Parasitic risk factors in migrant horticultural families from Bolivia settled in the rural area of La Plata, Buenos Aires, Argentina

Andrea Celina Falcone [a,*], María Lorena Zonta [a], Juan Manuel Unzaga [b], Graciela Teresa Navone [a]

[a] *Centro de Estudios Parasitológicos y de Vectores (CEPAVE-CONICET-UNLP- asociado a CICPBA), La Plata, Argentina*
[b] *Laboratorio de Inmunoparasitología (LAINPA), FCV-UNLP, La Plata, Argentina*

A B S T R A C T

Objective: The aims were to diagnose intestinal parasites in migrant horticultural families in the rural area of La Plata, and assess factors that increase the risk of parasitic infection.
Materials and methods: Serial stool samples and anal swabs of 350 individuals were processed using sedimentation and flotation techniques. Socio-sanitary and environmental characteristics were surveyed using a semi-structured questionnaire. A generalized linear model was used to assess the change in parasitic prevalence with different predictor variables.
Results: Of all examined individuals, 79.1% were parasitized, and 12 parasites were identified. *Blastocystis* sp. (58.9%), *Entamoeba coli* (26.3%), *Enterobius vermicularis* (26.0%), and *Giardia lamblia* (24.0%) were the most prevalent species. Risk factors were age group (<12 years), sampling site, and a basic education of parents.
Conclusion: The high prevalence of intestinal parasites in horticultural families is associated with inadequate environmental sanitation, a limited access to education, and insufficient hygienic habits. An increase in parasitological references in integrated studies (human, animal and environmental health) would result in an understanding of the parasitic etiology, and the development of effective actions for the control of intestinal parasites.

1. Introduction

Intestinal parasites are relevant in public health due to the high prevalence rates and they affect individuals around the world, especially vulnerable communities in developing countries [35]. It has been estimated that approximately 3 million people are infected with intestinal parasites (e.g. *Giardia lamblia, Enterobius vermicularis, Ascaris lumbricoides*) [8].

Parasitic diseases mainly occur in children, affecting the nutritional status, physical development, and cognitive capacity [20,54]. In adults, intestinal parasites affect labor efficiency negatively impacting on economic and social progress [46]. The transmission of infectious diseases depends on interactions between humans, animals and environmental health [42]. In this respect, the propagation of intestinal parasites is favored by fecal contamination of the environment, and the lack of sanitary services. Likewise, insufficient hygienic habits are associated with parasitic infections, as well as limited access to healthcare and education [9,25].

The distribution of intestinal parasites depends on ecological and socio-cultural factors, as well as the presence and effective transmission to susceptible individuals [17]. In this sense, migrations of people and animals, and their settlement conditions in rural and urban areas have implications for global public health [50]. Different studies have reported an elevated prevalence of intestinal parasites in rural populations globally, despite the different socio-economic and environmental characteristics of each region [16,30,34,39,40]. Studies in rural populations that includes farming families realised in South Africa, Honduras, and southern Ethiopia showed high values of prevalence of helminth (83.2%, 72.5%, and 63.0%, respectively), while in Burkina Faso high values of prevalence of protozoa were observed (84.7%) [1,15,44,45]. In addition, a review by Ruiz-Taborda et al. [43] on intestinal parasites and social determinants in South America revealed that living in rural areas, with low incomes, and inadequate sanitary infrastructure are the most favorable conditions for infections caused by intestinal parasites

[43].

In Argentina, prevalence values and the specific richness reflect a decreasing tendency from north to south and east to west, according to geographic and socio-environmental factors [32]. In the central region, prevalence values between 58.0 and 74.0% have been observed by different authors [6,17,20,53]. In this regard, prevalence values higher than 65.0% were observed in the Buenos Aires province, especially in La Plata [12,17,37]. Moreover, a study by Gamboa et al. [18] showed that the values of prevalence higher in rural populations than in urban ones (63.4% versus 55.8%, respectively) [18].

La Plata Horticultural area (Buenos Aires province, Argentina) is the most important rural area in the country for leafy vegetables production. This area was consolidated in the 90s as a result of the migration wave coming from Tarija (Bolivia), and these horticulturists supplied a socio-cultural network in the region. In this sense, intensive labor strength, greenhouse technology and proximity to the largest market in the country -Buenos Aires city and surrounding areas- allowed the La Plata horticulturists to have a highly competitive production [5,11,19]. Consequently, family orchards for self-consumption were transformed into horticultural establishments, turning them into the main production and supply area of leafy vegetables. However, the 2001 crisis and market liberalization affected the economic and social development of the region, strongly impacting family agriculture. Due to this the Bolivian horticulturists were exposed to limited access to land ownership, and therefore to the lack of healthcare infrastructure which resulted in unfavorable living conditions that put their health and the environment at risk [27]. In addition, the horticulturists had a limited access to healthcare, and this situation contributed to the "invisibility" of pathologies and diseases and, consequently, their lack of control.

Our study is based on the hypothesis that the inadequate socio-sanitary and environmental situation to which the horticultural families are exposed increases the risk of parasitic infection. The aims of this study were to diagnose intestinal parasites in migrant horticultural families in La Plata rural area, and relate them to the socio-environmental characteristics and behavioral habits in horticultural population as risk factors of parasitic infection.

2. Materials and methods

2.1. Study area and population

La Plata Horticultural rural area (34°56′S, 58°02′W) is located in the south of the Buenos Aires Horticultural productive region (Buenos Aires province, Argentina). It is characterized by a temperate climate with an average temperature of 16.2 °C, an annual average rainfall of 1040 mm, and an annual relative humidity of 77% [23]. The predominant soil type is argiudoll which is silty-loam in texture with abundant organic matter [22].

According to the last census performed in 2005, Buenos Aires province had 2934 horticulturists (80% of producers), and La Plata Horticultural rural area recorded 749 productive units [11]. Also, Lemmi [27] showed that horticulturists usually live in houses of precarious construction with the toilets, and water supply located outside, near to the productive area due to the pressure of work for leafy vegetable production [27].

The present study was carried out in the southeast of La Plata Horticultural rural area, in the neighborhoods of Abasto (sampling site 1), Melchor Romero (sampling site 2), Angel Etcheverry (sampling site 3), and El Peligro (sampling site 4) (Fig. 1).

2.2. Study design

A cross-sectional study was carried out between 2016 and 2018. The sample selection was non-probabilistic and largely determined by voluntary participation. This study included participants who gave written consent and who had not received parasitic treatment before the research started. Children without parental or guardian consent and people with chronic diseases or pathological conditions were excluded.

2.3. Samples collection

Information workshops on intestinal parasites and environmental sanitation were carried out in educational and health centers, and in the greenhouses of horticultural families. Workshops enabled interchange of knowledge between participants and an understanding of the biology and transmission of the intestinal parasites. Also, free parasitological tests were offered to all families and each participant was provided with two vials containing formalin 5% for stool samples and anal swabs to diagnose intestinal parasites. The samples were collected by parents or legal guardians during 5 successive days according to verbal and written instructions. Participants were asked to fill a vial with a nut-sized stool sample every day. Anal swabs were specifically obtained each morning before getting up by rubbing the perianal margins with sterile gauze.

2.4. Parasitological analysis

Stool samples were processed using the modified Ritchie and Sheather concentration techniques. The modified Ritchie technique is a biphasic (formalin-ethyl acetate) sedimentation technique, which uses an initial centrifugation as modification, for the detection of fecal
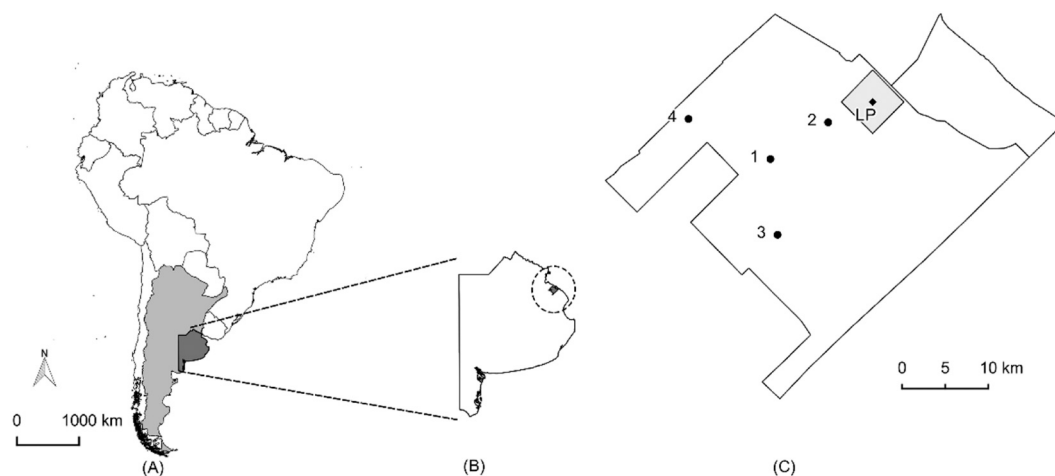

Fig. 1. Geographic location of Argentina in South America and Buenos Aires province in Argentina (A), District of La Plata (B) and rural sampling areas analyzed (C). LP: La Plata city; 1: Abasto (sampling site 1), 2: Melchor Romero (sampling site 2), 3: Angel Etcheverry (sampling site 3), 4: El Peligro (sampling site 4).

parasitic protozoa and helminths, recommended by the World Health Organization [52]. Together with this method, the Sheather technique, a flotation procedure in a saturated sucrose solution (δ: 1.3 g/ml), was also employed complementarily in the laboratory. The anal-swab vials were agitated vigorously and centrifuged for 10 min at 400 *g* to obtain a pellet with the highest possible concentration of *E. vermicularis* eggs [4,52]. The Ziehl-Neelsen technique was applied for observation of resistant acid-alcohol oocysts, and non-permanent stains such as lugol were used [21]. The observation was made with an optical microscope at $100\times$, $400\times$ and $1000\times$ magnifications. Identification of parasitic elements (eggs/larvae/cysts/oocysts) was based on their measurements and morphological characteristics [49,51].

2.5. Socio-sanitary and environmental analyses

The socio-sanitary and environmental analyses were carried out with semi-structured and non-invasive questionnaires which were answered by parents or legal guardians [12]. The living conditions of families were analyzed by taking account of the housing construction materials (walls and flooring), access to public services, overcrowding (more than three people per room), health insurance, food and monetary support, parents' education level, hygiene habits, parasitic knowledge prior to the intervention, and pet ownership, among others.

2.6. Statistical analyses

A sample was considered positive when at least one parasite species was observed by any diagnostic method. The prevalence was calculated as the number of parasitized participants divided by the total number of analyzed participants expressed as a percentage. Also, the number of parasite species was calculated in the analyzed population (specific richness). The percentage of parasitism was determined as mono-, bi- and polyparasitism (more than three parasite species per participant). The age was discriminated by age groups of 1-12 (preschoolers and schoolchildren), 13-17 (secondary school students), and ≥18 (adults) years. The association between species pairs, and between the intestinal parasites detected and the demographic characteristic were evaluated using the Chi- square test ($\chi2$) and, when the expected values were lower than 5, Fisher's exact test was performed. Also, risk factor variables for the detected species were considered according to a previous bibliographic search. Moreover, variables related to horticultural populations, such as nationality, prior knowledge of intestinal parasites, sampling site, health insurance, flooding, hygienic habits, education, housing construction materials (walls and flooring), wastewater disposal, waste disposal, overcrowding were analyzed individually or grouped in the conception of two indicators: family education indicator (FEI), and precariousness indicator (PI). The drinking water variable was not considered because the analyzed population had a protected well. Additionally, an exploratory analysis of the analyzed people in relation to the sampling site and the PI was carried out using a point's graphic.

Variables selected were introduced in a generalized linear model (GLM) of the binomial family to assess the change in parasitic prevalence by different predictor variables. The variables were: nationality, age groups, prior knowledge of intestinal parasites, hygienic habits, health insurance, sampling site, flooding, FEI and PI. The Akaike information criteria (AIC) were chosen to select the most parsimonious model. The goodness of fit of the model was evaluated by residual deviance and the variables with Wald statistics significant at 5%. All statistical analyses were processed using R software (version 3.5.0) [48].

2.7. Ethics statement

The study was carried out without affecting the physical, psychic or moral integrity of the participants, and protecting their identity. The present study was conducted according to the principles proclaimed in the Universal Declaration of Human Rights (1948), the ethical standards established by the Nüremberg Code (1947), the Declaration of Helsinki (1964), and its successive amendments were taken into consideration. Special attention was also paid to Article 5 from the Regulation Decree of National Law 25.326.

The Working Protocol of the research group was endorsed by the Central Consultative Committee of Bioethics of the National University of La Plata (Exp. No. 100–20,120/18).

All families received their parasitological diagnosis results in a written certificate. A workshop was held to develop effective preventive strategies based on the species found and the housing conditions of each family. Positive cases were referred to healthcare units for specific treatment.

3. Results

3.1. Parasitological analysis

Of the total vials offered it was only possible to recover 40.1%. The study included 350 participants, 54.9% (192/350) females and 45.1% (158/350) males, aged from 1 to 65 years old. The 63.1% (221/350) was represented by children between 1 and 12 years, 26.6% (93/350) between 13 and 17 years, and 10.3% (36/350) by ≥18 years. Of the total analyzed population, 79.1% (277/350) was parasitized by at least one parasite species. Among parasitized individuals, the females were more parasitized than the males (53.0% versus 46.9%, $p < 0.05$). Participants from 1 to 12 years were more parasitized than those from 13 to 17 years, and ≥ 18 years (66.8%, 24.9% and 8.3% respectively, $p < 0.05$).

The total number of parasite species detected was 12. Parasitic infections were more frequently caused by protozoa than helminths (73.7% versus 27.1%). *Blastocystis* sp. (58.9%), *E. vermicularis* (26.0%), *E. coli* (26.3%), and *G. lamblia* (24.0%) were the most prevalent species (Table 1).

Monoparasitism was more frequent (39.3%) than biparasitism (32.1%) and polyparasitism (28.5%). The maximum number of parasite species found in one person was 6. Statistically significant associations were observed between *E coli/Endolimax nana*, *E. coli/Iodamoeba bütschlii*, *E. coli/G. lamblia*, *E. coli/Hymenolepis nana*, *E. nana/ Blastocystis* sp., *E. nana/H. nana*, *G. lamblia/Enteromonas hominis*, and *G. lamblia/ E. vermicularis* ($p < 0.05$).

The modified Ritchie technique recovered a greater percentage of positive cases than the Sheather technique (96.0% versus 52.0%). Moreover, *E. hominis*, *Ascaris lumbricoides*, and *Strongyloides stercoralis* were only detected by the Ritchie technique. The highest percentage (26.0%) of *E. vermicularis* infection was detected in anal swabs.

Table 1

Absolute frequency and prevalence (%) of parasite species detected in the population from rural area.

Parasite species	Absolute frequency	Prevalence (%)[a]
Parasitized	277	79.1
Protozoa	258	73.7
Blastocystis sp.	206	58.9
Giardia lamblia	84	24.0
Cryptosporidium spp.	9	2.6
Entamoeba coli	92	26.3
Endolimax nana	51	15.7
Iodamoeba bütschlii	8	2.3
Chilomastix mesnili	6	1.7
Enteromonas hominis	2	0.6
Helminths	95	27.1
Enterobius vermicularis	91	26.0
Hymenolepis nana	4	1.1
Ascaris lumbricoides	2	0.6
Strongyloides stercoralis	1	0.3

[a] Prevalence estimated in relation to total number of analyzed population (*n* = 350).

3.2. Socio-sanitary and environmental analyses

The results obtained from the questionnaires showed that the families were composed of several nationalities: Bolivian (66.6%), Argentinians (26.6%), Paraguayans (3.7%) and Peruvians (0.6%), the Bolivian families being settled in the region for over 20 years. Also, the family education indicator (FEI) according to the parents' educational level was determined as a basic education corresponding to either an incomplete or complete primary level; a lower middle education corresponding to an incomplete secondary level, and a higher middle education that is defined by a complete secondary level. The FEI showed that most of the families had a basic educational level (66.3%), mainly having an incomplete primary level (56.0%). In respect to lower and higher middle education both were observed with low percentages (11.8%). Additionally, most of them attended public hospitals (91.4%) (Table 2).

On the other hand, 72.8% of the total population declared they did not own the land, and they worked in a framework of legal informality. The horticulturists analyzed received their water supply from a protected well (95.4%), and most of them used latrines, and septic tanks without cladding material for wastewater disposal (97.1%). In addition, they incinerated their domestic and planting waste (74.0%) as they had no access to appropriate public waste disposal services. Moreover, the participants had critical overcrowding (more than three people per room) (66.2%), and shared single beds (49.6%). Also, most houses were

flooded frequently (35.1%), and they had not received prior information on intestinal parasites (55.7%) (Table 3).

The PI was considered mild if houses had walls of sheet and wood and cement floors, septic tanks, public waste collection, and the families did not have a critical overcrowding; the PI was considered severe if houses had walls of sheet and wood and dirty floors, latrines, no public waste collection, and the families lived with critical overcrowding. Of the total population that was parasitized, 68.0% (238/350) showed the severe type of PI. The sampling sites 1, 2 and 4 had a high proportion of parasitized people with the severe type of PI. However, sampling site 3 showed a mild type of PI (Fig. 2).

Regarding the hygienic habits of the child-youth population, it was observed that they always washed their hands before eating (55.7%), and after going to the toilet (48.5%), and playing with pets (40.9%). Also, they always playing with soil (37.1%), walked barefoot (12.6%), and they had onychophagia (51.0%). Adult populations did not boil or chlorinate the drinking water (30.9% and 35.4%, respectively), and they always washed fruit and vegetables (41.6%).

The GLM analysis indicated that risk factors of intestinal parasites were the age group, sampling site and FEI. These results were obtained in comparison with the following reference scenario (age group 1–12, sampling site 2 and highly educated). The odds ratio was reduced by 20% as the age group increased to 13–17 (OR = 0.2, 95% IC: 0.06–0.60)

Table 2
Socio-economic variables of the analyzed population from rural area.

Socio-economic characteristics	Frequency[a]	
	n	%
Nationality		
Argentinian	93	26.6
Bolivian	233	66.6
Paraguayan	13	3.7
Peruvian	2	0.6
Not answered	9	2.6
Mother's education		
Unschooled	0	0.0
Primary	197	56.3
Secondary	55	15.7
Tertiary/University	0	0.0
Not answered	98	28.0
Father's education		
Unschooled	0	0.0
Primary	197	56.3
Secondary	46	13.1
Tertiary/University	0	0.0
Not answered	107	30.7
Mother's employment		
Unemployed/housewife	0	0.0
Temporary	349	99.7
Employed or freelance	1	0.3
Not answered	0	0.0
Father's employment		
Unemployed	0	0.0
Temporary	349	99.7
Employed or freelance	1	0.3
Not answered	0	0.0
Monetary support	165	47.6
Food support	23	6.6
Farming practice	350	100.0
Animal husbandry	59	17.0
Greenhouse	350	100.0
Health insurance	30	8.6
Pet ownership		
Dog	345	98.6
Cat	47	13.4

[a] Frequency was estimated in relation to the total population with socio-economic data (n = 350).

Table 3
Socio-environmental variables of the analyzed population from rural area.

Structural qualities and amenities	Frequency[a]	
	n	%
Lodging or house tenure status		
House owner	50	14.3
Lease holder	255	72.8
Free lodging	0	0.0
Not answered	45	12.9
Building materials		
Fired-brick masonry	104	29.7
Sheet and wood	246	70.3
Makeshift material	0	0.0
Not answered	0	0.0
Flooring		
Concrete or other	316	90.3
Dirt	31	8.9
Not answered	3	0.8
Wastewater disposal		
Sewage system	5	1.4
Septic tank	209	59.7
Latrine	131	37.4
Open-air defecation	5	1.4
Not answered	0	0.0
Drinking water (main source)		
Piped water system	16	4.6
Protected well	334	95.4
Public tap	0	0.0
Not answered	0	0.0
Solid waste disposal		
Public waste collection	67	19.1
Incineration or non-sanitary burial	259	74.0
Open-air pits	24	6.9
Non-answered	0	0.0
Flooding		
Never	156	44.6
Occasionally	90	25.7
Always	33	9.4
Not answered	71	20.3
Overcrowding (more than three people per room)	174	66.2
Bed-sharing	133	49.6
Received prior information on intestinal parasites	195	55.7

[a] Frequency was estimated in relation to the total population with socio-environmental variables data (n = 350).
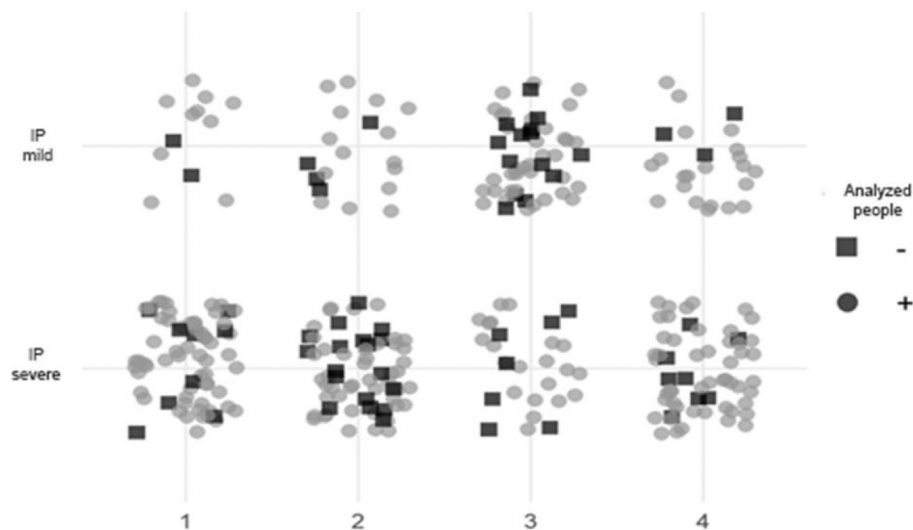
Fig. 2. Analyzed people correlated with the precariousness indicator and sampling site from rural area (1: Abasto, 2: Melchor Romero, 3: Angel Etcheverry, 4: El Peligro).

and in ≥18 years by 80% (OR = 0.8, 95% IC: 0.33–2.01). Also, it was either tripled in sampling site 1 (OR = 2.9, 95% IC: 1.22–7.38) or quadrupled in sampling site 3 and 4 (OR = 3.8, 95% IC: 1.64–9.97; OR = 4.1, 95% IC: 1.22–11.02). Finally, it was lower in half of the families with higher education than the average (OR = 0.5, 95% CI: 0.33–0.90) (Table 4).

4. Conclusions

This study provides parasitological and socio-environmental data related to a horticultural population from the La Plata Horticultural area, the most important rural region for leafy vegetable production in Argentina. In this regard, knowledge of the parasitic epidemiology of these horticultural families would be of utmost importance to public health. Furthermore, these results increased the parasitological knowledge in La Plata Horticultural area, of which there are few studies.

The prevalence of intestinal parasites in farming families was elevated (79.1%). This result was similar to that observed by Zonta et al. [55] in northeast the La Plata Horticultural rural area (83.8%) [55]. In this sense, when comparing these populations, we observed that both present limited access to public services (wastewater disposal, drinking water and solid waste disposal). However, the farming practices in these rural areas were different, for example in the northeast most vegetable production was realised in orchards with organic fertilizer, whereas in the southeast it was with the greenhouse technology and chemical fertilizers [13,38]. Also, studies carried out in other populations in non-productive areas of La Plata city showed lower prevalence values

Table 4
Risk factors for intestinal parasites in the analyzed population from rural area[a].

Risk factors	Model coefficients			
	β	SE	OR	*P* value
Participants from 13 to 17 years	−1.6	0.6	0.2	0.01**
Participants ≥18 years	−0.2	0.5	0.8	0.66
Sampling site 1	1.1	0.5	2.9	0.03*
Sampling site 3	1.4	0.5	4.1	0.01**
Sampling site 4	1.3	0.6	3.8	0.04*
Basic education	−0.6	0.3	0.5	0.04*

β (beta): regression coefficient; SE: standard error; OR: odds ratio.
  * p value <0.05.
  ** p value <0.01.
  [a] Other models were considered but only the ones selected are shown. Selected model: Residual deviance = 183.8; Akaike Information Criterion = 197.8.

(65.0%) [17,37]. This difference in prevalence values may be because this region is located between urban and rural areas, and consequently shows an intermediate situation regarding access to public services. Moreover, studies carried out in rural areas in neighboring countries indicated a prevalence of intestinal parasites between 62.0% and 73.0%. This variation could be related to the environmental heterogeneity, and the different cultural and social patterns of analyzed populations [3,14,24,26].

In this research monoparasitism was more frequent (39.0%). This result was similar to that observed by Oyhenart et al. [37] in another area in the city of La Plata with limited access to public services (43.5%) [37]. However, other studies showed that polyparasitism was more frequent, suggesting that participants are constantly exposed to infestation with different species of parasites [33,55]. Likewise, *Blastocystis* sp. showed the highest value of prevalence in the protozoa, followed by *E. coli* and *G. lamblia* (58.9%, 26.3% and 24.0%, respectively). The presence of *Blastocystis* sp. (species of controversial pathogenesis) and *G. lamblia* (a pathogenic species) could be explained by their cosmopolitan distribution and their main transmission route through the consumption of contaminated water and vegetables [36]. In this sense, the lack of piped water and sewage systems observed in the analyzed population, as well as the high frequency of species indicators of fecal contamination (*E. coli* and *E. nana*), showed that the ground water was contaminated due to the overflow of septic tanks. In addition, the association observed between pairs of species, such as *E. coli/G. lamblia*, *E. coli/H. nana*, *E. nana/ Blastocystis* sp., *E. nana/H. nana*, would show the frequency of non-pathogenic species as indicators of the sanitary conditions of a population, and this kind of information may be useful in practical terms for healthcare because it could indicate the presence of other pathogenic microorganisms, such as bacteria and viruses [25].

The most prevalent helminth species was *E. vermicularis* (26.0%). The transmission of this species by the anus-hand-mouth route or by inhalation of eggs is favored by habits, such as onychophagy, overcrowding, and sharing beds and clothes. These habits were frequent in both the horticultural population, and in populations analyzed by other authors [2,10]. Finally, different studies have highlighted that the parasitic species *Blastocytis* sp., *G. lamblia*, and *E. vermicularis* are the most frequent in Argentina [25,32].

The prevalence of geohelmints was low with *A. lumbricoides* and *S. stercoralis* being the only species detected (0.6% and 0.3%, respectively). Moreover, studies in the La Plata city by Gamboa et al. [17], and Cociancic et al. [12] showed prevalence of geohelminth values between 1.4 and 4.7% [12,17]. Also, geohelminths are more prevalent in the

north of the country since they require warm climates and high humidity for their development [41,46]. Furthermore, the viability of geo-helminths depends on the conditions of the substrate. The use of agro-chemicals, and the type of intensive production with greenhouse technology affect the chemical and physical properties of the soil (e.g. high salinization, alkalization and compaction of the substrate) [19]. In addition, the present study showed that the horticultural population has been settled in the region for more than 20 years, although it came from endemic areas of these intestinal parasites. Thus, it is important to highlight that the settling of Bolivian families in the region and their cultivation practices determine a substantial limitation to the development of soil-transmitted helminths.

The modified Ritchie technique gathers more parasitological information than the Sheather technique. Likewise, Navone et al. [31] in a comparative study of parasitic concentration techniques recommended the use of least one complementary flotation technique [31,52].

The PI showed a direct relationship between a severe precariousness type and a high proportion of parasitized people in at least three (sampling sites 1, 2 and 4) of the four sampling sites evaluated. In this sense, it was observed that all sites have similar housing construction materials (walls and flooring). However, sampling sites 1, 2 and 4 had latrines and septic tanks of precarious construction, and the participants incinerated their domestic and planting waste. Conversely, sampling site 3 had high access to public waste collection, but only septic tanks for wastewater disposal. In relation to the hygienic habits, it was observed that families did not have the habits of boiling or chlorinating water or of washing their hands before eating, or after going to the toilet. Finally, most participants had incomplete primary level education, and had not received any information on intestinal parasites. Different studies carried out in vulnerable populations showed that sanitary conditions, hygienic habits and access to education are the most important factors in the transmission of these infections [29,47].

The GLM analysis indicated that the risk factors of intestinal parasites in the analyzed populations were the sampling site, family education indicator and age group. These results were similar to studies in Bolivia and in different Argentine provinces, where higher parasitoses were found in rural populations than in urban ones [30,32]. In this sense, the differences observed in sampling sites 1, 3 and 4 in respect to site 2, could be explained by a greater distance to the urban area and consequently, greater rurality (with limited scope to public and health services). Furthermore, the distance to schools and access to education are of utmost importance for knowledge about preventive strategies of diarrheal infections and diseases. These results were similar to those of Garraza et al. [20] and Cociancic et al. [12], when they observed that a lower educational level increases the percentage of parasitized people [12,20]. In respect to age group, children from 1 to 12 years old were the most parasitized, and this trend was reduced as the age group increased. This could be explained by the gradual learning of hygienic habits by the younger children (e.g. hand washing) and their relationship with the environment. In this sense, it is important to highlight that the immune system of young children (i.e. under 12 years) is not completely developed and consequently they become infected with more frequent because they are more exposed to the transmission cycles of intestinal parasites (contact with the soil and insufficient hygiene). Also, a study by Brito Núñez et al. [7] showed high prevalence of intestinal parasites in children living in an unhealthy environmental context [7].

The high prevalence of intestinal parasites in horticultural families is associated with inadequate environmental sanitation, a limited access to education, and insufficient hygienic habits. In this context, we understand that both the identification of the etiological agent of a disease and a social and integral view of health are required before implementing possible control measures. In this respect, most horticulturists are migrants of irregular conditions, and this situation limited their access to land ownership, affecting the possibility of building a fired-brick house, and contributing to critical overcrowding with limited access to drinking water and/or a proper sewage system [28]. Therefore, it is necessary to create programs based on the different social realities of the families analyzed, and to intensify health education.

It is expected that preventive strategies, based on the resources available in the population and the knowledge acquired during the workshops, would reduce the risk of infections that affect horticultural families. Furthermore, these conditions could be resolved by following the recommendations of the World Health Organization which recognizes that the information obtained in this type of integrated analysis would reduce health inequities through relevant epidemiological programs and social policies. Therefore, an increase in parasitological references in integrated studies (human, animal and environmental health) through interdisciplinary strategies would result in an understanding of the parasitic etiology in the populations involved and the development of effective actions for the control and prevention of intestinal parasites.

Limitation.

The rural context of horticultural families, the difficult access to the streets and houses aggravated by climatic conditions, and a change in the productive unit due to increase in rentals did not allow a greater scope of analysis. However, the collaboration of horticultural labor cooperatives was highly active, and of the total of 876 vials offered it was possible to recover 350 samples, but it was not possible to obtain fresh stool samples to apply other diagnostic techniques (e.g. PCR). Despite those limitations, the results of this study revealed very important parasitological information, and showed the need to increase parasitological references in food producing families.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] A. Abossie, M. Seid, Assessment of the prevalence of intestinal parasitosis and associated risk factors among primary school children in Chencha town, southern Ethiopia, BMC Public Health 14 (2014) 1–8, https://doi.org/10.1186/1471-2458-14-166.

[2] T.S. Anuar, L. Jalilah, M. Norhayati, M.Y. Azlin, M.S. Fatmah, H.M. Al-Mekhlafi, New insights of Enterobius vermicularis infection among preschool children in an urban area in Malaysia, Helminthologia 53 (1) (2016) 76–80.

[3] M. Barra, L. Bustos, X. Ossa, Desigualdad en la prevalencia de parasitosis intestinal en escolares de una escuela urbana y dos rurales de la comuna de Puerto Montt, Rev. Med. Chil. 144 (2016) 886–893, https://doi.org/10.4067/S0034-98872016000700009.

[4] M. Becerril Flores, R. Romero Cabello, Parasitología médica: De las moléculas a la enfermedad, 2004.

[5] R. Benencia, Horticultores bolivianos en el interior de la Argentina. Procesos de inmigración, trabajo y asentamiento conflictivo, Relac. Int. UAM 36 (2017) 197–214, https://doi.org/10.15366/relacionesinternacionales2017.36.010.

[6] R. Bracciaforte, M.F. Díaz, V. Vottero Pivetta, V. Burstein, H. Varengo, M.Á. Orsilles, Enteroparásitos en niños y adolescentes de una comuna periurbana de la provincia de Córdoba, Acta Bioquím. Clín. Latinoam. 44 (2010) 353–358.

[7] J.D. Brito Núñez, J.A. Landaeta Mejías, A.N. Chávez Contreras, P.K. Gastiaburú Castillo, Y.Y. Blanco Martínez, Prevalencia de parasitosis intestinales en la

comunidad rural apostadero, Municipio Sotillo, Estado Monagas, Venezuela, Rev. Científica Cienc. Médica 20 (2017) 7–14.

[8] G. Cardozo, M. Samudio, Factores predisponentes y consecuencias de la parasitosis intestinal en escolares paraguayos, Pediatría (Asunción) 44 (2017) 117–125, https://doi.org/10.18004/ped.2017.agosto.117-125.

[9] L. Celia, G. Jumbo, M.C. del Luzuriaga, I. Zúñiga, Intestinal parasitosis in children from 1 to 3 years of the good living centers of children in zone 7 - Ecuador, Espirales Rev. Multidiscip. Investig. Científica 3 (2019) 110–120, doi:10.31876.

[10] K.Y. Chen, C.M. Yen, K.P. Hwang, L.C. Wang, *Enterobius vermicularis* infection and its risk factors among pre-school children in Taipei, Taiwan, J. Microbiol. Immunol. Infect. 51 (2018) 559–564, https://doi.org/10.1016/j.jmii.2016.12.013.

[11] CHFBA, Censo hortiflorícora de la Provincia de Buenos Aires, 2005.

[12] P. Cociancic, M.L. Zonta, G.T. Navone, A cross-sectional study of intestinal parasitoses in dogs and children of the periurban area of La Plata (Buenos Aires, Argentina): zoonotic importance and implications in public health, Zoonoses Public Health 65 (2018) e44–e53, https://doi.org/10.1111/zph.12408.

[13] J.P. Del Río, J.A. Maidana, A. Molteni, M. Pérez, M.L. Pochettino, L. Souilla, E. Turco, El rol de las "quintas" familiares del Parque Pereyra Iraola (Buenos Aires, Argentina) en la conservación de la agrobiodiversidad, Kurtziana 33 (1) (2007) 217–226.

[14] V. Díaz, P. Funes, G. Echagüe, L. Sosa, I. Ruiz, J. Zenteno, L. Rivas, D. Granado, Estado nutricional-hematológico y parasitosis intestinal de niños escolares de 5 a 12 años de cuatro localidades rurales de Paraguay, Memorias Inst. Investig. Ciencias Salud 16 (2018) 26–32.

[15] S. Erismann, S. Diagbouga, P. Odermatt, A.M. Knoblauch, J. Gerold, A. Shrestha, T. Grissoum, A. Kaboré, C. Schindler, J. Utzinger, G. Cissé, Prevalence of intestinal parasitic infections and associated risk factors among schoolchildren in the plateau central and Centre-Ouest regions of Burkina Faso, Parasit. Vectors 9 (2016) 1–14, https://doi.org/10.1186/s13071-016-1835-4.

[16] S. Fletcher, G. Caprarelli, J. Merif, D. Andresen, S. Van Hal, D. Stark, J. Ellis, Epidemiology and geographical distribution of enteric protozoan infections in Sydney, Australia, J. Public Health Res. 3 (2014) 83–91, https://doi.org/10.4081/jphr.2014.298.

[17] M.I. Gamboa, L.A. Giambelluca, G.T. Navone, Distribución espacial de las parasitosis intestinales en la Ciudad de La Plata, Med. (Buenos Aires) 74 (2014) 363–370.

[18] M.I. Gamboa, L.E. Kozubsky, M.E. Costas, M. Garraza, M.I. Cardozo, M.L. Susevich, P.N. Magistrello, G.T. Navone, Asociación entre geohelmintos y condiciones socioambientales en diferentes poblaciones humanas de Argentina, Rev. Panam. Salud Publica. 26 (2009) 1–8, https://doi.org/10.1590/s1020-49892009000700001.

[19] M. García, Horticultura de La Plata (Buenos Aires). Modelo productivo irracionalmente exitoso, Rev. Fac. Agron. 114 (2015) 190–201.

[20] M. Garraza, M.L. Zonta, E.E. Oyhenart, G.T. Navone, Estado nutricional, composición corporal y enteroparasitosis en escolares del departamento de San Rafael, Mendoza, Argentina, Nutr. Clin. y Diet. Hosp. 34 (2014) 31–40, https://doi.org/10.12873/341garraza.

[21] R. Girard de Kaminsky, Manual de parasitología: técnicas para laboratorio de atención primaria de la salud y para el diagnóstico de las enfermedades infecciosas desatendidas, OPS 2012 (2014), https://doi.org/10.1017/CBO9781107415324.004.

[22] M.A. Hurtado, J.E. Giménez, M.G. Cabral, M. Da Silva, O.R. Martínez, M.F. C. Camillón, C.A. Sánchez, D. Muntz, J.A. Gebhard, L. Forte, L. Bof, A. Crincoli, H. Lucesoli, Análisis ambiental del Partido de La Plata, Aportes al Ordenamiento Territorial, Instituto de Geomorfología y Suelos, 2006.

[23] P. Imbellone, L. Mormeneo, Vertisoles hidromórficos de la planicie costera del Río De La Plata, Argentina, Ciencia del Suelo. 29 (2011) 108.

[24] E. Jacinto, E. Aponte, V. Arrunátegui-Correa, Prevalencia de parásitos intestinales en niños de diferentes niveles de educación del distrito de San Marcos, Ancash, Perú. Rev. Medica Hered. 23 (2012) 235–239.

[25] M.M. Juárez, V.B. Rajal, Parasitosis intestinales en Argentina: Principales agentes causales encontrados en la población y en el ambiente, Rev. Argent. Microbiol. 45 (2013) 191–204, https://doi.org/10.1016/S0325-7541(13)70024-5.

[26] E. Lacoste Laugart, F.M. Rosado García, F.Á. Núñez, M.S. Rodríguez Peña, I. C. Medina Fundora, R. Suárez Medina, Aspectos epidemiológicos de las parasitosis intestinales en niños de Vegón de Nutrias, Venezuela Aspects on children epidemiology of intestinal parasites in Vegón Nutrias, Venezuela, Rev. Cubana Hig. Epidemiol. 50 (2012) 330–339.

[27] S. Lemmi, Conflicto y organización en la horticultura del Gran La Plata (Buenos Aires, Argentina), 1994-2002, Rev. Interdiscip. Estud. Agrar. 43 (2015) 28.

[28] S. Lemmi, M.A. Waisman, Movilidad social y recambio étnico nacional en la horticultura platense, in: V Seminario Internacional Desigualdad y Movilidad Social en América Latina 31 de mayo y 1° y 2 de junio de 2017 Ensenada, Argentina, Universidad Nacional de La Plata. Facultad de Humanidades y Ciencias de la Educación. Centro Interdisciplinario de Metodología de las Ciencias Sociales, 2017.

[29] T.A. Lucero-Garzón, L.A. Álvarez-Motta, J.F. Chicue-López, D. López-Zapata, C. A. Mendoza-Bergaño, Parasitosis intestinal y factores de riesgo en niños de los asentamientos subnormales, Florencia-Caquetá, Colombia, Rev. Fac. Nac. Salud Pública 33 (2015) 171–180, https://doi.org/10.17533/udea.rfnsp.v33n2a04.

[30] F. Macchioni, H. Segundo, S. Gabrielli, V. Totino, P. Gonzales Rojas, E. Salazar, R. Bozo, A. Bartoloni, G. Cancrini, Dramatic decrease in prevalence of soil-transmitted helminths and new insights into intestinal protozoa in children living in the Chaco Region, Bolivia, Am. Soc. Trop. Med. Hyg. 92 (2015) 794–796, https://doi.org/10.4269/ajtmh.14-0039.

[31] G.T. Navone, M.I. Gamboa, L.E. Kozubsky, M.E. Costas, M.S. Cardozo, M. N. Sisliauskas, M. Gonźlez, Estudio comparativo de recuperación de formas parasitarias por tres diferentes métodos de enriquecimiento coproparasitológico, Parasitol. Latinoam. 60 (2005) 178–181, https://doi.org/10.4067/s0717-77122005000200014.

[32] G.T. Navone, M.L. Zonta, P. Cociancic, M. Garraza, M.I. Gamboa, L.A. Giambelluca, S. Dahinten, E.E. Oyhenart, Estudio transversal de las parasitosis intestinales en poblaciones infantiles de Argentina, Rev. Panam. Salud Publica. 41 (2017) 1–9, https://doi.org/10.26633/RPSP.2017.24.

[33] J. Nematian, E. Nematian, A. Gholamrezanezhad, A.A. Asgari, Prevalence of intestinal parasitic infections and their relation with socio-economic factors and hygienic habits in Tehran primary school students, Acta Trop. 92 (3) (2004) 179–186.

[34] R. Ngui, S. Ishak, C.S. Chuen, R. Mahmud, Y.A.L. Lim, Prevalence and risk factors of intestinal parasitism in rural and remote West Malaysia, PLoS Negl. Trop. Dis. 5 (2011) 1–7, https://doi.org/10.1371/journal.pntd.0000974.

[35] OPS, Neglected infectious diseases in the Americas, in: Success stories and innovation to reach the neediest, 2016, p. 2016.

[36] M. Osman, D. El Safadi, A. Cian, S. Benamrouz, C. Nourrisson, P. Poirier, B. Pereira, R. Razakandrainibe, A. Pinon, C. Lambert, I. Wawrzyniak, F. Dabboussi, F. Delbac, L. Favennec, M. Hamze, E. Viscogliosi, G. Certad, Prevalence and risk factors for intestinal protozoan infections with *Cryptosporidium* sp., *Giardia* sp., *Blastocystis* sp. and *Dientamoeba* sp. among schoolchildren in Tripoli, Lebanon, PLoS Negl. Trop. Dis. 10 (2016) 1–17, https://doi.org/10.1371/journal.pntd.0004496.

[37] E.E. Oyhenart, M. Garraza, M.L. Bergel, M.F. Torres, L.E. Castro, M.A. Luis, L. M. Forte, M.I. Gamboa, M.L. Zonta, M.F. Cesani, F.A. Quintero, M.E. Luna, G. T. Navone, Caracterización del estado nutricional, enteroparasitosis y condiciones socio-ambientales de la población infanto-juvenil del partido de La Plata, Rev. Argentina Antropol. Biológica 15 (2013) 47–60, https://doi.org/10.17139/raab.2013.0015.1.

[38] M. Pérez, G. Tito, E. Turco, La producción sin agrotóxicos del Parque Pereyra Iraola:¿ un sistema agroalimentario localizado en el periurbano, in: I. Velarde, A. Maggio, J. Otero (Eds.), (comps.), Sistemas agroalimentarios localizados en Argentina, 2008, pp. 102–121.

[39] R.L. Pullan, S.J. Brooker, The global limits and population at risk of soil-transmitted helminth infections in 2010, Parasit. Vectors 5 (2012) 1–14, https://doi.org/10.1186/1756-3305-5-81.

[40] L. Quihui, M.E. Valencia, D.W. Crompton, S. Phillips, P. Hagan, G. Morales, S. P. Díaz-Camacho, Role of the employment status and education of mothers in the prevalence of intestinal parasitic infections in Mexican rural schoolchildren, BMC Public Health 6 (2006) 1–8, https://doi.org/10.1186/1471-2458-6-225.

[41] M.R. Rivero, C. De Angelo, P. Nuñez, M. Salas, C.E. Motta, A. Chiaretta, O. D. Salomón, S. Liang, Environmental and socio-demographic individual, family and neighborhood factors associated with children intestinal parasitoses at Iguazú, in the subtropical northern border of Argentina, PLoS Negl. Trop. Dis. 11 (2017) 1–26, https://doi.org/10.1371/journal.pntd.0006098.

[42] M.R. Rivero, C. De Angelo, P. Nuñez, M. Salas, S. Liang, Intestinal parasitism and nutritional status among indigenous children from the Argentinian Atlantic Forest: determinants of enteroparasites infections in minority populations, Acta Trop. 187 (2018) 248–256.

[43] J.P. Ruiz-Taborda, A. Casas-Valencia, J.A. Cardon-Arias, Análisis del parasitismo intestinal y la malnutrición en Suramérica desde sus determinantes sociales, CES Salud Pública 8 (2018) 25–33.

[44] E. Saathoff, A. Olsen, B. Sharp, J.D. Kvalsvig, C.C. Appleton, I. Kleinschmidt, Ecologic covariates of hookworm infection and reinfection in rural Kwazulu-Natal/South Africa: a geographic information system-based study, Am. Soc. Trop. Med. Hyg. 72 (2005) 384–391, https://doi.org/10.4269/ajtmh.2005.72.384.

[45] A.L. Sanchez, J.A. Gabrie, M.T. Usuanlele, M.M. Rueda, M. Canales, T.W. Gyorkos, Soil-transmitted helminth infections and nutritional status in school-age children from rural communities in Honduras, PLoS Negl. Trop. Dis. 7 (2013) 1–9, https://doi.org/10.1371/journal.pntd.0002378.

[46] M.E. Socías, F. Anabel, J.F. Gil, A.J. Krolewiecki, Geohelmintiasis en la Argentina: Una revisión sistemática, Med. (Buenos Aires) 74 (2014) 29–36.

[47] M. Solano-Barquero, A. Montero-Salguero, D. León-Alán, C. Santamaría-Ulloa, A. M. Mora, L. Reyes-Lizano, Prevalence of parasitosis in children aged 1 to 7 years in vulnerable condition in the south central region of Costa Rica, Acta Med. Costarric. 60 (2018) 19–29.

[48] Team Core, R: A Language and Environment for Statistical Computing, Austria. R Found. Stat. Comput, Vienna, 2015.

[49] D. Thienpont, F. Rochette, O. Vanparijs, Diánostico de las helmintiasis por medio del examen coprológico, 1979.

[50] A. Vilajeliu Balagué, P.D.L. Heras Prat, G. Ortiz-Barreda, M.J. Pinazo Delgado, J. Gascón Brustenga, A. Bardají Alonso, Parasitosis importadas en la población inmigrante en España, Revista Española de Salud Pública 88 (6) (2014) 783–802.

[51] WHO, Medios Auxiliares para el diagnóstico de las parasitosis intestinales, 1994.

[52] WHO, Basic Laboratory Methods in Medical Parasitology, OMS, Geneva, 1991.

[53] M. Zonta, M. Bergel, P. Cociancic, M. Gamboa, M. Garraza, M. Cesani, E. Oyhenart, G. Navone, Enteroparasitosis en niños de Villaguay, Entre Ríos: Un estudio integrado al estado nutricional y al ambiente, Rev. Argentina Parasitol. 1 (2013) 86–108.

[54] M.L. Zonta, E.E. Oyhenart, G.T. Navone, Socio-environmental variables associated with malnutrition and intestinal parasitoses in the child population of Misiones, Argentina, Am. J. Hum. Biol. 26 (2014) 609–616, https://doi.org/10.1002/ajhb.22570.

[55] M.L. Zonta, M.L. Susevich, M.I. Gamboa, G.T. Navone, Parasitosis intestinales y factores socioambientales: Estudio preliminar en una población de horticultores, Salud(i)Ciencia 21 (2016) 814–822, https://doi.org/10.21840/siic/147782.