Past and present of cystic echinococcosis in Bolivia

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Abstract

Viable eggs of the canine intestinal tapeworm *Echinococcus granulosus sensu lato* (s.l.) infect various intermediate hosts causing cystic echinococcosis (CE). Furthermore, CE represents a serious zoonosis causing a significant global burden of disease. CE is highly endemic in South America, including Argentina, Brazil, Chile, Uruguay, and Peru. For Bolivia, no official data concerning the incidence in humans or the number of livestock and dogs infected are available. However, it is well known that CE occurs in Bolivia. We aim here to fill the gap in the current knowledge of the epidemiological situation of CE in Bolivia, providing a historical overview of documents published within the country, which have never been comprehensively reviewed. The very first documentation of *E. granulosus* infection in animals dates in 1910, while the first human case was reported in 1913. In total, 876 human CE cases have been reported in the scientific literature, with an apparent increase since the 1970s. In the absence of other epidemiological studies, the highest prevalence in human comes from Tupiza, Potosí Department, where 4.1% (51/1,268) of the population showed signs of CE at mass ultrasound screening in 2011. In the same report, 24% of dog faecal samples were positive for coproantigens of *E. granulosus s.l.* in ELISA. The highest prevalence in intermediate hosts reported at abattoir reached 37.5% in cattle from Potosí, followed by 26.9% in llamas from Oruro, 2.4% in pigs and 1.4% in sheep from La Paz. Finally, *Echinococcus granulosus sensu stricto* (s.s.), *Echinococcus ortleppi* (G5), and *Echinococcus intermedius* (G7) have been identified in Bolivia. Data reviewed here confirm that *E. granulosus s.l.* is circulating in Bolivia and that a proper prospective nationwide epidemiological study of CE is urgently needed to define transmission patterns as a basis for the planning and implementation of future control measurements.

Introduction

Cystic echinococcosis (CE), caused by *Echinococcus granulosus sensu lato* (s.l.), is highly endemic in regions of Argentina, Brazil, Chile, Peru, and Uruguay [1]. Substantial research on different aspects of the epidemiology of CE in these countries has been published.
Furthermore, these 5 countries have joined forces since 2004 in “The Regional Initiative for the Control of CE” sponsored by the Pan-American Health Organization (PAHO) [2]. In the case of Bolivia, data regarding any aspect of the epidemiology of CE are not well documented. Moreover, Bolivia is not yet an official member of the international control initiative mentioned above. Reviews of CE in South America have anticipated that the disease must be an important issue in Bolivia. First, Peter Schantz in the 1970s [3,4] highlighted the lack of information related to CE in Bolivia. The only available data (at the time) indicated that 75 CE surgeries were performed in a hospital from the Altiplano region in 10 years. Neghme [5] also suggested (in 1987) that CE was present in Bolivia, but it was less common than in other South American countries. By 1995, it was believed that CE was endemic in the mountainous regions of Bolivia [6]. Moro and Schantz [7] published, in 2006, the latest revision of the situation of CE in the Americas without adding new data due to the apparent lack of original publications from Bolivia. The most up-to-date map of the global distribution of *Echinococcus* spp. suggests that the disease has extended to La Paz, Cochabamba, and Potosí [1]. Recently, molecular characterisation of *E. granulosus* s.l. in different hosts in Bolivia identified *Echinococcus granulosus* sensu stricto (s.s.), *Echinococcus ortleppi*, and *Echinococcus intermedius* (G7) [8].

Bolivia has 10.9 million inhabitants from 36 ethnicities and 37 official languages, with 41% of the population identifying as indigenous [9,10]. Bolivia remains the poorest country in South America, with a gross national income of 6,290 USD per capita [11]. A reduction in the number of people living under extreme poverty has been recently observed from 37% in 2007 to 17.3% in 2014 [11]. Several infectious diseases, many conventionally called neglected, are endemic in different parts of Bolivia including tuberculosis [12], malaria [13], Chagas [14], leprosy [15], leishmaniosis [16], soil-transmitted helminths [17,18], fasciolosis [19], rabies [20], and emerging viral pathogens like dengue [21], chikungunya [22], and zika [23]. With such a plethora of important pathogens, it is not surprising that CE, which is a typically chronic disease (frequently asymptomatic), has received little attention in Bolivia. The absence of an official collection of data for human and animal infection has precluded the accurate understanding of CE’s epidemiology in this country. However, several documents showing data of *E. granulosus* s.l. in humans and animals in Bolivia have been published since 1910; these include undergraduate and postgraduate theses, case reports, retrospective studies, books, and government documents. Most of these documents are not available online and remain in local university libraries, institutional archives, or private collections. We aim to deliver a historical overview of such data providing an initial step for further epidemiological investigations of CE in Bolivia.

**Methods**

A literature search was conducted between 2015 and 2020. Scientific databases including PubMed, Web of Science, Scielo, and PAHO were consulted. We used combinations of the following keywords: Bolivia, *Echinococcus granulosus, Echinococcus, cystic echinococcosis, hydatidosis, hidatid disease,* and *Equinococcus*. However, most of the documents used in this review were acquired by physically visiting different university libraries in Bolivia. These included the Faculty of Medicine, Faculty of Pharmaceutical and Biochemical Sciences, and the Faculty of Agronomy at the Universidad Mayor de San Andrés (UMSA), La Paz; the “Centro de Información y Gestión de Conocimiento OPS/OMS-UMSA,” La Paz; the Faculty of Veterinary Medicine at the Universidad Gabriel René Moreno, Santa Cruz; the Universidad Mayor Real y Pontificia San Francisco Xavier de Chuquisaca; and the Municipal Library of La Paz. Articles (and grey literature) in English or mainly in Spanish, which were not available in the sources mentioned, were retrieved from particular libraries (or collections), including one of the most important private collections of medical literature in Bolivia owned by Dr Rolando Costa Arduz.
Cystic echinococcosis in humans

Reporting of CE cases in Bolivia. Table 1 summarises the 38 published CE case reports of Bolivian patients, including 2 individuals who lived shortly in the country and were later diagnosed and treated in the United States and Brazil [24,25]. The distribution of case reports in the different Bolivia Departments for which the patients’ origin was known is shown in Fig 1. The oldest mention of a CE case, which we were able to find in the literature, appeared in a book published in 1956, which summarises the history of Medicine in Bolivia [26]; in this book, the author reports CE occurring in 1913 in the liver and lung of patients from the Department of Sucre. While the first CE case report described in 1928 detailed information of CE affecting the pectoral muscle of an 18-year-old patient from the Sucre Department [27]. Interestingly, this author suggests that the parasite is rare in autopsies and livestock animals in this city. However, 3 other cases from Sucre are mentioned in the discussion of the same report affecting the liver, brain (subsequently published by Fernandez [28]), and the orbital cavity (later published by Solares [29]). The first paediatric case was reported in 1965 by Daza and colleagues [30], describing a 15-cm cyst located in the spleen of an 11-year-old female from La Paz. The youngest case published reported CE in a 3-year-old female patient who lived shortly in La Paz before moving to Sao Paulo (Brazil), where she was diagnosed and treated [25]. Paediatric cases are of particular importance since diagnosis in children is a sign of the parasite’s active recent transmission. Simultaneous CE and tuberculosis (TBC) infection have been reported [31], TBC can also complicate the proper diagnosis of pulmonary CE [32]. This is relevant since TBC is highly endemic in some areas of Bolivia. In 2012, a CE case reached national relevance in the media when a cyst of 15 kilograms was diagnosed in a 25-year-old female from La Paz; a video with a synopsis of the surgical procedure can be found on the internet [33]. In the discussion of some of the case reports summarised in Table 1, there are hints of the relevance and awareness of CE’s existence in Bolivia, showing how the perception of the disease’s presence changed over time. Solares [34], in 1948, suggested that CE was not uncommon in Bolivia. Differently, Boehme [35], in 1953, considered CE as a sporadic disease in Bolivia. Daza, in 1965, mentioned that CE cases became commonly diagnosed in recent years [30]. In 2005, Aguirre [36] noted that according to a study of the Bolivian National Statistical Institute, there were 500 new CE cases, with a mortality rate between 12% and 15%. Unfortunately, we could not have access to such a document. Vera and colleagues [37], in 2006, mentioned that CE has gone from a rare finding to become endemic due to the significant increase in lung cases in La Paz. Burgos-Burgoa also recognised that CE in the lungs had become also frequently diagnosed in Cochabamba in recent years [38].

Retrospective studies. To date, there are 8 published retrospective studies regarding CE in Bolivia [54–61], which, in total, account for 518 CE human cases (Table 2). Fig 1 shows the distribution of cases from retrospective studies in Bolivia’s different Departments for which the patients’ origin was known. The first retrospective study of CE is a thesis from the Universidad Mayor Real y Pontificia de San Francisco Xavier in Chuquisaca. CE was identified in the report of 29 out of 2,980 autopsies performed between 1940 and 1954 in the Department of Chuquisaca [60]. Moreno [56] reported 64 CE cases out of 948 thorax surgeries performed between 1968 and 1977 in 1 hospital from La Paz. Interestingly, Moreno and colleagues [56] described that a high proportion of the 64 CE cases lived in mining or urban areas and also highlighted the high number of dogs present in Bolivia at the time [56]. Different authors of retrospective studies suggested that the disease became a significant public health issue and was likely to be underdiagnosed [56,59,60]. An increase in number was also observed in paediatric surgical cases in infants from rural areas living in the peri-urban areas of La Paz and El Alto [58]. More recently, Rodriguez-Andrade and colleagues [61] reported 17 paediatric cases (under 15 years old) between 2015 and 2017 from the intensive care unit of the Children
Table 1. Chronological overview of case reports of human CE patients from Bolivia between 1913 and 2020.

| Year | Department   | Gender | Age (years) | Localisation          | Basis for defining a CE case | Laboratory confirmation | Comments                                      | Reference |
|------|--------------|--------|-------------|-----------------------|-----------------------------|------------------------|-----------------------------------------------|-----------|
| 1913 | Chuquisaca   | ND     | ND          | Lungs/Liver           | ND                          | ND                     | -                                             | [26]      |
| 1928 | Chuquisaca   | Male   | 18          | Muscle                | Surgery                     | Microscopy             | Clear fluid at the puncture                   | [27]      |
|      |              | ND     | ND          | Liver                 | Surgery                     | ND                     | -                                             |           |
|      |              | ND     | ND          | Orbital cavity        | Surgery                     | ND                     | -                                             |           |
| 1929 | Chuquisaca   | Male   | 58          | Brain                 | Autopsy                     | Microscopy             | Postmortem                                    | [28]      |
| 1932 | Potosí       | Female | 47          | Orbit                 | Surgery                     | Microscopy             | Surgically intervened                         | [29]      |
| 1948 | Unknown      | Unknown| Unknown     | Orbit                 | Surgery                     | ND                     | Two different cases                           | [34]      |
| 1953 | La Paz       | Male   | 33          | Bile ducts            | Surgery                     | Microscopy             | Polish patient lived in Argentina            | [35]      |
|      |              | ND     | ND          | Lungs                 | Surgery                     | ND                     | -                                             |           |
|      |              | ND     | Spinal cord  | Surgery               | ND                          | -                      | -                                             |           |
| 1965 | La Paz       | Female | 11          | Spleen                | X-ray, surgery              | Microscopy and histopathology | First paediatric case                        | [30]      |
| 1969 | Oruro        | Male   | 56          | Mediastinum           | X-ray, surgery              | Microscopy and histopathology | Initially diagnosed as lung cancer           | [39]      |
| 1969 | Santa Cruz   | ND     | ND          | Lungs                 | X-ray                       | ND                     | ND                                            |           |
|      |              | ND     | Lungs       | X-ray                 | ND                          | ND                     | -                                             |           |
| 1971 | Oruro        | Female | 20          | Lungs                 | X-ray, surgery              | ND                     | Simultaneous TBC                              | [31]      |
| 1973 | Santa Cruz   | Male   | 5           | Lungs                 | X-ray                       | ND                     | 25 cm diameter                                | [41]      |
| 1987 | US citizen   | Female | 16          | Lungs                 | X-ray, ultrasound, CT scan, | Microscopy and histopathology | Surgically intervened in the USA             | [24]      |
|      | who lived    |        |             | surgery               | Microscopy and histopathology |                       |                                               |           |
|      | shortly in   |        |             |                       |                             |                        |                                               |           |
|      | La Paz       |        |             |                       |                             |                        |                                               |           |
| 1995 | Potosí       | Female | NA          | Spine                 | Surgery                     | Histopathology         | Surgically intervened                         | [42]      |
| 2004 | La Paz       | Male   | 17          | Lungs                 | X-ray, ELISA (-), surgery   | ND                     | Four cysts surgically intervened             | [32]      |
| 2004 | Chuquisaca   | Female | 18          | Lungs                 | X-ray, CT scan, ELISA (-), | ND                     | -                                             |           |
|      |              |        |             |                       | surgery                   |                        |                                               |           |
| 2005 | La Paz       | Male   | 54          | Liver and peritoneum  | Surgery                     | Microscopy and histopathology | Lives with 4 dogs                            | [44]      |
| 2005 | La Paz       | Male   | 13          | Lungs                 | X-ray, vomica              | ND                     | Treated with albendazole                      | [45]      |
| 2005 | La Paz       | Female | 19          | Abdomen               | Ultrasound, surgery         | Microscopy and histopathology | Cyst measuring 80 cm in a pregnant woman (24 weeks) | [36]      |
| 2005 | La Paz       | Female | 37          | Spleen                | Ultrasound, surgery         | Histopathology         | Patient operated years before for pulmonary cysts | [46]      |
| 2006 | La Paz       | Male   | 19          | Lungs                 | X-ray, surgery              | ND                     | Cyst measuring 15 × 25 cm                     | [37]      |
| 2006 | La Paz       | Male   | 34          | X-ray, surgery        | ND                          | Cyst measuring 10 cm   |                                               |           |
| 2006 | La Paz       | Male   | 23          | X-ray, surgery        | ND                          | Cyst measuring 20 cm   |                                               |           |
| 2009 | La Paz       | Male   | 29          | Liver                 | Ultrasound, serology, surgery | Histopathology     | Cyst measuring 16 cm. Surgically treated      | [47]      |
| 2009 | La Paz       | Male   | 29          | Liver                 | Ultrasound, serology, surgery | Histopathology     | Cyst measuring 16 cm. Surgically treated      | [48]      |
| 2012 | La Paz       | Female | 25          | Abdomen               | Ultrasound, surgery         | Microscopy and histopathology | A primary giant cyst (15 kilograms) from a pregnant woman. Pregnancy ended successfully | [33]      |
| 2013 | Cochabamba   | ND     | 82          | Lungs                 | Ultrasound, CT scan, surgery | Microscopy and histopathology | Two cysts of 11 and 13 cm                     | [49]      |
| 2014 | Potosí       | Female | 33          | Lungs                 | X-ray, ELISA, surgery       | Histopathology         | A pregnant patient who has contact with dogs  | [38]      |
| 2014 | La Paz       | Female | 23          | Retropertioneum       | CT scan, surgery           | Histopathology         | -                                             | [50]      |
| 2015 | Potosí (treated in Cochabamba) | Male | 34          | Lungs                 | X-ray, ultrasound, western blot | No                    | Multiple lung cysts and one in the liver treated albendazole | [51]      |

(Continued)
| Year       | Department   | Gender | Age (years) | Localisation | Basis for defining a CE case | Laboratory confirmation | Comments                                                                 | Reference |
|------------|--------------|--------|-------------|--------------|-----------------------------|-------------------------|---------------------------------------------------------------------------|-----------|
| 2016       | La Paz       | Female | 33          | Lungs        | X-ray, ELISA, agglutination test | No                      | Has contact with dogs and sheep                                           | [52]      |
| 2018       | La Paz       | Female | 72          | Liver        | Endoscopy                   | No                      | Acute cholangitis                                                         | [53]      |
| 2020       | La Paz (treated in Brazil) | Female | 3           | Liver        | Surgical, X-ray, CT scan    | PCR                     | Born in a rural area near city of La Paz but lives in Brazil, 3 cysts of 9.3–10 cm | [25]      |

CE, cystic echinococcosis; ND, no data; TBC, tuberculosis.

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Fig 1. Distribution of human CE cases in Bolivia reviewed in this study from case reports and retrospective studies; maximum and minimum prevalence recorded in livestock at official postmortem examination at abattoir; and in dogs established at necropsy, acercoline purgation, after treatment with praziquantel, copro-ELISA, and PCR/sequencing. In total, there are 38 human case reports (for 2 cases, the origin is unknown) and 517 cases from retrospective studies; only 284 cases were included in the figure due to the lack of information about the origin of the patients. Original base layer of the map can be found here: https://commons.wikimedia.org/wiki/File:Bolivia_departments_blank.png. CR, case report; PM, postmortem; PZQ, praziquantel; RS, retrospective study.

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Hospital in La Paz. Only a single publication of the retrospective studies (Table 2) suggested that CE is not an essential public health issue after reporting only 9 hepatic cases between January 1996 and May 2008 from all abdominal surgeries performed at a hospital in La Paz [54]. The majority of the cases visited in these retrospectives studies originated in La Paz, followed by Potosí [57,59]. In the case of the retrospective study by Guzman [55], many patients diagnosed in Tupiza (Potosí) had relatives who previously received surgical treatment for CE. The latter agrees with the high prevalence of humans in Tupiza (4.1%) in 2011 [62]. The other 4 publications mentioned several CE cases without supplying detailed information (not included in Table 2). First, Perez Fontana [63] indicated that Bolivia’s representative in a meeting of PAHO reported 64 CE cases; some of these cases were diagnosed in Santa Cruz. Maldonado [31] mentioned in the discussion of a case report that 83 CE cases without concomitant TBC were surgically treated at the Thorax National Institute without supplying a time frame in which these cases were reported. Finally, in 2 reports for PAHO [3,4], Schantz mentioned that 75 surgeries were due to CE out of 1,500 thorax surgeries in 10 years in La Paz.

### Ultrasound diagnosis, treatment, and patient follow-up

The most accurate and recent data related to human CE cases in Bolivia are found in a government report that showed the

### Table 2. Chronological summary of retrospective studies of human CE reported in Bolivia by department.

| Period studied | Department (Hospital/University) | # of cases | Basis for defining a CE case | Comments | Reference |
|----------------|---------------------------------|------------|-----------------------------|----------|-----------|
| 1940–1954      | Chuquisaca, (Instituto de Patología, Facultad de Medicina) | 29         | Autopsy and histopathology  | 2,980 autopsies. Origin of the patients: 24 from Chuquisaca (82.8%), 3 from Potosí (10.3%), 1 from Santa Cruz (3.4%), and 1 from Oruro (3.4%) | [60] |
| 1968–1977      | La Paz (Servicio de cirugía de la Caja y Hospital COMIBOL) | 64         | Histopathology after surgery | These 64/75 were confirmed CE cases. All cysts located in the lungs. One patient presented vomica. | [56] |
| 1991–1996      | La Paz, Three hospitals: Instituto Nacional del Tórax, Luis Uria de la Oliva and Instituto de Gastroenterología Boliviano Japones plus Instituto Nacional de Laboratorios de Salud | 148        | X-ray for 86 thoracic cysts Ultrasound for 6 hepatic cases Histopathology after surgery for 92 cases DD5 for 56 patients | Origin of the patients: 112 from La Paz (75.7%), 17 from Potosí (11.5%), 7 from Tarija (4.7%), 5 from Oruro (3.4%), 4 from Chuquisaca (2.7%), and 3 from Cochabamba (2%) | [57] |
| 1995–2001      | La Paz (Hospital Obrero N° 1, and Luis Uria de la Oliva) | 113        | X-ray and tomography not in all cases. Histopathology after surgery | 71% with unique cysts in lungs and 36.1% with cysts in the liver. Several patients were from Tupiza (Potosí) | [55] |
| 1984–1999      | La Paz, (Hospital del Niño) | 31         | X-ray, DD5 for 11 cases. Histopathology after surgery | Paediatric cases: 25 patients presented cyst in lungs, 10 in the liver, and 9 in other organs. The majority of cases were patients from La Paz and El Alto. In 5 patients, the rupture of a cyst was the cause of hospitalisation, one of which died due to anaphylaxis. | [58] |
| 1998–2004      | La Paz, (Instituto Nacional del Tórax) | 106        | Histopathology after surgery | Cysts located in the lungs and liver. Origin of cases: 96 (90%) from La Paz, 8 (7%) from Potosí, and 2 (3%) from Oruro. | [59] |
| 1996–2008      | La Paz (Hospital La Paz) | 9          | Ultrasound, CT scan. Histopathology after surgery | All hepatic cases. No data regarding the origin of patients. | [54]** |
| 2015–2017      | La Paz (Hospital del Niño) | 17         | ND | All paediatric cases | [61] |

Total cases 517

*DD5, double diffusion arc 5.

**There is a lack of coherence between the period of study and the date of publication.

CE, cystic echinococcosis; ND, no data.

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results of an ultrasound mass screening performed in Tupiza (Potosí Department). In total, 52 out of 1,268 individuals (4.1%) showed CE’s ultrasound signs with active cysts in all patients. Additional thoracic X-ray showed CE in the lungs of 5 of the same patients with abdominal CE [62]. Patients were treated with albendazole 10 to 15 mg/kg/day for 4 months, and 92% completed the treatment. The follow-up showed that 60% of cysts were classified as transitional at the end of the first month after treatment. By the end of the therapy, 90% of the cysts were classified as inactive [64].

**Immunological testing of the Bolivian population.** We found only a few comments related to immunodiagnostic tests in humans in the literature. Schantz [3,4] briefly mentioned high reactivity in an intradermic test (with an antigen from *E. granulosus*) in employees of an abattoir in the Bolivian Altiplano. Commercial [65] and in-house ELISA [66] tests have been used to assess sensitivity and specificity using sera from confirmed CE cases from La Paz and Cochabamba and patients with other parasitic diseases. However, there was no attempt to perform a prevalence study in the general population. As part of the ultrasound study in Tupiza (mentioned above), ELISA and immunochromatography tests (Vircell) were used to detect antibodies against *E. granulosus* in the sera of 52 patients diagnosed with abdominal CE. In total, 96.7% of the ultrasound cases were positive in both ELISA and immunochromatography. Finally, a study carried out at the Parasitology, Tropical Medicine, and Environment Unit of the Instituto de Investigación en Salud y Desarrollo (IINSAD-UMSA) determined a CE prevalence of 6.3% (44/696) in population from the northern highland at the Department of La Paz using 2 commercial ELISA kits (Nova Tec Inmunodiagnostica and RIDASCREEN) [67].

**E. granulosus infection in dogs**

Data regarding prevalence in dogs in Bolivia are scarce; all reports of dog infection are summarised in Table 3. Fig 1 shows the Departments of Bolivia for which studies detecting *E. granulosus* in faeces have been performed. The oldest report of *E. granulosus* infection in dogs dates from 1973 Schantz [7], where 50% of dogs from La Paz were found infected after arecoline purgation. Methodologies to correctly identify *E. granulosus* have been used only in 5 publications: Barba [68] did not find positives in the necropsy of 100 dogs from Santa Cruz; Perez [69] did not find infections in 60 dogs purged with arecoline; Villena [70] found adult specimens of *E. granulosus* in the faeces of 14 out of 85 dogs (16.5%) treated with praziquantel in Tupiza; Subieta [71] determined a prevalence of 12.3% (45/367) in dogs from Tupiza by necropsy; and finally, Ali and colleagues [8] described 4.5% (6/131) of the dogs, from the Altiplano of La Paz, to be infected with *E. granulosus* s.s. or *E. ortleppi* based on PCR and sequencing. Other reports showed results based on coproantigen detection in faeces [62,72], a method known to produce cross-reactions with *Taenia* species, or microscopic detection of taeniid eggs [73–75], a technique that does not allow differentiation between *Echinococcus* and *Taenia* spp. From the reports using a coproantigen ELISA, Villena determined 24% (63/264) of dog faecal samples as positive with ratios varying between 15% and 62% in different localities of Tupiza (at the border with Argentina) [62]. Subsequently, also using coproantigen ELISA, Casas and colleagues [72] described 3.4% of dogs positive in urban samples from Villazon. In comparison, 30% were positives in the samples taken from a rural area (Lampaya) near the border with Argentina. On the other hand, using microscopic detection of taeniid eggs, Salinas [73] reported 1% (1/100) of dog samples as positive in La Paz. In comparison, Traverso [74] reported 13% of 100 dog faeces positive to taeniid eggs in dogs from Guaqui in La Paz (near the Titicaca lake) and 20.4% (29/142) in dogs from Chucuito at the Titicaca lake in Peru. Gonzales [75] reported 9.1% (31/340) of canine faecal sample infected with taeniid eggs in Tupiza.
Table 3. Summary of reports of canine echinococcosis and taeniid infection in Bolivia by departments, municipalities, and towns.

| Department/Municipality | Town                        | # dogs studied | # positives (%) | Diagnostic method          | Comment                                                                 | Reference |
|-------------------------|-----------------------------|----------------|-----------------|----------------------------|--------------------------------------------------------------------------|-----------|
| La Paz/ND               | ND                          | 100            | 1 (1)           | Sedimentation/microscopy*   | 1998 (positive case Munaypata)                                            | [73]      |
| La Paz/Guaqui           | Guaqui                      | 100            | 13 (13)         | Sedimentation/microscopy*   | Feaces from owned dogs                                                   | [74]      |
| La Paz/Batallas         | Batallas                    | 39             | 2 (5.1)         | Sedimentation/PCR/sequencing| Environmental faecal samples (E. granulosus s.s. was identified in each of the towns, E. ortleppi in Batallas and Tiahuanacu) | [8]       |
| La Paz/Pucarani         | Pucarani                    | 22             | 1 (4.6)         |                            |                                                                          |           |
| La Paz/Pucarani         | Lacaya                      | 22             | 1 (4.6)         |                            |                                                                          |           |
| La Paz/Tiahuanacu       | Tiahuanacu                  | 48             | 2 (4.2)         |                            |                                                                          |           |
| Total                   | 131                         |                | 6 (4.5)         |                            |                                                                          |           |
| Potosí/Tupiza           | Tupiza City                 | 340            | 31 (9.1)        | Sedimentation/microscopy*   | 1998–1999                                                               | [75]      |
| Potosí/Tupiza           | Salo                        | 8              | 5 (62.5)        | Copro-ELISA                |                                                                          | [62]      |
|                         | Peña Amarilla               | 19             | 10 (52.6)       |                            |                                                                          |           |
|                         | Talina                      | 5              | 2 (40)          |                            |                                                                          |           |
|                         | Palala                      | 14             | 5 (35.7)        |                            |                                                                          |           |
|                         | Rio Blanco                  | 17             | 6 (35.3)        |                            |                                                                          |           |
|                         | Santa Rosa                  | 15             | 4 (26.7)        |                            |                                                                          |           |
|                         | Tambo/Mochara               | 12             | 3 (25)          |                            |                                                                          |           |
|                         | Yurcuma                     | 18             | 4 (22.2)        |                            |                                                                          |           |
|                         | Tapaxa                      | 20             | 4 (20)          |                            |                                                                          |           |
|                         | Charaja                     | 15             | 3 (20)          |                            |                                                                          |           |
|                         | Iriccina                    | 6              | 1 (16.7)        |                            |                                                                          |           |
|                         | Tocloca                     | 13             | 2 (15.4)        |                            |                                                                          |           |
|                         | Villa Pacheco               | 20             | 3 (15)          |                            |                                                                          |           |
|                         | Aguaadita                   | 22             | 1 (4.5)         |                            |                                                                          |           |
|                         | San Gerardo                 | 30             | 0               |                            |                                                                          |           |
|                         | San Antonio                 | 10             | 0               |                            |                                                                          |           |
| Total                   | 244                         |                | 53 (21.7)       |                            |                                                                          |           |
| Potosí/Cotagaita        | Ramadas                     | 10             | 5 (50)          | Copro-ELISA                | 2010–2011                                                               | [62]      |
| Potosí/Villazón         | Chipihuyaco                 | 10             | 5 (50)          |                            |                                                                          |           |
| Potosí/Villazón         | ND                          | 59             | 2 (3.4)         | Copro-ELISA and copro-western blot | Dog population in Villazón 13,637                                       | [72]      |
| Potosí/Lampaya          | ND                          | 10             | 3 (30)          |                            |                                                                          |           |
| Potosí/Tupiza           | Yurcuma                     | 10             | 0               | Direct observation of adult worms in faeces | Samples collected after praziquantel treatment                           | [70]      |
|                         | Villa Pacheco               | 9              | 2 (22.2)        |                            |                                                                          |           |
|                         | Tocloca                     | 10             | 0               |                            |                                                                          |           |
|                         | Tapaxana                    | 9              | 3 (33.3)        |                            |                                                                          |           |
|                         | Talina                      | 5              | 1 (20)          |                            |                                                                          |           |
|                         | Santa Rosa                  | 10             | 1 (10)          |                            |                                                                          |           |
|                         | San Miguel                  | 10             | 2 (20)          |                            |                                                                          |           |
|                         | Salo                        | 7              | 5 (71.4)        |                            |                                                                          |           |
|                         | Iriccina                    | 5              | 0               |                            |                                                                          |           |
|                         | Charaja                     | 10             | 0               |                            |                                                                          |           |
| Total                   | 85                          |                | 14 (16.5)       |                            |                                                                          |           |
| Potosí/Tupiza           | San Antonio                 | 131            | 15 (11.5)       | Necropsy and detection of adult parasites                               |                                                                          | [71]      |
|                         | San Gerardo                 | 47             | 10 (21.3)       |                            |                                                                          |           |
|                         | Sud                         | 76             | 8 (10.5)        |                            |                                                                          |           |
|                         | Central                     | 79             | 5 (6.3)         |                            |                                                                          |           |
|                         | Villa Fátima                | 34             | 7 (20.6)        |                            |                                                                          |           |
| Total                   | 367                         |                | 45 (12.3)       |                            |                                                                          |           |
| Santa Cruz/Santa Cruz de la Sierra | Santa Cruz de la Sierra | 100 | 0 | Necropsy                              |                                                              | [68]      |
| Santa Cruz/Samaipata    | Samaipata                   | 60             | 0               | Arecoline purgation                                                   |                                                                          | [69]      |

ND, no data.

*Taeniid eggs detected at microscopic examination were mistakenly considered to be from E. granulosus.

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Cystic echinococcosis in livestock

No official documents from the government or scientific papers reporting CE in animals from Bolivia at a national level have been published. Table 4 summarises all the reports of CE in animals reviewed by us. Fig 1 shows the distribution of all the studies and their prevalences for different livestock species performed in Bolivia. The first mention of CE in animals from Bolivia is dated in 1910, in a book about the parasites found in the Bolivian Altiplano. Surprisingly, the disease was described in a horse and a donkey [76]. For this review, most data regarding CE in animals were acquired from theses, including 9 from the Faculty of Veterinary Medicine at the University Gabriel René Moreno in Santa Cruz de la Sierra; 1 thesis from the Universidad de El Alto, 1 from the Faculty of Agronomy at UMSA, and 1 from the Faculty of Veterinary Medicine at the University Tomas Frias (Table 4). A study in 1969 reported 31 animals with cysts in 1,403 (2.2%) cattle originating from various locations in Santa Cruz [40]. Interestingly, the area bordering Brazil showed the highest prevalence (3%) with all cysts being infertile [40,77]. Three years later, Camacho [78] reported a prevalence of 0.2% in 3,330 cattle with the highest prevalence in Terebinto at 6.3%. Then, Cadena [41] investigated the presence of CE in pigs in illegal abattoirs in Santa Cruz and La Paz and also at the official slaughterhouse in La Paz. From 820 animals, CE was found only in 1 animal in Santa Cruz (0.1%), while in La Paz, CE was found in 21 out of 1,450 animals (1.4%). Another investigation, carried out in 1985, in the official abattoir in Santa Cruz de la Sierra found 2.2% of infection after inspecting 504 cattle from Santa Cruz and Beni [79]. In 1988, Gonzalez [80] studied the prevalence in cattle including 59,272 animals (58,483 from Bolivia and 789 from Brazil). Cysts were found in 336 out of 47,818 animals examined from Santa Cruz (0.7%), in 6 out of 779 from Tarija (0.8%), and in 47 out of 9,874 from Beni (0.5%), no infection was found in 12 animals from Chuquisaca and in animals from Brazil. Interestingly, all cysts reported were infertile. Also, in Santa Cruz, Aponte [81] found 1.3% of the cattle slaughtered to be infected with *E. granulosus*.

The only study performed in Sucre included 699 cattle from 3 departments from which only 5 animals (0.7%) were infected with *E. granulosus*, including 1/37 from Santa Cruz (2.7%), 1/38 from Cochabamba (2.6%), and 3/607 from Chuquisaca (0.5%). At the same time, no infection was recorded in 17 animals from Potosí [83]. The only work investigating CE prevalence in sheep in the whole country described 38 out of 2,047 sheep (1.9%) positives from Batallas near the cities of La Paz and El Alto. According to the study, 45% of the sheep’s cysts were unfertile [88]. Prevalences in cattle between 0% and 9.7% have been reported in Potosí [83,85]. Unfortunately, there is no published work referring to CE in goats in Bolivia. However, infected goats are found in the valleys in the south of the country.

Finally, the most recent description of CE in cattle from different Bolivia Departments was published as a thesis in 2001 by Reinoso [82], reporting a prevalence of 6.2% from 3,119 cattle. The highest prevalence was identified in animals slaughtered in official abattoirs in La Paz (8.3%). Some areas within the La Paz Department showed prevalences as high as 16% in Pallcoc, 13.8% in Vilaque, and 7.8% in Batallas. Data from these theses show that the highest prevalences are at the northern Altiplano of the Department of La Paz, where the disease has been described in cattle, sheep, and pigs [41,82,88]. Unfortunately, only one of the theses included CE reports in sheep, which is the most important intermediate host for *E. granulosus s.s.* Finally, in the most recent survey of the prevalence of *E. granulosus* in animals in 2019, Calle [89] described 20.9% of infection in llamas in Oruro (263 out of 1,256 animals). This high level of infection suggests that llamas could play an essential role in transmitting *E. granulosus* in some areas of Bolivia. It remains unknown if *E. granulosus s.s.* or another species of *E. granulosus s.l.* complex is responsible for the infection in llamas in Oruro.
Table 4. Summary of reports of infection with *E. granulosus* in livestock species at postmortem examination at abattoir in the different departments and provinces of Bolivia.

| Department         | Province/Town                  | # of animals studied | # of positives (%) | Species | Fertility of cysts | Period       | Reference |
|--------------------|--------------------------------|----------------------|---------------------|---------|--------------------|--------------|-----------|
| Beni               | Moxos                          | 97                   | 1 (1)               | Cattle  | No                 | 1969         | [40]      |
| Beni               | ND                             | 9,874                | 47 (0.5)            | Cattle  | No                 | 1988 (7 months) | [80]      |
| Beni and Santa Cruz| ND                             | 895                  | 13 (1.4)            | Cattle  | No                 | 2001 (2 months) | [82]      |
| Santa Cruz         | ND                             | 504                  | 11 (2.2)            | Cattle  | No                 | 1985 (6 months) | [79]      |
| Santa Cruz         | Chiquitos/San José Chiquitos   | 334                  | 7 (2.1)             | Cattle  | ND                 | 1969         | [40]      |
|                    | Ñuño de Chavez/Tesoro          | 140                  | 2 (1.4)             |         |                    |              |           |
|                    | Angel Sandoval/San Matias     | 114                  | 2 (1.7)             |         |                    |              |           |
|                    | Velasco/NA                    | 106                  | 1 (0.9)             |         |                    |              |           |
|                    | Ñuño/Warnes                    | 74                   | 1 (1.3)             |         |                    |              |           |
|                    | Santiesteban/La Esperanza     | 45                   |                     |         |                    |              |           |
|                    | Border with Brazil             | 590                  | 18 (3.0)            |         |                    |              |           |
|                    | **Total**                      | **1,403**            | **31 (2.2)**        |         |                    |              |           |
| Santa Cruz         | German Busch/Puerto Suarez    | 418                  | 2 (0.5)             | Cattle  | No                 | 1969 (3 months) | [78]      |
|                    | Chiquitos/San José Chiquitos  | 549                  | 1 (0.2)             |         |                    |              |           |
|                    | Ñuño de Chávez/San Javier     | 191                  | 1 (0.5)             |         |                    |              |           |
|                    | Angel Sandoval/San Matias     | 131                  | 1 (0.7)             |         |                    |              |           |
|                    | Andres Ibáñez/Terebinto       | 16                   | 1 (6.3)             |         |                    |              |           |
|                    | Several other sites           | 2,025                |                     |         |                    |              |           |
|                    | **Total**                      | **3,330**            | **6 (0.2)**         |         |                    |              |           |
| Santa Cruz         | Cordillera/ND                 | 7,710                | 105 (1.4)           | Cattle  | No                 | 1988 (7 months) | [80]      |
|                    | Velasco/ND                    | 2,098                | 18 (0.9)            |         |                    |              |           |
|                    | Ñuño de Chavez/ND             | 10,719               | 49 (0.5)            |         |                    |              |           |
|                    | Angel Sandoval/ND             | 4,021                | 33 (0.8)            |         |                    |              |           |
|                    | Chiquitos/ND                  | 11,161               | 91 (0.8)            |         |                    |              |           |
|                    | Sara/ND                       | 564                  | 3 (0.5)             |         |                    |              |           |
|                    | German Busch/ND               | 687                  | 3 (0.4)             |         |                    |              |           |
|                    | Ñuño/ND                       | 1,384                | 5 (0.4)             |         |                    |              |           |
|                    | Andres Ibáñez/ND              | 8,730                | 29 (0.3)            |         |                    |              |           |
|                    | Santiesteban/ND               | 497                  |                     |         |                    |              |           |
|                    | Ichilo/ND                     | 204                  |                     |         |                    |              |           |
|                    | Florida/ND                    | 43                   |                     |         |                    |              |           |
|                    | **Total**                     | **47,818**           | **336 (0.7)**       |         |                    |              |           |
| Santa Cruz         | ND                             | 37                   | 1 (2.7)             | Cattle  | No                 | 1994 (3 months) | [83]      |
| Santa Cruz         | ND                             | 10                   | 0                   | Cattle  | No                 | 2001 (2 months) | [82]      |
| Santa Cruz         | Chiquitos/Abaroa              | 95                   | 2 (2.1)             | Cattle  | No                 | 1990 (4 months) | [81]      |
|                    | Chiquitos/Coralito            | 125                  | 1 (0.8)             |         |                    |              |           |
|                    | Chiquitos/Ipias               | 33                   | 4 (1.7)             |         |                    |              |           |
|                    | Chiquitos/Suárez Arana        | 60                   | 1 (1.7)             |         |                    |              |           |
|                    | Chiquitos/El Carmen           | 78                   | 2 (2.6)             |         |                    |              |           |
|                    | Chiquitos/Naranjo             | 36                   | 2 (5.6)             |         |                    |              |           |
|                    | Chiquitos/Aguas Calientes    | 70                   | 0                   |         |                    |              |           |
|                    | Chiquitos/Palmar de las Islas| 120                  | 0                   |         |                    |              |           |
|                    | Chiquitos/San Lorenzo         | 90                   | 0                   |         |                    |              |           |
|                    | Chiquitos/San Pedro           | 40                   | 0                   |         |                    |              |           |
|                    | Chiquitos/Sucuara            | 110                  | 0                   |         |                    |              |           |
|                    | Chiquitos/Trebol              | 98                   | 0                   |         |                    |              |           |
|                    | **Total**                     | **955**              | **12 (1.3)**        |         |                    |              |           |
| Santa Cruz         | ND                             | 78                   | 1 (1.3)             | Cattle  | ND                 | 2001 (3 months) | [84]      |
| Santa Cruz         | Florida/Samaipata             | 97                   | 1 (1)               | Pig     | Yes                | NA           | [41]      |
|                    | Several other sites           | 723                  |                     |         |                    |              |           |
|                    | **Total**                     | **820**              | **1 (0.1)**         |         |                    |              |           |

(Continued)
Table 4. (Continued)

| Department | Province/Town | # of animals studied | # of positives (%) | Species | Fertility of cysts | Period | Reference |
|------------|---------------|----------------------|--------------------|---------|--------------------|--------|-----------|
| Cochabamba | ND            | 60                   | 0                  | Cattle  | No                 | 2001 (2 months) | [82]      |
| Cochabamba | ND            | 38                   | 1 (2.6)            | Cattle  | No                 | 1994 (3 months) | [83]      |
| Chuquisaca | ND            | 607                  | 3 (0.5)            | Cattle  | No                 | 1994 (3 months) | [83]      |
| Chuquisaca | Luis Calvo/ND | 12                   | 0                  | Cattle  | ND                 | 1988 (7 months) | [80]      |
| Tarija     | Gran Chaco/ND | 779                  | 6 (0.8)            | Cattle  | No                 | 1988 (7 months) | [80]      |
| Tarija     | Arcé/ND       | 113                  | 3 (2.7)            | Cattle  | ND                 | 1996 (3 months) | [85]      |
| Tarija     | ND            | 16                   | 6 (37.5)           | Cattle  | ND                 | 2001 (3 months) | [84]      |
| La Paz     | Aroma/Vilaque | ND                   | 11                 | Cattle  | ND                 | 1992     | [86]      |
|            | Bautista Saavedra/Curva | ND | 1 | | | | |
|            | Ingavi/Desaguadero | ND | 27 | | | | |
|            | Ingavi/Lacaya | ND | 11 | | | | |
|            | Ingavi/Pocota | ND | 14 | | | | |
|            | Ingavi/Taraco | ND | 1 | | | | |
|            | Los Andes/Batllass | ND | 92 | | | | |
|            | Los Andes/Palco | ND | 27 | | | | |
|            | Omasuyos/Achacachi | ND | 82 | | | | |
|            | Omasuyos/Huatajala | ND | 2 | | | | |
| **Total**  |               |                      | **268**            |         |                    |         |           |
| La Paz     | Aroma/Lahuachaca | 20 | 0 | Cattle  | No                 | 2001 (2 months) | [82]      |
|            | Aroma/Palco | 430                  | 69 (16)            | Cattle  | No                 | 2010 (3 months) | [87]      |
|            | Aroma/Patamacaya | 182 | 12 (6.6) | | | | |
|            | Camacho/Puerto Acosta | 30 | 0 | | | | |
|            | Ingavi/Desaguadero | 41 | 3 (7.3) | | | | |
|            | Ingavi/Guaqui | 20                   | 0                  | | | | |
|            | Ingavi/Pocota | 274                  | 11 (4.0)           | | | | |
|            | Ingavi/Tiahuanacu | 25 | 0 | | | | |
|            | Larecaja/Vilaque | 189 | 26 (13.8) | | | | |
|            | Los Andes/Lacaya | 250 | 15 (6.0) | | | | |
|            | Los Andes/Batllass | 437 | 34 (7.8) | | | | |
|            | Omasuyos/Achacachi | 256 | 10 (3.9) | | | | |
| **Total**  |               |                      | **2,154**          |         |                    | **180 (8.3)** |           |
| La Paz     | Altiplano | 14,493               | 360 (2.5)          | Cattle  | ND                 | 2010 (3 months) | [87]      |
| La Paz     | Los Andes/Batllass | 245 | 5 (2.0) | Pig | Yes | NA | [41] |
|            | Camacho/Anconaimes | 125 | 3 (2.4) | | | | |
|            | Ingavi/Ticuy | 250                  | 4 (1.5)            | | | | |
|            | Murillo/daughterhouse | 470 | 6 (1.2) | | | | |
|            | Omasuyos/Huatajala | 360 | 3 (0.8) | | | | |
| **Total**  |               |                      | **1,450**          |         |                    | **21 (1.4)** |           |
| La Paz     | Los Andes/Batllass | 2,047 | 38 (1.9) | Sheep | 45% | 1998–1999 (3 months) | [88]      |
| Oruro      | Sajama/Colletana | 481 | 77 (16.0) | | | | |
|            | Sajama/Illinaca | 138                  | 29 (21.0)          | Llama   | ND                 | 2019 (2 months) | [89]      |
|            | Sajama/Illinaca | 138                  | 29 (21.0)          | Llama   | ND                 | 2019 (2 months) | [89]      |
|            | Sajama/Illinaca | 138                  | 29 (21.0)          | Llama   | ND                 | 2019 (2 months) | [89]      |
|            | Sajama/Illinaca | 138                  | 29 (21.0)          | Llama   | ND                 | 2019 (2 months) | [89]      |
|            | Sajama/Illinaca | 138                  | 29 (21.0)          | Llama   | ND                 | 2019 (2 months) | [89]      |
|            | Sajama/Illinaca | 138                  | 29 (21.0)          | Llama   | ND                 | 2019 (2 months) | [89]      |
| **Total**  |               |                      | **1,256**          |         |                    | **263 (20.9)** |           |
| Potosi     | ND            | 17                   | 0                  | Cattle  | ND                 | 1994 (3 months) | [83]      |

(Continued)
Genetic characterisation of *E. granulosus s.l.* in Bolivia

*E. granulosus s.s.* was described for the first time in Bolivia in a publication by Kamenetzky and colleagues [90] from a human sample. No information was given by the authors about the exact origin of the sample. The second characterisation of a human CE sample was recently published in a case report of a 3-year-old girl from a rural area near La Paz and El Alto (discussed in the case reports section) [25]. Finally, Ali and colleagues [8] reported the presence of *E. granulosus s.s.* in 30 cysts (from La Paz, Cochabamba, and Beni) from sheep, cattle, and humans, *E. ortleppi* (G5) in 5 fertile cysts from cattle (from La Paz and Cochabamba) and *E. intermedius* (G7) in 3 fertile cysts from pigs (from Santa Cruz). Additionally, *E. granulosus s.s.* and *E. ortleppi* were found in dog faecal samples collected in the La Paz Department.

Control of *E. granulosus* in Bolivia

An attempt to establish a national control programme for CE in Bolivia was proposed and mentioned in the First National Seminar for Control and Surveillance of Zoonoses in 1989 [91]. The plan was intended to last for 4 years; however, it was not implemented. A pilot study for diagnostic in humans and dogs was developed in Tupiza in collaboration with the "Southern cone sub regional initiative for control and surveillance of cystic echinococcosis" between 2009 and 2010. The results are shown in the "Ultrasound diagnosis, treatment, and patient follow-up” section of this review. Several recommendations and training in ultrasound were part of this pilot study [92]. Only a single dog deworming campaign was carried out [70]. Recently, the Ministry of Health established a guide for surveillance and prevention of *E. granulosus* and *Fasciola hepatica* [93].

On the other hand, the National Zoonosis Program of the Ministry of Health is limited to rabies vaccination of dogs, without activities against CE. Human CE notification is not compulsory, and the infected viscera from livestock are confiscated at the municipal abattoirs. Staff at the National Service of Agricultural Health and Food Safety (SENASAG) is notified, but not control measures are implemented. The sanitary inspection is limited to bovines in municipal abattoirs located in cities. The uncontrolled clandestine slaughter, mainly of pigs and sheep and South American camelids, persists even in communities close to large cities.

Epidemiological analysis of *E. granulosus* in Bolivia

Data reviewed here demonstrate that this zoonotic disease has been historically reported in 8 out of 9 Departments of this country except for Pando. The livestock population in Bolivia includes 9,304,572 bovines, 5,382,778 sheep, 2,941,827 pigs, 1,454,923 goats, and around 1

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**Table 4. (Continued)**

| Department          | Province/Town       | # of animals studied | # of positives (%) | Species  | Fertility of cysts | Period       | Reference |
|---------------------|---------------------|----------------------|--------------------|----------|--------------------|--------------|-----------|
| Potosí              | Sud Chichas/ND      | 183                  | 22 (12.0)          | Cattle   | ND                 | 1998 (3 months) | [85]      |
|                     | Omiste/ND           | 16                   | 1 (6.3)            |          |                    |              |           |
|                     | Nor Chichas/ND      | 20                   | 0                  |          |                    |              |           |
|                     | Cercado/ND          | 18                   | 0                  |          |                    |              |           |
|                     | **Total**           | **237**              | **23 (9.7)**       |          |                    |              |           |
| Potosí              | Saavedra/Betanzos   | 991                  | 33 (3.3)           | Cattle   | ND                 | 2001 (3 months) | [84]      |

ND, no data.

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million South American camelids [94]. Large-scale intensive livestock rearing, specialised in
cattle production, is restricted to the lowlands of the Departments of Beni, Santa Cruz, and
Pando in the northeast of Bolivia. In contrast, in La Paz and other Departments, farmers have
a small number of animals frequently mixing different species (bovines, ovine, pigs, and cam-
elids). This happens because of the shortage of forage due to the Altiplano’s bioclimatic condi-
tions [95]. Livestock rearing is usually combined with other agricultural activities; supervising
livestock is frequently the children’s responsibility.

Considering the available data, we propose the analysis of the CE in 3 ecological levels in
Bolivia: Altiplano (La Paz, Oruro, and Potosí), subtropical valleys (Cochabamba, Tarija, and
Chuquisaca), and tropical lowlands from the Amazon (Beni, Pando, and Santa Cruz). In the
case of the Altiplano, La Paz is the department that reported the majority of the cases and
more retrospective studies on CE (see Tables 1 and 2). Unfortunately, the cases’ actual origin is
not available in several reports, and the majority of reports are from hospitals in big cities
where surgeries were performed (passive detection). Cattle, sheep, and pigs are common in
this area, principally in the ecoregion named “wet puna.” The raising of South American cam-
elids is scarce in this region. In our experience, the Northern Bolivian Altiplano at La Paz
Department is one of the most endemic areas for CE in Bolivia. The transmission is low in cer-
tain valleys with few human cases reviewed here (Tables 1 and 2), while animal infection
reached up to 37.5% in Tarija, for example (Table 4).

In contrast, 44 human cases have been reported in Chuquisaca, including the first autoch-
thonous case from Bolivia; however, a low prevalence in livestock has been found in this
department (Table 3). More precise information is available from Potosí’s valleys. Only 1 epide-
miological study involving several communities in Tupiza reveals the prevalence of CE
between 2.1% and 13.3% in humans using ultrasound examination [62] and also the infection
in dogs. In the case of the lowlands, livestock is found in large-scale intensive systems primarily
cattle. Low CE prevalence has been described for this area for livestock, while no reports of CE
in humans have been described in recent years. However, the identification of *E. intermedius*
G7 in pigs from Santa Cruz [8] warrants further investigation in this Department. Previously,
*Echinococcus vogeli* was identified in Santa Cruz infecting *Cuniculus paca* [96].

Conclusions

The available information on CE in Bolivia does not allow a comprehensive countrywide estima-
tion of the disease’s epidemiological situation and burden. However, data summarised here show
that CE is present in 8 out of 9 Departments in Bolivia. CE became more commonly diagnosed in
the last 50 years. The maximum levels of infection recorded in livestock in different species from
Bolivia also show that the parasite is widely spread. Studies performed in dogs showed that the
parasite is actively transmitted in areas near major population centres like La Paz and El Alto.

Furthermore, the recent detection of 3 different species of *E. granulosus s.l.* in Bolivia warrants
further epidemiological investigations. Future baseline epidemiological data, including studies in
dogs and intermediate hosts and a systematic collection of human cases, are necessary. Data
acquired will form the basis for the discussion and implementation of national control pro-
grammes. Public health education will be essential due to the lack of knowledge of the disease in
the Bolivian population. Promote the interest related to CE and the sensibility of the national and
departmental authorities to assume influential and integral responsibilities in the context of “One
Health” is an objective of this work. The management based on standardised protocols of the
human CE in hospitals could clarify the disease’s epidemiological situation in this country.
Finally, further studies investigating other related species present in some South American coun-
tries including Bolivia, as *E. vogeli* or *Echinococcus oligarthrus*, are also indicated.
Key Learning Points

- There is no systematic collection of data for infection in humans, livestock, or dogs caused by *E. granulosus s. l.* in Bolivia.
- Human CE has been diagnosed in Bolivia since the first half of the 19th century, and cases have increased since the 1970s.
- Current evidence suggests an unequal geographic distribution of *E. granulosus s. l.* in Bolivia with higher infection in the departments of La Paz and Potosí.
- Llamas could play an essential role in maintaining the cycle of the parasite in the Bolivian Altiplano.
- There is an urgent need for studies to understand the epidemiology of CE in all departments of Bolivia.

Top Five Papers

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