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Short communication

Elimination of schistosomiasis japonica from formerly endemic areas in mountainous regions of southern China using a praziquantel regimen

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ABSTRACT

Schistosomiasis japonica is a major public health problem in China. Domestic animals play a major role in the transmission of *Schistosoma japonicum* to humans. To better understand the epidemiology of schistosomiasis japonica in domestic animals in the mountainous areas of China, we performed a 5-year longitudinal study of schistosomiasis in cattle and horses in Yunnan Province from 2009 to 2013. We also performed a concurrent drug-based intervention study in three settlement groups in Yunnan Province aimed at developing an effective means of controlling transmission in this region. The prevalence of infection in cattle fluctuated between 1.67% and 3.05% from 2009 to 2011, and monthly treatments of schistosome-positive animals reduced the prevalence to 0% ($P < 0.05$) from 2012 to 2013. Prior to the intervention, we found that schistosomiasis was prevalent from May to October, with the highest prevalence observed in June (10.00%). We surveyed for environmental schistosome contamination, and 94.29% of the miracidia found were from cattle. Our study showed that it is possible to eliminate schistosomiasis in domestic animals in the mountainous regions of China by monthly treating cattle and horses from schistosome-positive households from May to October.

1. Introduction

Human schistosomiasis is a chronic debilitating disease caused by blood-dwelling flukes of the genus *Schistosoma* (Gryseels et al., 2006), and it is common in many tropical and subtropical countries. Schistosomiasis japonicum is one of the most common serious parasitic diseases in the People's Republic of China (PRC), where it has remained a long-standing major public-health problem. This disease is endemic in the lake and marshland regions of the Jiangxi, Hunan, Jiangsu, Anhui, and Hubei provinces of southern China and the mountainous regions of the Sichuan and Yunnan provinces (McManus et al., 2010; Zhou et al., 2005).

Based on ecological, environmental, genetic, and molecular factors, Davis et al. (1999) categorized areas of schistosomiasis transmission in the PRC into discrete ecosystems representing four transmission modes, which

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included Poyang Lake (mode I), Dongting Lake (mode II), the Yangtze River islands of Anhui Province (mode II), the canals and water networks of Hubei Province (mode III), and the mountainous areas of the Sichuan and Yunnan provinces (mode IV). In addition to humans, *Schistosoma japonicum* is also known to infect over 40 species of animals (Chen, 1993), of which bovines are especially important for transmission to humans (Chitsulo et al., 2000; Wang et al., 2005; Gray et al., 2008).

Due to the zoonotic nature of schistosomiasis japonica, controlling *S. japonicum* infections in domestic animals is critical to the elimination of human schistosomiasis. Many parasitologists have suggested that this disease cannot be eliminated in China using only praziquantel-based control methods. In 2004, a comprehensive schistosomiasis control campaign aimed at blocking the transmission of *S. japonicum* from cattle, buffalos, and humans to snails was initiated over a wide geographic area of China (Wang et al., 2009). In Yunnan Province, the prevalence of schistosomiasis japonica in humans and bovines had been reduced to less than 1% in 2009 (Hao et al., 2010), meeting the national criteria for transmission control.

To better understand the epidemiology of schistosomiasis japonica in domestic animals in the mountainous areas of China, we performed a 5-year longitudinal study of schistosomiasis in cattle in Yunnan Province from 2009 to 2013. We also performed a concurrent drug-based intervention study in three settlement groups in Yunnan Province to develop an effective means of maintaining transmission control in this region of China. Within one year, schistosomiasis japonicum was eliminated in domestic animals in this region through monthly screening and the treatment of *Schistosoma*-positive animals.

2. Materials and methods

2.1. Study area

Our study was conducted in three settlement groups, Shitoudi, Achahe, and Jiligu, in the Zhonghe administrative village (25.05′ N, 100.18′ E) in Yunnan Province (Weibaoshan Township, Weishan County). Zhonghe is located at an altitude of 2160 m above sea level, and has a mean annual temperature of 15.6 °C. Zhonghe includes 14 settlement groups, and schistosomiasis japonicum has been endemic in three settlement groups (Shitoudi, Achahe, and Jiligu) of them since at least 1996. Zhonghe is geographically separated from other schistosomiasis japonicum-endemic areas in Weishan County by mountains. Cattle, goats, horses, and donkeys graze freely on the mountainsides, whereas most pigs are reared in stalls. The snail, *Oncomelania hupensis*, an intermediate host of *S. japonicum*, primarily inhabits the farmland and streams of Shitoudi, Achahe, and Jiligu.

In 2007 and 2008, local health and veterinary officials reported that the prevalence of schistosomiasis was 0% and 3.84% in humans and 0.75% and 1.36% in cattle, respectively, in the Zhonghe area. Snail control efforts consisted primarily of the application of chemical molluscicides once yearly and modification of mud ditch with cement. From 2006 to 2008, all of the cattle in the three settlement groups were screened for schistosomiasis in July or June of each year, and all of the *Schistosoma*-positive animals were immediately treated with single dose of praziquantel. From 2006 to 2008, all of the cattle, both *Schistosoma*-positive and *Schistosoma*-negative, were treated with a single dose of praziquantel in September or October.

2.2. Parasitological techniques and praziquantel treatment

All cattle and horses in the study areas were screened for schistosomiasis in May or June 2009 and 2010 using a miracidia-detection technique. From October 2010 to 2013, all of cattle and horses, and some of pigs, sheep, and dogs that were randomly selected by their owners, were screened for schistosomiasis. Fecal sampling and the parasitological analysis were performed as described previously (Liu et al., 2012). The fecal sample sizes used in the analysis were 150, 150, 60, 30, and 30 g for cattle, horses, pigs, sheep, and dogs, respectively. The fecal samples were divided equally into three subsamples, and three independent hatching tests were performed for each fecal sample.

The *Schistosoma*-positive animals were subject to treatment with a single dose of praziquantel (30 mg/kg) within 3 days. In September 2009 and October 2010, both *Schistosoma*-positive and *Schistosoma*-negative cattle, were treated with an additional single dose of praziquantel. From November 2010 to October 2011, all of the *Schistosoma*-positive animals screened monthly were also treated with praziquantel within 3 days. In 2012 and 2013, although no *Schistosoma*-positive animals were found, all of the cattle and horses were treated with one dose of praziquantel in July. The praziquantel was administered orally. Pregnant animals were not treated.

The baseline prevalence of schistosomiasis in cattle was based on the prevalences recorded in May or June from 2009 to 2011. The prevalence of schistosomiasis in cattle following the initiation of praziquantel treatment was recorded in April, June, August, and October of 2012 and June and August of 2013.

2.3. Seasonal dynamics of schistosomiasis

From November 2010 to October 2011, all of the cattle and horses were monthly screened to determine the seasonal dynamics of schistosomiasis. We also monthly screened 21 goats, 18 pigs (grazed), and 7 dogs that were randomly selected by their owners in November 2010.

2.4. Survey of environmental contamination with schistosome eggs

The survey was performed in June 2011. We selected four grazing-pasture areas in Shitoudi, each of which occupied 10,000 m^2, for the collection of fresh fecal samples (one dropping per sample for cattle and horse, and 50 g per sample for goats). Samples were classified based on their source, and weighed. The prevalence of *S. japonicum* in the fecal samples was determine based on one miracidial-hatching test per sample using 50 g samples for cattle, horses, and goats, respectively. For each