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Veterinary Parasitology 118 (2003) 51–60
veterinary parasitology
www.elsevier.com/locate/vetpar

Taeniosis–cysticercosis in man and animals in the Sierra of Northern Ecuador

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Received 12 June 2003; received in revised form 2 September 2003; accepted 16 September 2003

Abstract

Taenia solium is endemic in the Andean region of Ecuador. The recent rediscovery of *Taenia saginata* in humans urges to reconsider some assumptions in relation to the epidemiology of the taeniosis/cysticercosis complex in this country.

Therefore, data were compiled on the infection of both tapeworms in man and animals in Pichincha and Imbabura provinces in the Andean region, north of Quito. On post mortem inspection 3 out of 806 (0.37%) carcasses had *T. saginata* metacestodes, however, 35 sera out of 869 (4.03%) showed circulating antigen in a monoclonal antibody-based sandwich ELISA (Ag-ELISA). Porcine cysticercosis was detected in 15 out of 2896 (0.52%) carcasses and 93 out of 1032 serum samples (9.01%) were positive in Ag-ELISA. In humans, 4.99% (215 out of 4306) cases of antigen positives were found, whereas coprological examination of 1935 stools resulted in 30 positive cases (1.55%). The limited number of adult tapeworms (29) that were collected does not allow firm conclusions on the proportion of each species, but in total 21 specimen were identified as *T. saginata* and 8 as *T. solium*. These data have been discussed in view of the epidemiology of human cysticercosis.

Keywords: *Taenia saginata*; *Taenia solium*; Prevalence; Zoonosis; Ecuador

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doi:10.1016/j.vetpar.2003.09.019

1. Introduction

Taenia saginata is one of the tapeworms of the small intestine of man, its metacestode, is specific for cattle. Distribution is almost cosmopolitan but where *Taenia solium* is equally present, the importance of *T. saginata* is often overshadowed by the latter, being of greater medical importance.

Reports on the prevalence of adult *Taenia* in Ecuador are given by López (1969) i.e. 0.66% without indication of the species but later interpreted as *T. saginata* (Pawlowski and Schultz, 1972). The prevalence of adult *T. solium* in this country was reported by Jiménez (1976) and Cruz et al. (1989) as being, respectively, 1.02 and 1.6%.

T. solium cysticercosis has been reported both in humans i.e. 14.4% in the northern Sierra (Cruz, 1996) and in pigs in the southern Sierra of Ecuador i.e. 5.9% by Jiménez (1976) and 12% by Benítez (1995).

There are no published reports on the presence of *T. saginata* metacestodes in Ecuador, the only documented evidence can be found in final year dissertations and is limited to slaughterhouse observations in the coastal region of the country. As such, infection levels, observed by post mortem inspection varied from 1.89 to 0.04% (Briones, 1969; Aragundi, 1969; Intriago, 1976; Sosa, 1981; Aragundi, 1999). There is no evidence of studies on bovine cysticercosis in the Andean Sierra or in the Amazon region of the country.

The objective of the present study was to evaluate whether the presence of *T. saginata* should be taken into account in epidemiological studies of *T. solium*-cysticercosis. Therefore, a survey on cysticercosis in humans, pigs and in bovines and on intestinal *Taenia* in the same region of the northern Andes of Ecuador has been conducted.

2. Materials and methods

The observations were made in two provinces of the Andean Sierra: Pichincha province, with the capital Quito and the neighbouring province to the north, Imbabura province with Ibarra as the provincial capital.

2.1. Bovines

Surveys were organised in two slaughterhouses: in the “Camal Municipal de Rastro de Ibarra”, Imbabura Province and in the “Camal Metropolitano de Quito” Pichincha Province. The slaughterhouse of Ibarra was visited 20 times between December 2000 and January 2001; a total of 374 carcasses were inspected and 397 blood samples collected from bovines of different age, sex and race. The limited number of animals slaughtered per day allowed for a close inspection of the so-called predilection sites: masseters, myocard, oesophagus and diaphragm, which are usually not subject to regular inspection in this slaughterhouse. When an animal was found positive, the complete carcass and all the organs were submitted to a more thorough inspection.

The slaughterhouse of Quito was visited four times during February and March 2001. A total of 472 blood samples were collected and 432 carcasses inspected. In this slaughterhouse the workload is heavier, yet inspection of the predilection sites is

supposed to be part of the routine. Here again, positive cases were subjected to a thorough inspection.

2.2. Pigs

During 1998, on a total of 8154 carcasses, no infected carcasses were officially reported in the metropolitan slaughterhouse of Quito. This is the main slaughterhouse in the Sierra, where pigs from various regions are presented. For this apparent lack of detection, it was decided to concentrate activities on Imbabura province.

Two surveys were held in a slaughterhouse in Ibarra, where only local pigs are slaughtered. During the first survey, between February and April 1998, 1101 porcine carcasses were inspected by means of a single incision in the *Musculus masseter*, *Musculus biceps brachii*, *Musculus trapezius cervicis*, *Musculus glutaeus superficialis*, and by superficial inspection of the tongue, heart and diaphragm muscles. In addition, blood samples were randomly taken from 591 of these pigs. In the second survey from February until April 1999, 1795 pigs were sampled. Every carcass that was found positive for cysticercosis by routine meat inspection was subjected to a more profound examination, as agreed by the local authorities, which consisted of inspection of the brains and a total larval count of the tongue, heart and diaphragm. It was calculated that the remaining muscle mass represented on average 47% of the carcass weight. The larval burden of that mass was estimated by a larval count in 100 g of each of the following muscle groups: *M. masseter*, *M. biceps brachii*, *Musculus longissimus dorsi*, *Musculus psoas minor* and *M. glutaeus superficialis*. Thus, on the basis of the larval counts in the muscle samples (lg), the carcass weight (w) plus the sum of the larvae in the brains (lb), tongue, heart and diaphragm (lc), the total larval load could be estimated as $\mathrm{lg} \times 2 \times (w/100 \times 47) + \mathrm{lb} + \mathrm{lc}$. Organs, viscera and the inner surface of the carcass were macroscopically inspected for other plathelminthes.

2.3. Humans

2.3.1. Human cysticercosis

Between October 1997 and May 2002, 2368 blood samples were collected from inhabitants of Pichincha, visiting a health centre and 1938 blood samples from inhabitants of Imbabura province, consisting of 1292 samples from volunteers and 646 samples from patients, sent by general practitioners because of neurological complaints. The last group of patients volunteered, after informed consent, to have their sera analysed by the Ag-ELISA as described below and, when positive, to undergo a CT-scan of the brains. These scans were made by a CTMAX 640 "General Electric" and analysed by experienced neurologists. Samples came from both genders and age varied from 12 to 80 years.

2.3.2. Taeniosis

From January 2000 until May 2002, a total of 1935 faecal samples from human volunteers were collected: 695 samples came from inhabitants of Pichincha Province and 1240 from various rural communities of Imbabura province. *Taenia* carriers were offered anthelmintic treatment i.e. a single oral dose of praziquantel at 10 mg/kg b.w. and stools for species

identification of the collected tapeworms. In this study, both genders between 1 and 80 years were included.

2.4. Techniques

2.4.1. Stool examination

Stool samples were examined by the Ritchie technique.

2.4.2. Identification of cestodes

Metacestodes encountered in the muscles were dissected out and transferred to 90 ml saline plus 10 ml bovine bile at 37 °C to allow evagination and visualisation of the scolex.

Tapeworms collected from human stools following praziquantel treatment were identified according to the methods described by Rodriguez-Hidalgo et al. (2002).

2.4.3. Detection of circulating antigens (Ag-ELISA)

Blood samples were kept at 4 °C, centrifuged at 2500 × *g* for 5 min and serum stored at −20 °C until use. Sera from bovines, pigs and humans was tested in an Ag-ELISA (Brandt et al., 1992) with the modifications, including pre-treatment of the sera by trichloroacetic acid, as described by Dorny et al. (2000) and Erhart et al. (2002). To facilitate comparison between different plates, all results were expressed as a ratio, calculated by dividing the optical density of each sample by the cut-off value. This cut-off was calculated using a *t*-test based on the optical densities of eight negative samples of Ecuadorian origin, as such, any value above 1 is considered as being positive.

3. Results

An overview of the diagnosis of cysticercosis in the respective hosts, the results of carcass inspections in bovines and pigs and the coprological survey are presented in Table 1.

3.1. Bovine cysticercosis

Inspection on 374 carcasses in the slaughterhouse of Ibarra revealed one positive animal (0.27%). From the 397 sera collected, 23 were seropositive (5.79%; ratio range: 1.01–128.32) in the Ag-ELISA. This parasitologically positive animal had an Ag-ELISA ratio of 128.32. It was a 1-year-old steer of 350 kg from Carchi, in the northern part of the country. It was heavily infected with over 4000 metacestodes, mainly viable.

Meat inspection yielded two positives out of the 432 carcasses (0.46%) inspected in the Metropolitan slaughterhouse of Quito; out of the 472 bovine sera, 12 (2.54%) were positive in Ag-ELISA. In spite of a thorough search of the viscera and the carcass in both animals, only one living metacestode was found, each time located in the oesophagus muscle. One of the positive animals was seronegative in the Ag-ELISA whereas the other had a ratio of 1.4. Both animals were Zebu cross-breds, originating from Pichincha province with a liveweight of about 200 kg.

Table 1
Diagnosis of cysticercosis in bovines and pigs according to official inspection in the slaughterhouses in Quito (Pichincha Province) and Ibarra (Imbabura Province) and by the detection of circulating antigen in sera from bovines, pigs and humans. Detection of *Taenia* spp. by microscopical examination of faeces[a]

Province	Bovine cysticercosis		Porcine cysticercosis		Human cysticercosis	Taeniosis
	Ag-ELISA	Post mortem	Ag-ELISA	Post mortem	Ag-ELISA	Ritchie
Pichincha	2.54 (12/472)	0.46 (2/432)	–	(0/8154)	4.90 (116/2368)	2.45 (17/695)
Imbabura	5.79 (23/397)	0.27 (1/374)	6.77 (40/591), 12.02 (53/441)	0.73 (8/1101), 0.39 (7/1795)	5.11 (99/1938)	1.05 (13/1240)
Total	4.03 (35/869)	0.37 (3/806)	9.01 (93/1032)	0.52(15/2896)[b]	4.99 (215/4306)	1.55 (30/1935)

[a] Percentage positives (number of positive cases/number examined).
[b] Excluding data from Pichincha.

Dissection of the larvae and evagination revealed morphological features i.e. an unarmed scolex, typical for *T. saginata* metacestodes.

3.2. Porcine cysticercosis

During the first survey in the slaughterhouse of Ibarra, post mortem inspection of 1101 carcasses revealed eight positives (0.73%). Forty out of 591 blood samples (6.77%) were positive in the Ag-ELISA. In the second survey in the same slaughterhouse 7 of the 1795 carcasses (0.39%) were found positive by the meat inspector. Results of the more thorough dissections of these seven pigs and their estimated total larval burden are given in Table 2. In the Ag-ELISA, 53 pigs out of the 441 (12.02%) were positive, among which pigs 1 and 2 that were thoroughly dissected (Table 2). No blood samples were collected from the five other parasitologically positive pigs. *Fasciola* spp. was found in two pigs, both seronegative for cysticercosis, hydatid cysts were found in four pigs seronegative for cysticercosis and in one seropositive pig with a ratio of 9. *Cysticercus tenuicollis* was found in six pigs, all with a ratio between 3 and 11. Discounting seven possible cross-reactions, 10.66% of the pigs were seropositive.

3.3. Human cysticercosis

Cysticercus cellulosae circulating antigen was detected in 215 serum samples in a total of 4306 serum samples (4.99%), with little variation between provinces: 116 positives out of 2368 in Pichincha (4.90%) and 99 positives out of 1938 samples tested from Imbabura province (5.11%). However, in the latter group 3.4% of the volunteers were positive whereas analysis by Ag-ELISA of the 646 neurological patients revealed 55 seropositives (8.51%). Brain CT-scans of these 55 patients resulted in 52 diagnoses of neurocysticercosis, the majority, however, i.e. 36 out of 52, without any complaints suggestive for cysticercosis, only three had a history of epileptic crises and 13 patients complained of recurrent headache problems.

Table 2
Porcine cysticercosis in Imbabura province[a]

Pig no.	Number of larvae in					Carcass weight (kg)	Estimated (total no. of cysticerci)
	Brains	Tongue	Heart	Diaphragm	Muscle groups		
1	1	1	2	3	10	30	289
2	3	4	17	6	12	60	707
3	1	78	0	21	225	30	6445
4	5	6	0	10	59	50	2794
5	2	23	17	0	269	25	6364
6	1	0	5	4	23	25	551
7	2	1	5	17	60	60	3409

[a] Results of thorough dissection of seven pigs found positive at routine meat inspection and estimation of the total number of metacestodes.

3.4. Human taeniosis

Coprological examination of 1935 stool samples resulted in 30 positive cases (1.55%) with 17 out of 695 (2.45%) from Pichincha and 13 out of 1240 (1.05%) from Imbabura province. The vast majority of stool samples (93%) were positive for either helminths (14%) or protozoan parasites (35%) or both (43%).

Praziquantel treatment resulted in recuperation of adult tapeworms from 17 hosts in Pichincha, 16 of these were identified as *T. saginata*, one as *T. solium*. In Imbabura, five hosts carried *T. saginata*, seven *T. solium* and in one case no worms could be recuperated. All hosts carried a single worm, except for one carrying a very small and two normal sized *T. saginata*.

4. Discussion and conclusion

Some authors (Heinz and MacNab (1965) cited by Joubert and Evans (1997)) found it striking that high rates of cases of human cysticercosis occur while the prevalence of intestinal *T. solium* in man is notoriously low and nicknamed this disproportion the "*T. solium*/cysticercosis paradox". In Ecuador, according to the scarce epidemiological data provided by the Ecuadorian Ministry of Public Health (Aguilar, 2002), in some provinces in the Sierra, like Bolivar, Cañar and Imbabura this paradoxical situation seems to exist as well, with official incidences of taeniosis/cysticercosis of 0/1.60, 0/1.36 and 0/3.57, per 100,000 habitants, respectively. Whereas, in the coastal provinces of Esmeraldas, Los Rios and Manabi the reverse has been reported i.e. the presence of adult *Taenia* with no or hardly any cases of human cysticercosis, i.e. 1.36/0, 11.11/0.30 and 1.01/0 per 100,000 habitants, respectively.

From 1985 to 2001, according to FAO, WHO and OIE reports, no data on *Cysticercus bovis* in Ecuador, are available in spite of being notifiable (Welte, 1997; Handistatus II, 2002), before 1985, it was listed as exceptional. Even, a report specifying adult *T. saginata* has never been made in Ecuador where usually prevalences of *Taenia* are given without reference to the species (e.g. López, 1969). All references to adult *Taenia* were assumed to be *T. solium*, presumably because of the impact on public health.

This study confirms the presence of bovine cysticercosis in Ecuador, commonly assumed to be absent. This is very surprising and the latter statement may be untrue for the staff of slaughterhouses, which either did not report their observations or failed to recognise the metacestodes, hence officially *C. bovis* was considered to be either absent or at least present but beyond the detectable limit. The comparison with the study of Dorny et al. (2000) in Belgian cattle is interesting: 0.26% positives on post mortem inspection vs. 3.09% seropositives in Belgium with 0.37% positives on carcass inspection vs. 4.03% seropositives in the present study or an almost equal ratio (12 against 11, respectively) by which the post mortem data have to be multiplied to obtain the seroprevalences.

Even with proper training and supervised inspection, as in the present study, regional variations on cysticercosis in Ecuador will remain as indicated by official data (Aguilar, 2002) on human and porcine cysticercosis.

Estimating the prevalence of porcine cysticercosis is even more difficult. Ante mortem palpation of the tongue is a common practice on the markets in the region. As long as no financial compensation for condemnation of cysticercotic carcasses, through insurance or subvention, exists, it will be unlikely that animals with palpable cysticerci in the tongue will be presented in official slaughterhouses. On the other hand, all positive carcasses had high numbers of cysticerci which may suggest that light infections might escape the attention of the inspector. This may be a partial explanation of the failure to detect no positive carcasses on a total of 8154 pigs slaughtered in Pichincha, even more so since official meat inspection, limited to superficial inspection and a single incision only, was carried out without any intervention of the present investigators.

In any case, the limited number of complete dissections of the carcass does not allow any firm conclusion but data are not suggestive for clear-cut predilection sites of the metacestodes. The brains, however, of all seven pigs harboured cysticerci albeit in very low numbers, irrespective of the total larval load. Incidentally, routine post mortem inspection never includes the brains. The presence of porcine cysticercosis, in the Northern Andes of Ecuador as determined by Ag-ELISA lies well in the expected range of an endemic region i.e. 5–30% (Craig et al., 1996). The monoclonal antibodies, used in the latter test, were raised against metabolic antigens of *T. saginata* metacestodes (Brandt et al., 1992), as such, if those are reacting with antigens of *T. solium* metacestodes, then a cross-reaction with *Taenia hydatigena* metacestodes is equally likely. Therefore, the six cases of *C. tenuicollis* found in the 53 Ag-ELISA positives in Imbabura were discounted.

As for the infection rates of human cysticercosis, we cannot rule out a biased sampling. Samples came from patients visiting the outpatient's hospital and their willingness or that of the volunteers to co-operate might have been linked to being suspicious of a problem. Again in this study, the occurrence of intestinal *Taenia* seems low and probably an underestimation, even when these data, obtained by microscopy have to be multiplied by 2.6 (Allan et al., 1996). Nevertheless the official figures for 2001 (Aguilar, 2002) do not seem to be very realistic i.e. 1 and 2.15 cases of taeniosis and cysticercosis, respectively, per 100,000 habitants in Pichincha, in Imbabura 3.57 cases of cysticercosis and none for *Taenia* spp. Rodriguez-Hidalgo et al. (2002) differentiated 16 adult specimen from the same region as *T. saginata* and seven as *T. solium*. In *T. solium* endemic regions, prevalence of taeniosis is usually not higher than 1% (Gemmell et al., 1983) but can reach 2.7% (Allan et al., 1996). As for *T. saginata*, Geerts (1990) estimated that the incidence of intestinal *T. saginata* in Belgium was equal or even higher than the cases of bovine cysticercosis detected p.a. Obviously, many factors like culinary traditions or food-safety regulations, make comparisons about the proportion of adult tapeworm carriers and metacestode infections between different countries are often difficult. In addition, the limited number of samples and the diagnostic insensitivity related to intestinal *Taenia* does not allow a conclusion on the proportion in which both intestinal *Taenia* spp. are present. However, in Ecuador, our study confirms the presence of both *Taenia* spp. Given the relatively high numbers of bovine, porcine and human cysticercosis it is unlikely that current official estimates about the presence of adult *Taenia* are realistic which hinders a correct understanding of the epidemiology of the *T. solium*/cysticercosis complex.

Acknowledgements

This study was carried out with the financial support of VLlR (Vlaamse Interuniversitaire Raad—Flemish Interuniversity Coucil), and the Universidad Central del Ecuador. Part of the research was done within the framework agreement between the Belgian Directorate General for International Co-operation and the Institute of Tropical Medicine, Antwerp. The authors are indebted to the medical staff of the hospital in Atuntaqui, to the staff of the "Camal Metropolitano" in Quito, the "Camal Municipal de Rastro" in Ibarra and to the patients for their willingness to participate in this study.

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