al., 1995; Dueger and Gilman, 2001), only animals aged one year and older were eligible for inclusion. Age was determined objectively by examination of teeth eruption and wear (Moses and Aiello, 2012). There were no other inclusion criteria. Animals for which data were collected were representative of carcasses sold for consumption at local markets where dogs would have access to infected, discarded offal. Thus, this sample is likely to be representative of slaughtered animals.

Sheep and goats were followed through the slaughter process by assigning a unique identification number to each eligible animal. The liver and lungs of each animal were systematically inspected by visual examination and palpation. Due to local slaughter practices, the liver and lungs of sheep remained inside the sheep carcass while examination was carried out. Home slaughter of cattle was carried out by the local religious leader, and skilled butcher, the Ahong. During the butchering process, the liver and lungs were completely removed from the carcass, after which systematic visual examination and palpation of liver and lungs were carried out. The number and location of cysts consistent in appearance with *E. granulosus* metacestodes were recorded. The presence of *F. hepatica*, determined by visual inspection, was also recorded. All animal examinations were completed by a single member of the research team who had been trained by a veterinarian experienced in the detection of *E. granulosus* cysts.