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Original Article

Ocurrence of enteroparasites with zoonotic potential in animals of the rural area of San Andres, Chimborazo, Ecuador

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A R T I C L E I N F O

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A B S T R A C T

Objective: The aim of this research was the identification of the enteroparasites harbored by the animals of the San Andrés community, to evaluate their role as susceptible hosts and sources of infection for other animals, humans (zoonoses), as well as parasite forms spreaders to the environment in this rural area, located in the province of Chimborazo, Ecuadorian Andean region.

Material and methods: The study was carried out combining 3 coproparasitological techniques: direct examination, Ritchie and Ziehl-Neelsen in 300 animal stool samples

Results: *Blastocystis* sp., *Entamoeba* spp., *Giardia* spp., *Balantidium* spp., *Cryptosporidium* spp., *Ascaris* spp., *Toxocara* spp., *Ancylostoma* spp., Strongylida, *Hymenolepis nana* and *Echinococcus* spp., were detected. Infection by protozoa (87.3%) was higher than helminths (31.0%). All cattle, sheep and guinea pigs were found parasitized, and the presence of *Blastocystis* sp., *Entamoeba* spp. and *Cryptosporidium* spp. by all groups of animals stands out. It is also remarkable the presence of *Giardia* spp. in swine (19.2%), big herbivores-livestock (11.5%), leporids (8.3%) and carnivores (5.9%); *Balantidium* spp. in swine (19.2%), big herbivores-livestock (5.8%) and carnivores (1.2%); *Hymenolepis nana* in guinea pigs (2.1%); and *Toxocara* spp. (15.7%), *Echinococcus* spp. (9.6%) and *Ancylostoma* spp. (6.0%) in dogs.

Conclusion: Animals from San Andrés have a wide spectrum of intestinal parasitic forms in their feces, being a source of infection to other animals and humans, and a source of contamination of the environment, posing a risk factor and reinforcing the idea of the need for more effective treatments and hygienic measures to improve livestock production and cutting its transmission.

1. Introduction

In rural areas of Latin America, people have certain behaviours derived from the lack of hygienic and sanitary education, culture of indigenous groups, extreme poverty, lack of attention from their leaders to obtain sanitary improvements in the communities and lack of economic aid for cattlemen to obtain veterinary care of their animals. These factors condition the high transmissibility of enteroparasites in these areas, that ultimately translate into financial losses for breeders, constituting one of the main obstacles for livestock industry development. Chronic parasitosis persist in animals that decrease meat and dairy production, even their excreta constitute a water and soil contaminant due to direct defecation or when used as fertilizers. In addition, they act as reservoirs for parasites, which pose a risk as a source of infection for other susceptible hosts, including humans (Jones and Garcia, 2019).

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Vélez-Hernández et al. in 2014 recorded that worldwide parasites causing human diseases transmitted by animals are on the rise, with prevalence of parasitic zoonoses reaching 35% and representing an important public health problem. Zoonoses constitute 60% of the diseases that affect humans and 75% of emerging diseases.

Isolated protozoa from various hosts, such as cattle, sheep, goats and pigs, have been subjected to molecular studies, allowing the identification of species, genotypes and subtypes that can affect humans. Naser (2020) confirmed the transmission of 5 genotypes of zoonotic *Entamoeba histolytica* in cattle and sheep. Several authors referred to the circulation of different zoonotic genotypes of *Giardia duodenalis* in dogs (Feng and Xiao, 2011; Wang et al., 2012; Kostopoulou et al., 2017), in cats (Feng and Xiao, 2011; Kostopoulou et al., 2017), in horses (Traub et al., 2005; Feng and Xiao, 2011; Ng et al., 2011), in cattle (Langkjær et al., 2007; Feng and Xiao, 2011; Khan et al., 2011; Ng et al., 2011; Abeywardena et al., 2012), in sheep (Feng and Xiao, 2011; Ye et al., 2015), in pigs (Langkjær et al., 2007; Feng and Xiao, 2011), in rabbits (Feng and Xiao, 2011; Pantchev et al., 2014) and in guinea pigs (Pantchev et al., 2014; Meutchieye et al., 2017).

Similarly, zoonotic species of *Cryptosporidium* have been detected in cattle, sheep, pigs, guinea pigs and dogs (Chrisp et al., 1992; Langkjær et al., 2007; Ng et al., 2011; Abeywardena et al., 2012; Zanzani et al., 2014). By studying the molecular epidemiology of *Blastocystis* sp., zoonotic subtypes were shown to circulate among birds, livestock, and pets (Mokhtar and Youssef, 2018; Moura et al., 2018; Udonsom et al., 2018; Liao et al., 2020). *Balantidium coli* has been identified in domestic animals, especially in the pig as a normal host, which are sources of infection to humans (Schubnell et al., 2016; Paul et al., 2019; Ahmed et al., 2020).

In relation to the zoonotic transmission of helminths, the role of rodents as reservoirs of *Hymenolepis nana* and *H. diminuta* stands out (Galán-Puchades et al., 2018). Likewise, the close contact with dogs (Banda et al., 2020) and cats (Kostopoulou et al., 2017), the most common pets, constitutes a risk factor associated with zoonotic transmission, especially in the case of children.

Livestock owners are unaware of the transmission patterns and possibilities of prevention of enteroparasites in their animals. This constitutes a public health problem in the Ecuadorian Andean rural areas. Consequently, the main objective of this research was the identification of enteroparasites harbored by the animals of the San Andrés community, to evaluate their veterinary importance and their role as sources of infection for other animals and humans, and contaminants of the environment.

2. Methods

2.1. Characteristics of population and area

Government records indicate that 47.9% of the rural population of Ecuador live in poverty, with an average monthly family income of $ 84.05 and 27.5% is in extreme poverty, with an average income of $ 47.7. The province of Chimborazo has an illiteracy rate of 13.5% and the San Andrés parish has an indigenous population of 36.9% (INEC, 2020). Hence, their training is based on habits and customs acquired from their ancestors, lacking hygienic-sanitary measures. The most remote communities build septic tanks and the communities closest to the capital have sewers, but they drain wastewater into rivers and streams (PDOT San Andrés, 2014-2019).

The community of San Andrés, Guano canton, Chimborazo province, Ecuador, is located at 3900 m above sea level. The temperature ranges between 5 °C and 18 °C, with an average of (11.2 °C) and rainfall varies between 500 and 1000 mm/year. There are two rainy periods of rain, between February–May and October–November, the remaining months are transitional, with moderate rains.

Evapotranspiration affects the drought of soil, originated from volcanic ash, they have variable textures, most of which are shallow silty loam, with a pH between 4.5 and 6.5. There are loamy soils in the areas with the highest agricultural production, but they are affected by chemical fertilizers. Also, there are sandy soils with low fertility because they do not retain moisture and nutrients, and the action of the steep slopes makes them susceptible to erosive processes, so crops and sowing grass are not very abundant, however agricultural (34,5%) and cattle raising activity (50.4%) are the main means of financial income for the population (PDOT San Andrés, 2014-2019).

2.2. Design and sampling

The present research is a quantitative, cross-sectional and exploratory-descriptive study which was carried out during the months of June and July 2019.

The snowball sampling technique was applied, whereby a farmer helped locate the nearest farm and so on. All the animals found in the farms were included in the sampling, excluding those that had been dewormed during the last month.

2.3. Ethical statements

Ethical principles of the study were in accordance with the International Standards for Research with Animals of the Council of International Organizations of Medical Sciences, on experimentation with animals, guaranteeing animal welfare, and taking into account the animal protection regulations of the Comprehensive Organic Criminal Code, in Article 2504, avoiding abuse and any action that incurs stress on the animal.

2.4. Sampling

The owners collected the stools from the rectum of large animals. In each case, the farmers used a plastic sleeve to cover their hand, and it was used as a collection container. Small animals were put in a cage until they defecated; the sample was taken from the upper part that had no contact with the cage. Each sample was encoded and transferred in refrigerated plastic containers at 4 °C to the Research Laboratory of the Faculty of Health Sciences (Universidad Nacional de Chimborazo) where they were analyzed within two hours of being obtained. 300 stool samples were collected, one per animal, belonging to 104 big herbivore livestock (45 cattle, *B. primigenius taurus*; 18 sheep, *Ovis orientalis aries*; 28 horses, *Equus ferus caballus*; 4 donkeys, *Equus africanus asinus*; and 9 llamas, *Lama glama*); 26 omnivores (pigs, *Sus scrofa domestica*); 85 carnivores (83 dogs, *C. lupus familiaris*; and 2 cats, *Felis silvestris catus*); 13 birds (7 chickens, *Gallus gallus domesticus*; 3 geese, *A. anser domesticus*; and 3 pigeons, *C. livia*); 48 small herbivore rodents (guinea pigs, *C. porcellus*); and 24 small herbivore leporids (rabbits, *Oryctolagus cuniculus*).

The differentiation of herbivores into big herbivore livestock and small herbivore rodents and leporids is because epidemiologically it works differently, big herbivore livestock are kept free in a field, while small herbivores are kept in peridomicile captivity.

2.5. Parasitological analyses

Fresh stool samples, 100 g of from small animals and 300 g from large ones, were processed using three complementary coproparasitological techniques: direct examination to detect the movement of protozoan trophozoites, helminth larvae and to highlight all the parasitic structures that aid recognition; modified Ritchie concentration served to concentrate small and large parasites and cold Ziehl-Neelsen (Garcia et al., 1983) was used for the recognition of coccidia, being previously sieved with 4 stainless steel meshes (400, 300, 200, 100 μm), to eliminate the excess of cellulose and other artifacts when necessary.

2.6. Statistical analysis

A database was built in Microsoft Excel, which was exported to the SPSS Statistic 24.0 software. The comparison of the parasitic frequencies was carried out between different animal groups animal species and parasite genera, using the Chi square test, considering as significant a $p < 0.05$.

3. Results

Of a total of 300 animals analyzed, 271 (90.3%) were parasitized. It should be noted that when comparing the prevalence of total parasitization between the groups of animals (Table 1), although rodents and omnivores showed the highest percentage, and birds emitted the lowest number of parasites, no statistically significant differences were found.

Considering all samples, a significant larger number of protozoa (87.3%) than helminths (31.0%) was detected ($X^2 = 197.029$, $p < 0.0001$), fact that was confirmed in the following groups of animals: big herbivore livestock ($X^2 = 86.720$, $p < 0.0001$), omnivores ($X^2 = 37.452$, $p < 0.0001$), carnivores ($X^2 = 54.826$, $p < 0.0001$), birds ($X^2 = 7.721$, $p = 0.00055$), small herbivore rodents ($X^2 = 10.766$, $p = 0.0010$) and small herbivore leporids ($X^2 = 16.800$, $p < 0.0001$) (Table 1).

All the individuals analyzed from the cattle, sheep and guinea pig species were parasitized. When performing the analysis per group of animals, among big herbivore livestock, the maximum variety of protozoa was observed in cattle (100%) and of helminths in guinea pigs (75%). The lowest rate of parasitism was detected in birds, both for protozoa (69.2%) and for helminths (15.4%).

The most parasitized animals were a pig, harboring nine distinct parasites (*Blastocystis* sp., *Entamoeba* spp., *Iodamoeba büetschlii, Giardia* spp., *Balantidium coli*, *Cryptosporidium* spp., *Eimeria* spp., *Ascaris suum* and some representatives of the suborder Strongylida); and a guinea pigs with seven different parasites (*Blastocystis* sp., *Entamoeba* spp., *Endolimax nana*, *Retortamonas intestinalis*, *Cryptosporidium* spp., *Eimeria* spp. and some representatives of the suborder Strongylida).

The parasitic genus/species identified in each group of animals can be consulted in Table 2. In the case of protozoa, the high prevalence of *Eimeria* spp. (45.3%), *Entamoeba* spp. (44.7%) and *Blastocystis* sp. (39.3%), stands out.

It should be noted that swine infection totals 96.2%, highlighting a wide spectrum of protozoa such as *Entamoeba* spp. (65.4%), *Blastocystis* sp. (50.0%), *Giardia* spp. (19.2%), *Balantidium* spp. (19.2%) and *Cryptosporidium* spp. (7.7%). Similarly, guinea pig infection totals 100%, and the most frequent parasites in this case were *Entamoeba* spp. (54.2%), *Blastocystis* sp. (35.4%), *Cryptosporidium* spp. (8.3%) and *Hymenolepis nana* (2.1%).

In relation to the results within the group of herbivores, the highest degree of parasitism was observed in cattle (100%), and the genus involved in this case were *Entamoeba* spp. (91.1%), *Blastocystis* sp. (55.6%), *Giardia* spp. (20.0%), *Balantidium* spp. (11.1%) and *Cryptosporidium* spp. (8.9%).

Likewise, when carnivores were discriminated, dogs reached a total percentage of infection of 86.7%, with a wide variety of parasitic genus/species including both protozoa and helminths, such as *Blastocystis* sp. (38.6%), *Entamoeba* spp. (38.6%), *Cryptosporidium* spp. (6.0%), *Giardia* spp. (4.8%), *Balantidium* spp. (1.2%), *Toxocara* spp. (15.7%), *Echinococcus* spp. (9.6%) and *Ancylostoma* spp. (6.0%).

Table 1
Distribution of the frequency parasite excretion according to animal species.

Animals	Total		Protozoa		Helminths	
	np/ns	(%)	np/ns	(%)	np/ns	(%)
Herbivores						
Cattle	45/45	100	45/45	100	6/45	13.3
Sheep	18/18	100	16/18	88.9	10/18	55.6
Horses	23/28	82.1	23/28	82.1	2/28	7.1
Donkeys	2/4	50.0	2/4	50.0	0/4	0
Llamas	4/9	44.4	3/9	33.3	4/9	44.4
Subtotal	92/104	88.5	89/104	85.6	22/104	21.2
Omnivores						
Pigs	25/26	96.2	25/26	96.2	3/26	11.5
Subtotal	25/26	96.2	25/26	96.2	3/26	11.5
Carnivores						
Dogs	72/83	86.7	69/83	83.1	22/83	26.5
Cats	2/2	100	2/2	100	1/2	50.0
Subtotal	74/85	87.1	71/85	83.5	23/85	27.1
Birds						
Chickens	5/7	71.4	5/7	71.4	0/7	0
Geese	3/3	100	2/3	66.7	2/3	66.7
Pigeons	2/3	66.7	2/3	66.7	0/3	0
Subtotal	10/13	76.9	9/13	69.2	2/13	15.4
Rodents						
Guinea pigs	48/48	100	47/48	97.9	36/48	75.0
Subtotal	48/48	100	47/48	97.9	36/48	75.0
Leporidae						
Rabbits	22/24	91.7	21/24	87.5	7/24	29.2
Subtotal	22/24	91.7	21/24	87.5	7/24	29.2
Total	271/300	90.3	262/300	87.3	93/300	31.0

np/ns: number of parasitized animals / number of analyzed animals.

4. Discussion

Animals that act as reservoirs (wild or domestic vertebrate animals which share parasitic species with humans), such as in the case of *G. intestinalis*, *C. parvum*, *Toxocara* spp., etc., or those in which the parasite only passes through their digestive tract, play an important role among the risk factors associated with the transmission of human intestinal parasites. The parasitic infectious forms released by animals can contaminate the soil and water, for further human, veterinary and agricultural use (González-Ramírez et al., 2020).

The parasitic infectious forms released by animals can contaminate the soil and water, for further human, veterinary and agricultural use (González-Ramírez et al., 2020). In addition, crops can be contaminated by fertilization with fresh excreta or by the direct defecation of animals kept free in the field, including cattle, sheep and pigs (Budu-Amoako et al., 2011; González-Ramírez et al., 2020); birds, dogs and cats (Kostopoulou et al., 2017); rabbits and rodents (Pantchev et al., 2014; Meutchieye et al., 2017; Galán-Puchades et al., 2018).

It is important to emphasize that, because it is a farming area, crops products are commercialized at a local, regional and national and international level, without prior control or washing, and probably contaminated. Among vegetables, those that are consumed raw, such as fruits (Alemu et al., 2019) and green leafy vegetables (Machado et al., 2018) turn out to be major routes of human infection, as proven in salads packed in Italy (Caradonna et al., 2017).

Another risk habit in this rural area is the direct contact between people and animals, as described in cattle breeders in India (Khan et al., 2011) and New Zealand (Abeywardena et al., 2012). The transmission between pets and their owners has been recognized, especially in children (Kostopoulou et al., 2017; Sarzosa et al., 2018; Kurnosova et al., 2019; Villamizar et al., 2019; González-Ramírez et al., 2019; Liao et al., 2020).

In the present study, samples were obtained from all farm animal present in the community, although some were scarce, the results are still important due to the biological verification of the parasitic infection. Obtaining cat stool was difficult as they were buried after defecation. Sauda et al. (2019) assured that 19.7% of the cats analyzed in their work in Italy, were infected with potentially zoonotic protozoa. Kostopoulou et al. (2017) considered helminth infection in cats to be more important in Greece, while Kurnosova et al. (2019), gave equal importance to both zoonotic protozoa and helminths. The low number of birds and rabbits analyzed is due to the fact that they are rarely bred because they are not profitable. However, the results are assessed by the possible zoonotic genotypes of *Blastocystis* sp. and *Cryptosporidium* spp. in birds (Mokhtar and Youssef, 2018; Jones and Garcia, 2019); and *Blastocystis*

Table 2
Distribution of parasitic species according to animal groups.

Parasites	Herbivores		Omnivores (Pigs)		Carnivores		Birds		Rodents (Guinea pigs)		Leporidae (Rabbits)		TOTAL	
	ns = 104		ns = 26		ns = 85		ns = 13		ns = 48		ns = 24		ns = 300	
	np	(%)	np	(%)	np	(%)	np	(%)	np	(%)	np	(%)	np	(%)
Blastocystis spp.	44	42.3	13	50.0	32	37.6	6	46.2	17	35.4	6	25.0	118	39.3
Entamoeba spp.	51	49.0	17	65.4	33	38.8	3	23.1	26	54.2	4	16.7	134	44.7
Endolimax nana	6	5.8	5	19.2	9	10.6	1	7.7	7	14.6	0	0	28	9.3
Iodamoeba buetschlii	8	7.7	10	38.5	3	3.5	0	0	0	0	0	0	21	7.0
Giardia spp.	12	11.5	5	19.2	5	5.9	0	0	0	0	2	8.3	24	8.0
Enteromonas spp.	0	0	0	0	0	0	0	0	1	2.1	0	0	1	0.3
Retortamonas spp.	0	0	2	7.7	0	0	0	0	1	2.1	0	0	3	1.0
Chilomastix spp.	0	0	0	0	4	4.7	0	0	5	10.4	0	0	9	3.0
Balantidium spp.	6	5.8	5	19.2	1	1.2	0	0	0	0	0	0	12	4.0
Cryptosporidium spp.	6	5.8	2	7.7	5	5.9	2	15.4	4	8.3	2	8.3	21	7.0
Eimeria spp.	68	65.4	7	26.9	13	15.3	5	38.5	31	64.6	12	50.0	136	45.3
PROTOZOA	89	85.6	25	96.2	71	83.5	9	69.2	47	91.7	21	87.5	262	87.3
Ascaris spp.	1	1.0	1	3.8	0	0	0	0	0	0	0	0	2	0.7
Toxocara spp.	1	1.0	0	0	13	15.3	0	0	0	0	0	0	14	4.7
Ancylostoma spp.	0	0	0	0	6	7.1	0	0	0	0	0	0	6	2.0
Strongylida	22	21.2	3	11.5	0	0	2	15.4	35	72.9	7	29.2	69	23.0
Echinoccus spp.	0	0	0	0	8	9.4	0	0	0	0	0	0	8	2.7
Hymenolepis nana	0	0	0	0	0	0	0	0	1	2.1	0	0	1	0.3
HELMINTHS	22	21.2	3	11.5	23	27.1	2	15.4	36	75.0	7	29.2	93	31.0
TOTAL	92	88.5	25	96.2	74	87.1	10	76.9	48	100	22	91.7	271	90.3

np/ns: number of parasitized animals / number of analyzed animals.

sp., *Cryptosporidium* spp. and *Giardia* spp. in rabbits (Zhang et al., 2012).

Animals can be infected with eight *Giardia* species: *G. duodenalis G. agilis*, *G. ardeae*, *G. psittaci*, *G. muris*, *G. microti*, *G. peramelis* and *G. cricetidarum*. Likewise, *G. duodenalis* is a complex consisting of eight genotypes or assemblages (A-H), with A and B predominant in humans (Ryan and Zahedi, 2019); C and D in dogs (Hernández et al., 2021); E in cattle, sheep and pigs; F in cats; G in rats and H in pinnipeds (Ryan and Zahedi, 2019).

Assemblages described in animals were thought not to be infectious to humans, until cases of assemblage C were reported in people from China and Slovakia (Hopkins et al., 1997; Monis et al., 1998), data reconfirmed by Sarzosa et al. (2018), in children from a semi-rural area near Quito-Ecuador. Assemblage D in German travellers (Broglia et al., 2013), E in Egyptian children (Abdel-Moein and Saeed, 2016) and F in hospitalized patients and children from Ethiopia (Gelanew et al., 2007).

There are few publications on zoonoses in Ecuador, although the detection of *G. duodenalis* (13.1%) and *C. parvum* (1.1%) by molecular methods has been described in children and domestic animals in a semi-rural area near Quito (Vasco et al., 2016). Continuing this research, the zoonotic transmission of *G. duodenalis* genotypes B and C from domestic animals to children was verified (Sarzosa et al., 2018).

Our results point towards a possible zoonotic transmission of *G. duodenalis*, in view of the fact that four groups of animals (livestock, omnivores, carnivores and leporids) of the six studied released cysts to the environment (González-Ramírez et al., 2020).

Regarding to the genus *Cryptosporidium*, it is known that includes at least 26 valid species, of which *C. hominis*, *C. parvum* and *C. meleagridis* are responsible for 95% of human infections (Ryan et al., 2014). Livestock is one of the most important host and source of infection to human with zoonotic species (Budu-Amoako et al., 2011), *C. parvum* is responsible for approximately 85% of infections in pre-weaned calves (Brankston et al., 2018). Also, human infection by *C. suis*, a typical species in pigs, has been reported (Bodager et al., 2015) and recent studies have detected infections in dogs with *C. parvum* (Liao et al., 2020).

Naser in 2020, recorded a percentage of infection with *E. histolytica* in human, cattle and sheep amounted to 79.1%, 100%, 75% and *E. dispar* of 33.3%, 22.2%, 12.5%, respectively. The caracterization of *E. histolytica* by q-PCR showed the presence of 5 different genotypes (I, II, III, IV, V). The genotype "I" being shared between humans and cattle; II, III and IV among humans, cattle and sheep, results that confirm the circulation of the different genotypes between animals and people.

Molecular epidemiological surveys have been carried out in several countries to elucidate the genetic diversity of *Blastocystis* sp. in different hosts, zoonotic subtypes were shown to circulate among pigs, sheep, cattle, goats, dogs, birds and guinea pigs (Mokhtar and Youssef, 2018; Udonsom et al., 2018; Moura et al., 2018; Li et al., 2018; Liao et al., 2020). Maloney et al. (2020) detected *Blastocystis* infection in domestic and captive wild birds. At least one of the three zoonotic subtypes identified (ST5, ST6, and ST7) was found in 81.3% of positive samples, suggesting the role of birds as susceptible host and as reservoirs. These results should be highlighted because birds occupied the second place in prevalence of *Blastocystis* (46.2%), behind pigs (50%) among the animals analyzed in the present study.

Special attention should be paid to the parasitism of pigs as it is one of the animal species that harbor the highest number of protozoa (65.4% *Entamoeba* spp., 50% *Blastocystis* sp., 19.2% *Giardia* spp., 19.2% *Balantidium* spp., and 7.7% *Cryptosporidium* spp.), as has been verified by Udonsom et al. (2018) who describe the circulation of *Blastocystis* ST1 in pigs and ST3 in dogs, which is important due to its proximity to humans.

In the case of parasitism by *Balantidium coli,* the infection of cattle (54.7%) and pig (42.0%) in Bangladesh has recently been described (Paul et al., 2019), these results contrast with those obtained in the present work, in which the cattle reach 11.1% and pig 19.2% of parasitism.

The excretion of representatives of the order Strongylida is not considered as anthropozoonotic importance due to the community is located at a high altitude (3900 m above sea level), where soil-transmitted helminths that affect humans find it difficult to complete their biological cycle due to the extreme environmental conditions (González-Ramírez et al., 2020).

Canines are of epidemiological importance since they carry a large number of zoonotic parasites (Vélez-Hernández et al., 2014; Wang et al., 2014; Duncan et al., 2020) which can cause intestinal infections by protozoa, and more severe diseases caused by helminths such as: *Ancylostoma* spp., *Toxocara* spp., and *Echinococcus* spp., which produce cutaneous, ocular or visceral larva migrans syndromes and hydatidosis, respectively. Meanwhile, as host of protozoa, highlight the cattle (100%) and pigs (96.2%), with a high probability of infecting humans in accordance with previous reports (Budu-Amoako et al., 2011; Udonsom et al., 2018; Naser, 2020).

Other researchers in Ecuador have warned about the zoonotic potential of four genera of helminths: *Toxocara, Ancylostoma, Echinococcus* and *Hymenolepis*, having reported about *Toxocara canis* in 22.7% of domestic dogs, and in 36% of the children who live with these dogs in Jipijapa, Manabí province (Orlando-Indacochea et al., 2018). Likewise, there are reports of Cutaneous Larva Migrans in Ecuador. The most recent published by Coello et al. (2019), who described the infection of an 8-year-old boy, in an urban area of Vinces, Los Ríos province, serpentine palpable lesion on the sole of the right foot, which was due to the zoonotic transmission of *Ancylostoma caninum* from domestic dogs; 120 dog stool samples were examined and 62.5% contained *Ancylostoma* larvae.

In addition, there are declared cases of human hydatidosis, but publications about it are scarce. Nevertheless, Ramírez Robinson et al. (2000), claim to have found an 84-year-old female patient, from Guayaquil, with pain in the right upper quadrant, jaundice, dizziness, nausea, vomiting and meteorism. A cyst was detected in the left lobe of the liver after image analysis, confirmed by positive serological tests for *Echinococcus*.

Other cestodiases have been verified as zoonotic species in young Quichua children in rural communities in the highlands of Ecuador, with a prevalence of 11.3% of *Hymenolepis nana* (Jacobsen et al., 2007).

We are aware of the need to determine, through the application of molecular techniques, the zoonotic potential of the parasitic genotypes and subtypes circulating among these animals, which it is essential to know the route of transmission. This limitation of our work will be proposed in later studies, continuing the investigation until the situation is clarified.

However, it is considered that parasites detected in animals are of veterinary importance due to the signs and symptoms presented by the animals. It is important to highlight the state of health of the livestock in the community of San Andrés. Cattle are affected by parasites, the disease of cows was evidenced by clinical pictures that include deterioration of the general state, thinness, shaggy and dull hair, increased abdominal volume, watery or dysenteric diarrhea, excretion of adult worms, and low milk/meat production (PDOT San Andrés, 2014-2019).

Regarding the handling of animals, it should be clarified that the Ecuadorian Ministry of Agriculture and Livestock has conceived a Sanitary Plan, which contemplates the quarterly and semi-annual treatment of young and adult animals, at a cost of 10 $ per animal that must be paid by the breeder. Due to the precarious socioeconomic conditions of San Andrés inhabitants, the animals' owners do not hire professional services to treat livestock with diarrhea, they resort to use indigenous traditional medicine giving them mallow (*Malva sylvestris*), plantain (*Plantago major*) or chamomile (*Chamaemelum nobile*). However, when the symptoms persist, they are treated empirically by their owners, who administer unknown doses of benzimidazoles or ivermectin, which may be lower than those required, because a subsequent resistance of parasites has been observed to ivermectin (Vinueza-Veloz et al., 2021).

They only resort to veterinary service, when the diarrhea or dysentery are persistent, they administer trimethoprim sulfamethoxazole or tetracyclines that have a cost of 60 $ per cattle, 30 $ for pigs or camelids and 25 $ for sheep or goats, and the treatment should be repeated monthly in case of coccidiosis. When the producer cannot pay for the treatment, the animals suffer from chronic diarrhea that leads to dehydration, anorexia, and death.

Economic losses for producers are also evidenced by cattle's low weight (150–200 kg), which translates into low meat production, they never reach the 500 kg required by international regulations. Nevertheless, the herds accept low weight animals. Regarding milk production, the average records reach to 5 L of milk per day per cow (PDOT San Andrés, 2014-2019).

It is important to clarify that there is a change in the density of pig populations during the second half of the year (to benefit them during Christmas), which may increase its role as a source of infection by pathogenic parasites. Consequently, having carried out the sampling in June and July, allowed to make the diagnosis in a greater number of pigs. Likewise, that the rest of the animal species are kept at a constant density, small animals and birds reproduce at the same rate at which they are slaughtered, as far as cattle are generally kept for dairy production, they sporadically slaughter cattle.

We consider that the parasite density in animals does not vary significantly during the year, since Ecuador is a tropical country, there are no marked seasonal changes, we have not analyzed the prevalence in times of greater rainfall, so we cannot compare prevalence during these periods. But we believe that due to the considerable transmission detected in the dry season (June and July), the transmission of enteroparasites should be very similar along the rest of the year.

It is important to comply with the health plan indicated by the Ecuadorian Ministry of Agriculture and Livestock and make breeders aware of their livestock health deterioration, making them aware of economic benefits that they would obtain by keeping their animals healthy. In the same way, they must reflect on the role of these animals as sources of parasites infection for other animals, which result in economic losses and in the human aspect because they or their relatives can be affected, especially children. In addition, contamination of water, soil and crops must be considered, that acts as vehicles for infecting parasitic forms that contribute to their dispersal into the environment.

A mitigation plan which includes hygienic-sanitary measures to prevent the transmission of parasites in this farming region should be implemented, including the health education of the population, veterinary control and antiparasitic treatment of humans and animals.

5. Conclusions

Animals from San Andrés have a wide spectrum of intestinal parasitic forms in their feces, being a source of infection to other animals and humans, and a source of contamination of the environment, posing a risk factor of intestinal parasites and reinforcing the idea of the need for more effective treatments and hygienic measures to improve livestock production and cutting its transmission.

Ethical statements

Ethical principles of the study were in accordance with the International Standards for Research with Animals of the Council of International Organizations of Medical Sciences, on experimentation with animals, guaranteeing animal welfare, and taking into account the animal protection regulations of the Comprehensive Organic Criminal Code, in Article 2504, avoiding abuse and any action that incurs stress on the animal.

The owners collected the stools of their animals, using plastic bags, which were encoded and transferred in refrigerated plastic containers to the Research Laboratory of Faculty of Health Sciences (Universidad Nacional de Chimborazo).

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