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## SHORT REPORT: EVIDENCE AND POTENTIAL FOR TRANSMISSION OF HUMAN AND SWINE *TAENIA SOLIUM* CYSTICERCOSIS IN THE PIRACURUCA REGION, PIAUÍ, BRAZIL

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**Abstract.** The study conducted in the *Cocal dos Alves* municipality, located in the Piracuruca region of Piauí State, Brazil in November of 2003 was based on both a socio-behavioral survey and analysis of serum antibodies and parasitic materials. Pig raising is the main economic activity with 91.4% using extensive farming. On the studied population, 54.3% of people did not apply any sanitary measures to wastewater, 45.7% used septic tanks, and 69.1% consumed water without treatment. The data collected indicated the occurrence and active transmission of the taeniasis-cysticercosis complex in the region. One of seven voluntary persons was positive in antibody-ELISA tests using both native and recombinant antigens. Multiplex PCR and DNA sequencing of cyst samples obtained from a pig revealed the presence of the Afro-American genotype of *Taenia solium*. This study revealed the occurrence of human and porcine cysticercosis in the Piracuruca region of Piauí State, middle-north of Brazil.

*Taenia solium* is an etiologic agent of taeniasis and cysticercosis, an important zoonotic infection involving humans and swine. Cysticercosis is caused by the ingestion of eggs of *T. solium* by susceptible intermediate hosts. Pigs are the common intermediate hosts. However, humans and even dogs can also contract cysticercosis by ingesting eggs of *T. solium*.<sup>1</sup> Human cysticercosis warrants special attention when cysticerci are located in the nervous system because it is a major cause of seizures and epilepsy.<sup>2</sup> The disease is highly endemic in Latin America, Asia, and Africa.<sup>2,3</sup> Cysticercosis in pigs is also a cause of carcass condemnations particularly in heavy infections, constituting an economical problem. Thus, the interruption of the cycle in definitive and intermediate hosts is key strategy for the control of this morbid condition.<sup>4–6</sup>

Brazil is a country known to be endemic for cysticercosis.<sup>2</sup> Cases of human cysticercosis have mainly been reported in southern states of Brazil with sporadic notifications in the northeast region, including Piauí state.<sup>7</sup> According to the Brazilian Department of Animal Origin Products Inspection (DIPOA) of the Ministry of Agriculture, Livestock and Food Supply (MAPA), reports of swine cysticercosis are mainly from southern and southeastern states. However, it had not been notified by slaughter houses in the Piauí state in the period between 2002 and 2004,<sup>8</sup> when this survey was carried out.

Brazil is politically divided into 5 regions: north, south, northeast, west central, and southeast. Northeast region, which includes Piauí state, can be divided into 4 different ecosystems: Coastal Region, Semi-arid Region, Forest Zone, and the Middle-North also known as Palm Zone.

The Middle-North is characterized as the transitional area between the semi-arid region of the Northeast and the Ama-

zon region. It is characterized by increasing humid climate and exuberant vegetation towards the West. Middle-North also concerns the northern areas of the Tocantins state and parts of the states of Maranhão and Pará. All these areas have similar climatic and geographical characteristics, and consequently similar human and animal occupation, including socio-behavioral aspects.

This study was conducted in Cocal dos Alves city, Piracuruca region, Piauí state, Middle-North of Brazil (Figure 1, Figure 2A), in November of 2003. Cocal dos Alves city is a principal city for pork production for neighboring cities and located in the main route from Teresina (the state capital) to Ceará state and to the Parnaíba river delta and “Sete Cidades” National Park, the most important and popular tourist areas of Piauí state. Although the region is designated in endemic area for cysticercosis,<sup>2</sup> there is no documented report of cysticercosis in this region. Therefore, this study was carried out to confirm the presence of human and porcine cysticercosis in Cocal dos Alves.

The study area is located 200 km northeast from Teresina, the capital of Piauí state (03°43'43"S, 41°26'56"W). With an area of 288.42 sq km (111.35 sq miles), altitude of 100 m (328 feet), Cocal dos Alves is a city with estimated population of 5438 inhabitants in 2004.<sup>9</sup> The area is important as the main tourist route to the “Sete Cidades” National Park, to the Parnaíba river delta and Fortaleza (the capital of the neighbor state Ceará), which are very popular tourists' areas in Brazil (Fig. 1).

One hundred and ninety-seven people were questioned in a socio-behavioral–epidemiologic survey focused on the taeniasis-cysticercosis complex, including questions regarding life-style, food consumption behavior, sanitary management of water and wastewater, medicine consumption, past and present diseases, and symptoms. The data generated was analyzed using Epi Info™ (Centers for Disease Control and Prevention, Atlanta, GA) software version 3.3.2.

Seven asymptomatic individuals residing in the risk area volunteered to provide blood samples. For detection of specific antibodies for cysticercosis in humans, ELISA was per-

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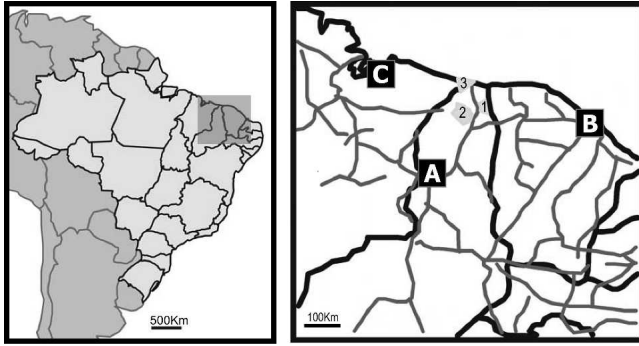


FIGURE 1. Left: map of Brazil with political division; Right: Amplification of the hachurated area of the left panel with main routes (in dark grey). "A" correspond to Teresina (Capital of Piauí state), "B" is Fortaleza (Capital of Ceará state), and "C" is São Luís (Capital of Maranhão state). Number 1 corresponds to the study area—Piracuruca region, 2 and 3 correspond to touristic areas; "Sete Cidades" National Park and Parnaíba River's Delta.

formed using both highly specific glycoproteins (GPs) in cyst fluid purified by isoelectric focusing and recombinant chimeric antigens (RecTs) prepared as previously described.<sup>10,11</sup>

Specimens were collected from a pig necropsied after tested positive for the tongue inspection (Figure 2B). Identification of taeniid cysticerci collected from the infected pig was carried out based on nucleotide sequence of cytochrome *c* oxidase subunit 1 gene (*cox1*) amplified by multiplex PCR.<sup>12</sup> Samples for DNA sequencing were prepared with an *ABI PRISM BigDye Terminator Cycle Sequencing Ready Reaction kit*, and the amplicon was sequenced on an ABI Prism 310 Genetic Analyzer.

According to the data of hospital morbidity from 2002 (*Brazilian Single Health System*) for Cocal dos Alves city,<sup>9</sup> 1.8% of hospital admissions were due to mental disorder or idiopathic behavioral disorder in the population with age between 15 and 49 years; although specific neurologic diagnoses were not reported. From this study, it became evident that most residents were pig farmers. Socioeconomic standings are low and sanitary facilities are poor. Many socio-behavioral characteristics of the population suggested the existence of the taeniasis-cysticercosis complex. The surveyed population widely practiced pork consumption; 65.3% raise pigs mostly by extensive farming (91.4%). There is no public sewage treatment. The use of septic tanks by 45.7% of the population indicates a concern about the sewage disposal; however 54.3% do not use any kind of sewage management. According to the data obtained in this epidemiologic survey, 61.4% of the surveyed population was familiar with anti-parasitic medication. However, the drugs mentioned for the management of parasitic diseases were mebendazole (36.4%) and metronidazole (5.3%), which are not indicated for the treatment of *Taenia* spp. infections. For this reason, the specific treatment of taeniasis was considered nonexistent in the studied area.

Other aggravating factors for infectious and parasitic diseases are associated with the water supply; 55.3% of the population use water from cisterns without treatment, 13.8% uses other sources without treatment, and only 30.9% of the population use treated water. Another problem is the population misinformation leading to improper diagnosis of taeniasis.<sup>13</sup> Although there was no report of pathognomonic signs and symptoms of taeniasis and cysticercosis in the stud-

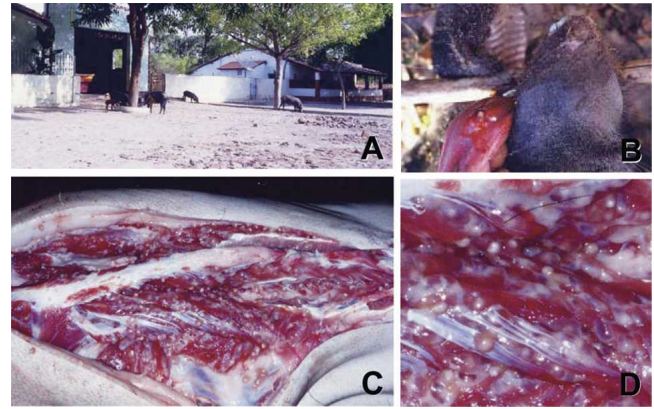


FIGURE 2. A, General view of Cocal dos Alves city, with pigs roaming freely in the main avenue; B, Pig positive at tongue inspection; C, Dorsal muscles full of cysts at pig's necropsy; D, Cysts in a detail of C. This figure appears in color at [www.ajtmh.org](http://www.ajtmh.org).

ied population, the analysis of the results of the epidemiologic survey pointed out several factors suggesting the occurrence and maintenance of the taeniasis/cysticercosis cycle in the region.

Due to the high specificity of available immunodiagnostic tests, serology is one of the best presumptive diagnostic methodologies.<sup>6,10,11</sup> Multiplex PCR was used for the confirmation of parasitological material; the technique is highly specific and allows identification of parasitological material even when the morphologic identification is not possible.<sup>12</sup>

Of the 7 asymptomatic volunteers tested serologically, one was positive by ELISA with the use of GPs (OD 0.031) and RecTs (0.042) with a cutoff of 0.029 and 0.038 for GPs and RecTs, respectively. This case was considered to be a highly suspicious cysticercosis case, since the test used is highly specific for cysticercosis and no cross-reaction was observed from other diseases so far we examined.<sup>6,10,11</sup> It is also important to consider that 43.3–91% of autopsies in endemic areas reveal asymptomatic NCC.<sup>14</sup>

In the field, diagnosis of cysticercosis is made through tongue inspection. This examination can be performed *ante-mortem* in swine and aim to find superficial cysts. However, this technique has low sensitivity and specificity.<sup>6</sup> Usually, the tongue inspection method only detects pigs with heavy infections.

The necropsy of a "tongue inspection positive" pig revealed numerous cysts in the muscles (Figures 2C, 2D). The cysticerci were collected and mitochondrial DNA analysis was performed to identify taeniid species. As a result, a 720-bp *cox1* gene fragment was successfully amplified by multiplex PCR (Figure 3A). The product amplified was sequenced (AB243755) and aligned with similar sequences previously described.<sup>15</sup> It confirmed Afro-American genotype of *T. solium* with 100% of similarity. The homology of differential nucleotides at positions 619, 690, 723, 861, 867, and 1065 confirmed to be the American origin genotype (Figure 3B).

*T. solium* infection is known to be a potentially eradicable parasitic zoonosis.<sup>5</sup> Prophylactic measures based on epidemiologic data and applied in a continuing sanitary education process are essential ingredients for the control and eradication of parasitic diseases.

Nowadays Cocal dos Alves city, a major supplier of pork

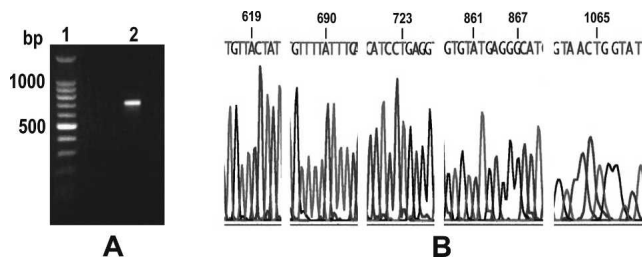


FIGURE 3. Left: Multiplex PCR result of the specimen collected from a swine in Cocal dos Alves—PI, Brazil, 2003. Lane 1, 100-bp ladder DNA size marker; Lane 2, 720 bp amplicon. Right: Partial nucleotide sequences of the multiplex PCR amplicon. Arrows indicates the differential positions of *T. solium* American origin genotype with respective numbers indicated upside.

for the region of Piracuruca, is expected to be a natural reservoir for taeniasis and cysticercosis, since there has been no action for the control of the disease. Therefore, the present situation has led to the existence of tapeworm carriers around the region, neighbor states, and even other countries. It should be kept in mind that the city is in the route of tourists circulating from Teresina (the state capital) to the Parnaíba River delta, “Sete Cidades” National Park, and also in the route from Teresina to Fortaleza, the capital of its neighbor state Ceará (see Fig. 1). The population consuming food in the region is expected to be susceptible to the infection by the adult and the metacestode forms of *T. solium*.

Currently it is now evident that both taeniasis and cysticercosis are endemic in the Middle-North of Brazil. Consequently, a very important initial task is to establish the natural history of the taeniasis-cysticercosis complex inside the region. It is necessary to perform more studies comprising a wider area as well as a larger number of specimens. The epidemiologic mapping of taeniasis and cysticercosis in the Middle-North of Brazil will then provide essential information for the subsequent establishment of programs for the control and eradication of this important zoonosis.

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