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Hyperendemic human fascioliasis in Andean valleys: An altitudinal transect analysis in children of Cajamarca province, Peru

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ABSTRACT

A coprological survey including 476 2–18 year old school children from six rural localities between 2627 and 3061 m altitude was performed in Cajamarca province, Peru. Prevalences of fascioliasis ranging from 6.7 to 47.7% (mean 24.4%) proved to be the highest so far recorded in that human hyperendemic area. Higher prevalences in females and in the 2–5 year old group were not significant. Intensities ranged from 24 to 864 eggs per gram (arithmetic mean: 113; geometric mean: 68), the majority shedding less than 100, and without significant differences according to gender or age group. *Fasciola hepatica* was the most common helminth within a spectrum of 11–12 protozoan and 9–11 helminth species, 97.3% of the children showing infection with at least one parasite. The highest levels corresponded to coinfection with seven different species in females and subjects older than 5 years. Fascioliasis prevalence correlation with altitude appeared significant. An epidemiological characterisation of the valley transmission pattern of fascioliasis in Cajamarca is made by comparison with other better known hyperendemic areas. Results suggest that human fascioliasis may be widespread throughout different parts of Cajamarca province, even far away from the city, and that long-term fascioliasis chronicity and superimposed repetitive infections may be probably frequent.

1. Introduction

Fascioliasis was only considered a secondary disease in humans due to the relatively small number of only around 2500 reported cases before the 90s (Chen and Mott, 1990), despite its high pathogenicity well known in livestock since very long ago (Torgerson and Claxton, 1999). The human fascioliasis scenario began to change from that decade, due to the description of large endemic areas including even human hyperendemic situations in different continents. The recent fascioliasis emergence has been related to climate change, at least in part and in given countries (Mas-Coma et al., 2008, 2009b), given the dependence of fascioliasis transmission on climate and environmental characteristics (Ollerenshaw and Smith, 1969; Fuentes et al., 1999, 2001). Additionally, pathogenicity and immunity studies have shown this disease to be pronouncedly more complicated and with a greater impact in long-term infection than what was believed until the 90s (Valero et al., 2003, 2006, 2008; Girones et al., 2007). Emergence, long-term pathogenicity and immunological interactions are in the background of the decision taken by WHO to include this disease within the so-called neglected tropical diseases (NTDs). Their control and elimination is now recognized as a priority for achieving United Nations Millennium Development Goals and targets for sustainable poverty reduction (Hotez et al., 2007, 2008).

In the Americas, animal fascioliasis is caused by only *Fasciola hepatica* (Mas-Coma et al., 2009a) mainly transmitted by lymnaeid snail vectors of the *Galba*/*Fossaria* group (Bargues et al., 2007). Areas of high human impact seem to focus on Andean countries, above all in high altitude areas where fascioliasis transmission is increased as a consequence of the adaptation of both liver fluke and lymnaeid vectors to the extreme environmental conditions (Mas-Coma et al., 2001). Among Andean countries, Peru appears as the country presenting a larger human fascioliasis health problem. Human infection has been diagnosed in inhabitants from almost all Andean areas, including from the Altiplano (Esteban et al., 2002) up to inter-Andean valleys (e.g., Storck et al., 1973; Ortiz et al., 2000), and even urban areas surrounding the capital of Lima (Blancas et al., 2004)

Abbreviations: epg, eggs per gram of faeces; AM, arithmetic mean; GM, geometric mean.

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and low altitude areas closer to the Pacific coast (Picoaga et al., 1980). Many of these areas have proved to be human endemic. A rural population of almost 8 million people is estimated at risk in this country (WHO, 1995).

Within the human fascioliasis high altitude transmission pattern related to *F. hepatica* transmitted by lymnaeid vectors of the *Galba/Fossaria* group, two different subpatterns have been distinguished in Peru according to physiographic and seasonal characteristics (Mas-Coma, 2005; Mas-Coma et al., 2009a): (a) the altiplanic pattern, with endemicity distributed throughout an area of homogeneous altitude and transmission throughout the whole year due to high evapotranspiration rates leading lymnaeid vectors to concentrate in permanent water bodies (Mas-Coma et al., 1999); examples are the Northern Bolivian Altiplano and the Peruvian Altiplano of Puno; (b) the valley pattern, with endemicity distributed throughout an area of heterogeneous altitude and seasonal transmission related to climate (Claxton et al., 1997, 1999); Peruvian examples are the valleys of Cajamarca and Mantaro.

In recent years, WHO has launched a worldwide initiative against human fascioliasis (WHO, 2007, 2008), including action in different epidemiological situations and transmission patterns (Mas-Coma, 2005). The Cajamarca province was selected as representative of the valley pattern of human hyperendemic. The aim of the present study is to analyse the results obtained from the human surveys performed in different rural areas of Cajamarca province, to establish a baseline on which to carry out the pilot activities. The article focuses on the main epidemiological characteristics of prevalences, intensities and geographic distribution of human infection, as well as of coinfections of fascioliasis with other protozoan and helminth infections, in the way to characterize human fascioliasis by comparison with human hyperendemic areas in other Andean regions which have been more widely and deeply studied.

2. Materials and methods

2.1. Study area and population

Coprological studies were made in the Departmento de Cajamarca, which covers an area of around 35,400 km^2 in the northern Andean part of Peru and is inhabited by 1,416,000 people. This department comprises 13 provinces and the province of Cajamarca in its turn includes 12 districts. Surveys were performed in the schools of six communities (population data from 2005 census): La Colpa (07°13′24.9″S; 78°26′44.0″W) and Yanamango (07°13′35.7″S; 78°25′47.2″W) (Jesus district, with a total of 14,075 inhabitants and a density of 52.6/km^2); Llimbe (07°12′33.9″S; 78°24′03.5″W) and Shaullo Grande (07°10′31.2″S; 78°25′04.3″W) (Llacanora district, with 4651 inhabitants and a density of 94.1/km^2); Huayrapongo Grande (07°10′58.7″S; 78°26′55.6″W) (Baños del Inca district, with 31,764 inhabitants and a density of 114.9/km^2); and Santa Rosa de Chaquil (07°07′48.2″S; 78°21′06.8″W) (Encañada district, with 22,397 inhabitants and a density of 35.3/km^2) (Figs. 1 and 2).

The Departmento de Cajamarca includes many inter-Andean valleys irrigated by more or less wide and fast-flowing rivers. The mean yearly temperature is 15.3 °C, with pronounced daily variation (July: −5.0 to 23.8 °C; January: 0.2–24.2 °C) and wide monthly differences (extreme mean temperatures of 3 °C in July and 22 °C in November). The relative humidity is 64%, and the total yearly precipitation is 769 mm, with a monthly minimum of 6 mm in July and a maximum of 107 mm in October. The rainy season includes from October to April (mainly December to March), and the dry season from May to October. Mean annual evapotranspiration is 99 mm, with monthly variation between 84 mm in April–May and 109 mm in December.

Main economic activities are agriculture and mining, the latter above all in the western mountainous area. Around 75.3% of the population is rural, with agriculture focusing mainly on potato, barley, wheat, and corn. Dwellings are constructed with traditional materials and there is insufficient sanitary availability. About 33% of people does not have access to a treated water system and hence water is directly obtained from rivers and other natural water collections. A 76% of the population lacks access to a sewer system and rubbish removal service, and 80% lacks electricity (Instituto Nacional de Estadística e Informática, Peru: http://www.inei.gob.pe).

2.2. Stool collection and laboratory methods

The coprological survey involved 476 subjects (246 males and 230 females) of 2–18 years of age (mean ± S.D. = 9.1 ± 2.6). The surveys were made on randomly selected subjects on a given day among all participating students. The beginning of September was the period selected for the surveys, given the information on disease seasonality which indicates that livestock shows highest faecal egg shedding in August–September (Claxton et al., 1997, 1998). A clean, plastic, wide-mouth, numbered container with a snap-on lid was given to every participant. All subjects were then asked to try to fill the container with their own faeces and to return it immediately. One stool sample per subject was collected and personal data (name, sex, and age) were noted on delivery of the container. Faecal specimens were transported to a laboratory of the Universidad Nacional de Cajamarca within 1–3 h of collection. In this laboratory, a Kato-Katz slide was made from each stool sample following WHO recommendations, using a template delivering about 41.7 mg of faeces (Ash et al., 1994). These slides were initially examined within 1 h of preparation to avoid overclarification of some helminth eggs. If sufficient material of each stool sample was present, one aliquot was preserved in 10% formalin solution (1:3).

Coproparasitological studies were carried out at the Departamento de Parasitología (Valencia, Spain). Samples fixed in 10% formalin were processed by a formol-ether concentration technique (Knight et al., 1976) and one aliquot of sediment obtained with this technique was stained using a modified Ziehl–Neelsen technique (Henriksen and Pohlenz, 1981). Two slides per specimen were fully examined by one of the authors (LCG) and finally by the second author (JGE). Microscopic slides and materials from the human parasite collection of the Parasitology Department of the University of Valencia were used for quality control when needed. Recent corrections introduced into liver fluke egg characteristics for the coprological diagnosis in both human and animals were taken into account (Valero et al., 2009).

The sediments of the concentration technique and the Kato-Katz slides were used for prevalence data. According to the techniques used, prevalence results of the pinworm, *Enterobius vermicularis*, may not be considered definitive because anal swabs would be the adequate technique for the detection of the eggs of this nematode species. The Kato-Katz slides were analysed for egg counts. Intensity of infection, measured as eggs per gram (epg) as an indicator of *F. hepatica* burden in infected subjects, was described by range, arithmetic mean (AM), geometric mean (GM) and intensity classes.

2.3. Statistical analysis

Statistical analyses were done using SPSS 15 software package (SPSS Institute, Chicago, IL) for Windows. For the evaluation of categorical variables, the chi-square test or Fisher's exact test was used. The Mann–Whitney *U* test and Kruskal–Wallis (*H*) test were used for non-normally distributed data. Associations between liver