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An eco-epidemiological study of contamination of soil with infective forms of intestinal parasites

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Abstract. The objectives of the present work were to screen topsoil samples collected from public squares in two cities within the Argentine Patagonia for the presence of infective forms of intestinal parasites and to examine the possible relationship between positive findings and the environmental, socioeconomic, and cultural conditions of that region. For this purpose we studied 13 public squares, their 13 custodians, and 44 family groups within their respective surrounding areas. Of the 226 topsoil samples analyzed, 44.3% proved positive for infective forms of intestinal parasites, with 17.3% of these containing more than one species. The frequency of appearance of positive samples was dependent on the season of the year ($p < 0.001$), while presence of the parasites was related to the soil pH ($p < 0.05$) but independent of the soil relative humidity ($p > 0.05$). Some of the organisms detected are associated with zoonoses. We observed the presence of *Capillaria* spp. and *Spirocerca* spp. under cool desert climatic conditions. Within the group of custodians we detected hematologic alterations one positive serology for toxoplasmosis and documented behavior conducive to risk of infection with the parasites found in those squares. Within the family group an acquaintance with parasitic zoonoses and their prevention was an inconsistent finding, with toxocarosis and toxoplasmosis being the diseases associated with the greatest degree of ignorance. Furthermore, we consider the failure to deparasitize pets and the practice of feeding them with raw meat, as typically found in our family survey, to be factors contributing to a greater likelihood of public square contamination. From the results obtained here, we propose a spatial organization approach for the purpose of detecting zones at risk of contracting zoonotic parasitoses within urban environments.

Key words: Contamination, Intestinal parasites, Patagonia Argentina, Socioeconomic factors, Top soil, Zoonoses

Abbreviations: IFIPs = infective forms of intestinal parasites; INDEC = National Institute of Statistical and Census; IPs = intestinal parasites; Md = middle; Mo = mode; $Q = Q$ coefficient; RH = relative humidity; SD = standard deviation; μS = micro Siemens; VC = variation coefficient; $\bar{x}$ = mean

Introduction

Numerous socioeconomic, cultural, and environmental conditions contribute to the presence and propagation of parasitoses [1–4]. The ingestion of oocysts, cysts, or ova as well as the penetration of the skin by infectious larvae constitute entrance routes for disease producing parasites in man. *Toxoplasma gondii*, *Entamoeba histolytica*, *Echinococcus granulosus*, *Toxocara canis*, and *Ancylostoma* spp. are pathogens exemplifying these modes of contagion [5].

The soil can be a source of pathogenic parasites for humans. *Ascaris lumbricoides*, *Toxocara* spp., and *Taenia* spp. ova as well as *Giardia* spp. and *Entamoeba* spp. cysts have been recovered in soil specimens obtained from public places in studies conducted over periods of less than one year in duration [6–10].

A measure of the degree of contamination of soil by infectious parasites has been proposed as an indicator of a population's risk of contracting parasitoses [11]. A comparative study of the frequency of appearance in soil of infective forms of intestinal parasites (IFIPs) over the four seasons of the year should allow an advance in our understanding of the variation that occurs annually in the parasitic burden as a result of the typical seasonal changes in the different meteorologic parameters within a given geographical region.

The specific characteristics of an urban environmental, socioeconomic, and cultural system are essential considerations when attempting to implement measures for the effective control of IFIP infection within a given population since a parasite is inextricably dependent on both its host(s) and its environment [1]. No prior studies within this region have investigated soil contamination with IFIPs in relation to socioeconomic, cultural, and physicochemical environmental variables.

The objective of the present work was thus to screen topsoil samples collected from public squares in two cities within the Argentine Patagonia for the presence of IFIPs and to examine the possible relationship between variations in the level of those pathogens and the afore mentioned societal factors as well as the changes in the climatic conditions that normally occur during the seasons of the year.

Materials and methods

We carried out this work in the form of two studies:

Environmental study

This experimental approach involved a longitudinal model that took place throughout the different seasons of the year from the beginning of July, 1999 through the end of June, 2000 and included three of the five public squares in the city of Rada Tilly as well as 10 of the 55 in Comodoro Rivadavia. These cities lie within 10 km of each other, with both being located in the extreme southeast of the Province of Chubut within the Argentine Patagonia (45° S, 68° W).

In each public square selected we collected at random a conglomerate sampling of five specimens of topsoil. From each spot we transferred about 200–300 g of earth within a debris free area of 10 cm^2 to a resealable polyethylene bag and kept the samples at 4 °C until processing. As a pretreatment, each specimen was triturated and homogenized and an aliquant of 2 g sieved and dried in an oven at 25 °C for 24 h. The moisture free material was then processed by means of the Sheather flotation and Telemann and formol acetate sedimentation techniques before examination in duplicate by optical microscopy both with and without Lugol's iodine for the presence of IFIPs. We use morphological criteria to differentiate and identify soil nematode larvae.

We measured the in situ temperature and determined the conductivity, pH, and humidity of the soil, using a Hanna HI 8424 pH meter (accuracy, ± 0.01 pH unit) and a Parsec Inc. conductivimeter (standard error, 1%) with the paste of each soil sample [12]. We determined humidity by a gravimetric method using an Acculab V-200 balance (readability, 0.01 g) and expressed the data as relative humidity (RH). For this purpose we dried portions of 30 g of each soil sample to constant weight at 105 °C.

The meteorological data on temperature, rainfall, and winds came from the daily records of the Davies Meteorological Station and the harbor station of the Georeference Information Base of the National University at San Juan Bosco in the Patagonia.

For the cartographic representation of the data we utilized the Map Maker Pro software.

Population study

This approach involved a transverse study model extending from November, 2000 to November, 2001. For this study we defined two different population groups based on the probable risk of exposure to the IFIPs found at each of the previously studied squares.

Group 1, characterized by a major exposure level, was composed of 13 square caretakers. Each worker was orally interviewed in order to obtain information about habits and job practices. We then performed serological studies to screen for toxoplasmosis, toxocarosis, cystic hydatid disease, and hematological status after obtaining their written consent. These assays consisted in the indirect hemoagglutination (HAI, Wiener Lab) and confirmatory ELISA test (Abbot Laboratories) for toxoplasmosis, the ELISA test (Melotest) for toxocarosis, and the k-elisa (made in Prevalence Disease Laboratories, Chubut Province, Argentine) for hydatidosis.

Group 2, characterized by a low exposure level, included the people living within a radius of five blocks of the public squares studied. We carried out a semistructured survey by visitation and oral interview of the housewife or the chief family member of each home. The information sought after was the person's understanding of zoonotic parasites, their access to public health information, their daily practices with pets, and their socioeconomic status. For the last of these variables, we used the National Institute of Statistical and Census (INDEC) criteria involving the following indicators: dwelling characteristics, number of inhabitants per room, drinking water supply, excrement disposal system, work activity, medical insurance coverage of the head of the household, and combined family income. We then evaluated these indicators quantitatively in order to assign each family group to a corresponding INDEC socioeconomic class on the basis of the total score obtained. For this purpose we used a random process to select 2% of the total family groups ($n = 2300$) who are living in those areas.

We performed statistical analysis of the data obtained using the Chi Square independence test (χ^2), the homogeneous proportion test, and Yule's Q coefficient to association degree estimation. We considered a value of Q greater than 0.61 as a strong degree of association, a value between 0.41 and 0.61 as a moderate one, and Q values between 0.21 and 0.40 as weak association. Values of Q lower than 0.21

have no correlation with association [13]. We took a p value of greater than or equal to 0.05 as grounds for accepting the null hypothesis.

Results

Environmental study

During the studied period between the beginning of July, 1999 and the end of June, 2000, we analyzed 226 topsoil samples. Of these, 100 (44.3%) proved positive for IFIPs, while 39 (17.3%) contained more than one species of pathogen. Table 1 shows the distribution of the frequency of appearance of these contaminants according to the season of the year with respect to both the number of positive samples and the number of those that contained more than one species. The differences among these data throughout the year were highly significant ($p < 0.001$).

Among these same topsoil samples, we detected the presence of helminths in 82 (36.3%) and of protozoa in 74 (32.7%) of the total examined, with the distributions of these two parasite classes being independent of one another ($p = 0.42$). The appearance frequencies of protozoa and helminths during the period evaluated also proved to be independent of one other ($p > 0.05$). The ratio between the appearances of these two classes of contaminants protozoa/helminthes during the four seasons of the year was 1/1.1 in summer, 1/5.6 in autumn, 1/8 in winter, and 1/1.6 in spring.

Table 2 shows the nature of the IFIPs found and the seasonal distribution of their appearance frequencies along with the corresponding probability values for the association of this latter parameter with the season. In this regard, we found that whereas the presence of *T. gondii*-like oocysts and *Entamoeba* spp. was associated with seasonal variations ($p < 0.001$), the appearance frequency of *Toxocara* spp. and nematode larvae exhibited no such dependence on the season of the year ($p > 0.05$). Because of the low appearance frequency obtained from the other genera we could not estimate their individual p values. Table 3 summarizes the seasonal variations in the climatic parameters that were under consideration as possible influences in the establishment of parasites in the area sampled.

Figure 1 is a cartographic representation of the appearance frequency of *Taenia* spp./*Echinococcus* spp. eggs within the city of Comodoro Rivadavia.

The parasitic forms recovered were the following: cysts (*Entamoeba* spp.), oocysts (*Isospora* spp., *Toxoplasma gondii*-like), larvate or embryonate eggs

Table 1. Frequency of topsoil samples positive for IFIPs from the squares of Comodoro Rivadavia and Rada Tilly, Province of Chubut, in the Argentine Patagonia during the period beginning in July, 1999 and ending in June, 2000

Positive topsoil samples	Winter	Spring	Summer	Autumn
Total number studied	51	65	58	52
Number of positive samples for IPs	15	46	25	14
(%)	(29)	(71)	(43)	(27)
Number of positive polyparasite samples	3	20	12	4
(%)	(5.9)	(31)	(21)	(7.7)

Table 2. Frequency of IFIPs found in topsoil samples from the squares of Comodoro Rivadavia and Rada Tilly, Province of Chubut, in the Argentine Patagonia from the period beginning in July, 1999 and ending in June, 2000

	Number of samples (%)				
Intestinal parasites	Winter	Spring	Summer	Autumn	p
Total number of samples	51 (100)	65 (100)	58 (100)	52 (100)	
Protozoa	2 (3.9)	56 (86)	13 (22)	3 (5.7)	NC[a]
Isospora spp.	1 (2.0)	–	3 (5.2)	–	<0.001
Toxoplasma gondii-like	1 (2.0)	27 (42)	4 (6.9)	1 (1.9)	<0.001
Entamoeba spp.	–	29 (45)	6 (10)	2 (3.8)	
Helminths	16 (31)	34 (52)	15 (26)	17 (33)	0.95
Toxocara spp.	4 (7.9)	13 (20	7 (12)	5 (9.6)	0.49
Nematoda	10 (20)	16 (25)	3 (5.2)	6 (12)	NC[a]
Trichuris spp.	–	–	–	1 (1.9)	NC[a]
Spirocerca spp.	–	1 (1.5)	2 (3.4)	1 (1.9)	NC[a]
Capillaria spp.	–	–	1 (1.7)	–	NC[a]
Taenia spp./*Echinococcus* spp.	1 (2.0)	1 (1.5)	1 (1.7)	2 (3.8)	NC[a]
Dipylidium caninum	1 (2.0)	3 (4.6)	1 (1.7)	2 (3.8)	NC[a]

[a] Value of p could not be calculated.

Table 3. Climatic data for the region surrounding Comodoro Rivadavia and Rada Tilly, Province of Chubut, in the Argentine Patagonia during the period beginning in July, 1999 and ending in June, 2000

Climatic parameter	Winter	Spring	Summer	Autumn
Average temperature (°C)	8.0	15.5	20.4	14.7
Level of precipitation (mm)	13.4	22.2	2.3	25.7
Absolute maximum temperature (°C)	19.0	28.3	33.2	24.9
Absolute minimum temperature (°C)	−2.7	5.2	10.6	7.0
Mean ($\bar{x}$) wind velocity (km/h)	20.6	16.0	14.1	7.4
Prevailing wind direction	West	West	West	West

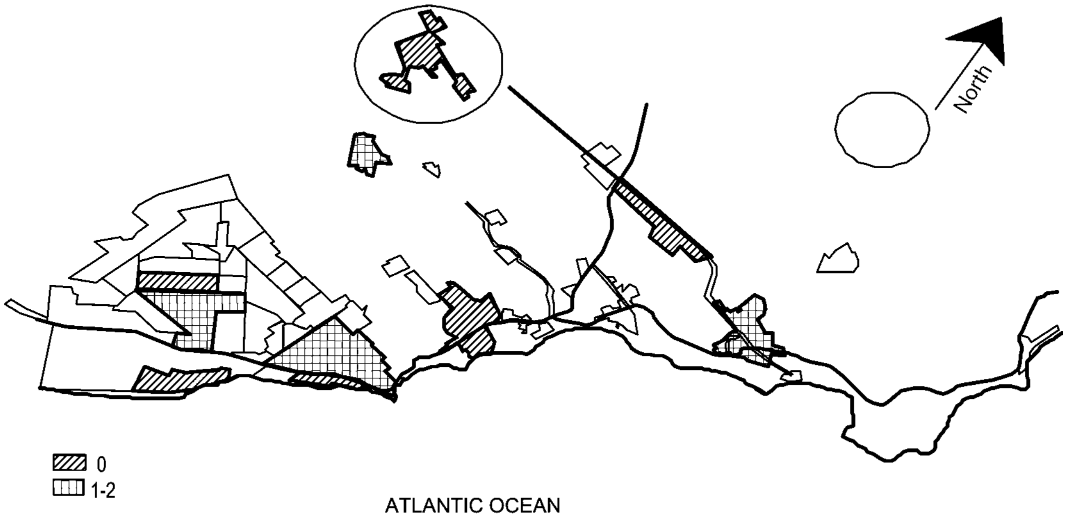

Figure 1. Appearance frequency of *Taenia* spp./*Echinococcus* spp. ova in 226 topsoil samples from the squares of Comodoro Rivadavia, Province of Chubut, in the Argentine Patagonia from the period beginning in July, 1999 and ending in June, 2000.

(*Toxocara* spp., *Capillaria* spp., *Spirocerca* spp., *Trichuris* spp., *Taenia* spp./*Echinococcus* spp.), oothecas (*D. caninum*), and larvae (Nematoda). The ratio of larvate to nonlarvate eggs of *Toxocara* spp. was 1/6 and 1/7 during the spring and autumn season, respectively; but we have no data to calculate the corresponding values for the winter and spring.

Table 4 summarizes the physicochemical characteristics of the 179 soil samples analyzed. The average values of RH, conductivity, and pH though each season were: 2.63%, 2061.3 μS, and 7.71 in the winter; 3.33%, 896.8 μS, and 7.73 in the spring; 5.07%, 834.2 μS, and 7.86 in the summer; and 10.68%, 421.4 μS, and 7.90 in the autumn. Soil temperature had a mean ($\bar{x}$) value of 13.7 °C (SD = 9.9 °C, VC = 0.72) over the total period studied. The minimum and maximum temperatures were −0.1 °C and +29 °C. With respect to the season of the year, the mean (plus minimum – maximum) temperatures recorded were: 8 °C (5–10 °C) in winter, 26.1 °C (23–29 °C) in spring, 20.2 °C (19–24 °C) in summer, and 4.1 °C (−0.1–8.5 °C) in autumn.

Table 4. pH, relative humidity (RH) and conductivity in 179 topsoil samples collected from squares of Comodoro Rivadavia, Province of Chubut, in the Argentine Patagonia from the period beginning in July, 1999 and ending in June, 2000

	pH	RH	Conductivity
Range	6.65–9.99	0.016–33%	21.4–14262 μS
$\bar{x}$	7.83	5.77%	961.1 μS
SD	0.55	6.27%	2023.9 μS
S^2	0.30	39.35%	41.106 μS^2
VC	0.07	1.09	2.11

The presence of the IFIPs in soil samples proved to be dependent on the soil pH ($p < 0.05$), with Q values of 0.5822 for the [6–8] and [8–10] ranges and $Q = 0.614$ for the [7–8] and [8–9] intervals. The major appearance frequency of IFIPs (at 96%) was observed between pH values of 7–9. The presence of IPs in soil samples was independent of the RH ranges obtained ($p > 0.05$).

Population study

Group 1: Of the square caretaker blood samples analyzed, 23% exhibited hematologic alterations, being leucocytic or eosinophil. Upon making a serological survey, we found one positive case of toxoplasmosis. Serology to toxocarosis and hydatidoses was negative in all the sera studied.

The interviews conducted showed that 100% of the caretakers collected garbage at the squares. Of these workers, 46% reported cleaning up canine and feline droppings, whereas 93% did so at least once a week; 62% used rakes in their clean up; and 27% employed animal excrements as home fertilizer. During those operations, none of them wore an aseptic mask to cover their nose and mouth although 92% used protective gloves and clothing. Among these workers, 40% prepared one or more meal on the job premises, while only 7% of them had an adequately isolated area to do so. Moreover, none of the caretakers interviewed had received any instruction what so ever in job related biosafety practices, nor had they any knowledge about parasitic zoonoses. The average job seniority of these workers was 3 years; 69% of them were cat or dog owners, while 84% maintained home gardens. The squares are irrigated with the municipal water supply.

Group 2: In this group we surveyed a total of 46 families although we had to discard the results from 2 of the households because of errors in the data recorded. Of the 44 remaining families analyzed, the socioeconomic level was the following: low, 17%; medium, 57%; and high, 26%. Figure 2 shows the age distribution of the individuals surveyed.

The highest educational level attained and the extent of knowledge about parasitic zoonoses are summarized in Tables 5 and 6, respectively.

1	479
2	233455999
3	02459
4	011112234788999
5	022277
6	9
7	345
8	14

Mo:41 ;Md:41,5; x:42,9

Figure 2. Age distribution of the surveyed population in Comodoro Rivadavia in the Argentine Patagonia. Age expressed in years as of the most recent birthday. Stem and leaf scheme. n = 44. Period, November, 2000, November, 2001.

Table 6. Extent of knowledge about parasite zoonoses in population surveyed in Comodoro Rivadavia in the Argentine Patagonia

	Extent of knowledge		
Disease	Low	Medium	High
Hydatidosis	15	12	17
Toxoplasmosis	30	6	8
Toxocarosis	39	3	2

n = 44. Period October 2001–November 2001.
$\chi^2 = 49.671$; $p = 0$.

The p value obtained upon analyzing the extent of knowledge about a given diseases compared to the accessibility of relevant public health information was 0.12088 with respect to hydatidosis. In the same way, the p value obtained comparing the extent of knowledge and the educational level was 0.72554 for the same disease. For this last analysis we considered the educational levels within the following ranges: [a–c] and [d–h] (see references on Table 5). We could not estimate the p values for toxoplasmosis or toxocarosis because of their low appearance frequencies in the groups with a medium and high extent of knowledge.

With respect to pet care, 68% (n = 30) of the persons surveyed had at least one animal and 7% had more than one kind of pet. The pets consisted in 25 dogs, 12 cats, a turtle, and a bird. Of the 30 pet owners, 29 had dogs and/or cats, with 9 of them using raw meat as a portion of their pets' food. Fifteen of these owners treat their pets for parasite infection, while 17 of them let their pets leave the house without supervision. Our assessment of the degree of pet ownership responsibility on the part of these 30 owners gave the following distribution: 1 low, 21 medium, and 8 high.

Discussion

Environmental study

Of the public spaces surveyed in this work, 100% contained IFIPs within their topsoil over the studied period.

Table 5. Maximum educational level attained in persons surveyed in Comodoro Rivadavia in the Argentine Patagonia

	Educational level								
Age ranges	a	b	c	d	e	f	g	h	Total
[14–19]	–	–	3	–	–	–	–	–	3
[22–57]	1	8	6	11	–	5	3	1	35
[68–84]	1	4	1	–	–	–	–	–	6

Distribution per age range n = 44. Period 2000–2001.
a: Primary school not completed, b: primary school completed, c: secondary school not completed, d: secondary school completed, e: tertiary school not completed, f: tertiary school completed, g: without university degree, h: with university degree.

We identified 10 different genera of IFIPs. With the single exception of *Spirocerca* spp., all are widely accepted as pathogens in man; although admittedly there does exist a controversy regarding the pathogenicity of *Isospora* spp. from domestic animals [14], while the infections of *D. caninum* in humans are but sporadic.

The definitive hosts for adult stage of the IFIPs that we detected are the following: dogs for *Toxocara* spp., *Capillaria* spp., *Spirocerca* spp., *Trichuris* spp., *Taenia* spp./*Echinococcus* spp., *D. caninum*, *Isospora* spp. and *T. gondii*- like as *Neospora caninum* and *Hammondia heydorni* and cats for *Toxocara* spp., *Capillaria* spp., *Taenia* spp., *D. caninum, Isospora* spp., *T. gondii* and *T. gondii*-like as *Hammondia hammondi* and *Besnoitia* sp. Since these animals eliminate the parasites in question by excretion, our results constitute evidence for the previous contamination of those public spaces we surveyed by dog and cat feces those being from pets, either unsupervised or not cleaned up after by their masters, or alternatively from stray animals. With respect to this observation, we would stress that a previous survey of ours examined 481 canine fecal droppings collected from the same public parks that we studied here, with 41.8% of them being positive for IFIPs [15]. The genera and species detected were: *Isospora* spp., *Sarcocystis* spp., *Entamoeba* spp., *Endolimax* spp., and *Giardia* spp. along with the protozoa *Taenia* spp./*Echinococcus* spp., *D. caninum, Toxocara* spp., *Uncinarias* spp., *Spirocerca* spp., *Capillaria* spp. and Nematoda larvae along with the helminths.

Zunino et al. [16] reported in a previously published survey a medium degree of prevalence of canine intestinal parasites (IPs) in Comodoro Rivadavia, Chubut. Their conclusions are the result of the evaluation of 31 canine faeces collected from one public park during one morning in January/1996. They do not studied soil samples. They detected one positive sample to *Toxocara* sp. and three positive to *Strongyloides* sp. Free living nematode larvae are common in soil and they could contaminate fecal dropping collected from the environment. It is strongly suggested to perform a larvae tipification to asses whether the larvae founded are rabditiform or filariform *Strongyloides* sp. larvae and not free living contaminating nematode larvae. In that survey the authors did not distinguish those larvae forms. For the above mentioned it is difficult for us to make a comparation between their work an ours.

Hydatidosis is endemic within the Province of Chubut [17], though the disease does exhibit a lesser prevalence of 0.3% in Comodoro Rivadavia and its surrounding area. For this reason, the detection of eggs morphologically compatible with an identification of *E. granulosus* in the topsoil samples we obtained from public squares in that city is highly relevant to the issue of hydatidosis control since such a finding could indicate the occurrence of behavior contributing to a greater risk of maintaining the cycle propagating that disease. Information on the spatial distribution of the appearance frequencies of those parasitic elements among different neighborhoods within a populated area such as Comodoro Rivadavia would be useful in enabling the identification of zones of particular risk for that zoonosis.

The analysis of the climatic records showed a BWk cool arid weather pattern according to the Köpen classification system [18]. 'B' represents dry weather in which evaporation exceeds the mean level of rainfall. 'Wk' identifies a cool desert climate characterized by polar winds during winter and tropical continental winds during summer. In such a climate the wind becomes an important meteorologic factor. The constant occurrence of prevailing winds during year accordingly enhances soil evaporation.

The IFIPs contamination of the soil appeared to exhibit a seasonal fluctuation, with the greatest number of positive samples occurring in the spring and summer. Indeed, a statistical analysis of the data obtained confirmed that the overall appearance frequency of IFIPs within the samples we studied was, in fact, significantly linked to the climatic season ($p < 0.001$).

With respect to individual parasitic forms, we detected *T. gondii*-like oocysts, *Toxocara* spp., Nematoda, *Taenia* spp./*Echinococcus* spp., and *D. caninum* during the entire period studied. By contrast, whereas *Entamoeba* spp. and *Spirocerca* spp. were absent in winter, we were able to recover *Capillaria* spp. only in summer and *Trichuris* spp. only in autumn, with *Isospora* spp. being observed in both winter and summer. The analysis of individual appearance frequencies over the year indicated that the presence *T. gondii*-like and *Entamoeba* spp. was season associated in a statistically significant fashion ($p < 0.05$) for both IFIPs.

Capillaria spp. and *Spirocerca* spp. are parasites associated with warm tropical or subtropical climates [19]. Accordingly, in our survey they were found during the spring, summer, and autumn months, when the absolute minimum temperatures ranged between 5.2 and 10.6 °C and the mean temperatures between 14.7 and 20.4 °C. During this period there were also low levels of precipitation in this region, and the prevailing winds were from the west. We thus conclude that these genera would be expected to be found within the environment under ambient conditions characteristic of a cool desert climate.

The IFIPs forms that we detected in the soil samples are resistant stages such as cyst, oocyst, or ova used by parasites for survival or reproduction within the environment. Among the ova, certain that we found corresponded to those of geohelminthic parasites, such as *Trichuris* spp. and *Toxocara* spp. These ova are discharged into the surroundings within the feces of their definitive hosts and there either develop into infectious embryonate or larvate ova or else burst releasing larvae that then, under adequate conditions of temperature and humidity, mature to the L-III larval stage [20]. O'Donnell et al. [21] reported the recovery of *Trichuris* spp., *Toxocara* spp., *Ascaris* spp., and *Hymenolepis diminuta* ova in soil samples after 3 months of exposure to natural environmental conditions. In the present work, the recovery of ova, cysts, oocysts and larvae in topsoil samples under different climatic conditions indicates both the persistence and the dispersion of infectious parasitic forms within the environment long after the disappearance of the associated feces.

The VCs obtained from analysis of the different soil sample characteristics indicated that the RH and conductivity were more variable than the pH. The SD in each instance would also indicate a notably greater dispersion in RH and conductivity than in pH. The RH is a property related to the permeability and the water retention capacity of the soil, the intensity of rainfall, frequency of irrigation, and the wind induce evaporation [12]. In our study we registered a low mean annual rainfall level, a constant wind frequency, and an inconsistent irrigation of the squares. Those conditions could contribute to the low mean value for the RH in the soil samples. The mean soil temperature was furthermore similar to the mean environmental temperature during both the winter and summer. In autumn, however, the mean soil temperature was 10.6 °C lower than air temperature, while during spring the former resulted 11.1 °C higher than the latter.

O'Donnel et al. [21] created an experimental model in which they were able to demonstrate a marked effect on the viability of *Toxocara* spp. ova by ambient temperature as well as by the vehicle of preservation used with respect to topsoil as compared with the effluent sludge from domestic sewage treatment plants. They reported that whereas 5% of the ova retained their viability for a period of 8 months at 25 °C and 33% for up to 25 months at 4 °C when preserved in sludge, 83% remained viable for those respective lengths of time at either temperature when maintained in topsoil. In our study involving topsoil and seasonal variations in temperature, we observed that the ratio of larvate to nonlarvate *Toxocara* spp. ova was 1:6 in summer and 1:7 in autumn, with the minimum and maximum temperatures registered during those respective seasons being 10.6 °C and 33.2 °C vs. 7.0 °C and 24.9 °C. With respect to the vehicle of preservation, we would compare our findings with a study mentioned earlier involving a survey of canine fecal material collected from the same public spaces during those two seasons. There the ratio of larvate to nonlarvate ova proved to be 1:4 in summer and 1:1.5 in autumn [15]. The yield of stage L-II larvae from *Toxocara* spp. ova would thus appear to be considerably greater in feces as a preservation vehicle than in topsoil.

Coman [22] reported a 56 day persistence time when *T. pisiformis* was exposed to 33% RH and a temperature of 5 °C. Those ova, however, did not retain the capability of producing cysticerci in rabbits. A RH of 27% and a temperature of the 25 °C also resulted in a loss of the infectious potential in *E. multilocularis* [23]. Although we found Taenidae ova in soil under conditions of low RH and high temperature such as occur in our summer, we have not investigated their infectivity. Nevertheless, we would emphasize here that in our study the presence of IPs proved to be independent of the level of soil RH ($p > 0.05$).

In the study mentioned above, O'Donnell et al. [21] failed to observe an effect of soil pH (ranging from 6.0 to 9.5) on the viability of *Trichuris* spp., *Ascaris* spp., and *Hymenolepis diminuta* ova; rather, *Toxocara* spp. was the only organism whose ova viability was altered by this parameter. In our study the presence of IFIPs in the soil samples analyzed was dependent on pH over the entire range of pH [6–10], the degree of association was moderate ($0.41 < Q < 0.61$); whereas within the narrower interval of pH [7–9], the degree of correlation was strong ($Q > 0.61$). Because of the low appearance frequency for individual genera recovered throughout different pH ranges we were not able to perform a statistical analysis on each genus by itself.

In general, within our present experimental design, we could not make any statistical evaluation with respect to the parasites that were encountered at an especially low frequency, although studies in the future involving longer surveillance periods could well contribute to a resolution of the question concerning those contaminants. Such long-term longitudinal surveys would, however, have to involve periods far greater than one year in duration.

Population study

Group 1: The prevention of health problems requires actions aimed at reducing the probability of the occurrence of disease [24]. Health education, individual protection, and an early detection of a disease are some of the primary and secondary preventive steps that can intervene in its prepathogenic and the pathogenic phases.

The results of our study would indicate that the potential exposure of the square caretakers to the pathogenic forms of the IPs present in the areas they tend represents an occupational hazard for those employees.

Moreover, in addition to the routine removal of animal droppings and the use of such excrement for home fertilizer, the practices of not wearing a respiratory mask or protective clothing or not using a rake in the clean up of such biohazardous material, when applicable, would also be considered as factors contributing to the likelihood of contracting a zoonotic infection with these IPs. Furthermore, the caretakers' ignorance regarding biosafety practices and their unawareness of the relationship between canine and feline borne IPs and the transmission of zoonotic illnesses constitute glaring evidence of the lack of health related educational information as part of these employees' job training.

The results we obtained from the blood work in this group could constitute an initial step in gaining information about the immunologic status of these people with respect to hydatidosis, toxoplasmosis, and toxocarosis. A systematic serological follow up on the square caretakers would assist in making an early diagnosis of those diseases.

Finally, the adoption of the mentioned primary and secondary preventive practices by the caretakers of the squares would serve to reduce the risks to these employees from both the environment and their own behavior and would as a consequence improve the health related conditions of their occupational circumstance.

Group 2: Of the total number of residents surveyed from the neighborhoods surrounding the squares, 79.5% were in the [22–57] years of age, while 82.6% were rated as living at a medium or high socioeconomic level since their homes had adequate sanitary facilities and were connected to the municipal utility services.

More than 65% of the population studied had a low extent of knowledge regarding toxoplasmosis and toxocarosis. The latter parasitosis also had the highest appearance frequency here (89%). With respect to cystic hydatid disease, we observed a low extent of knowledge the least frequently (34%) and a high extent the most so (39%). This parameter did not distribute itself in a homogeneous fashion among the people studied ($\chi^2 = 49.671$; $p > 0.05$).

Of the individuals surveyed, 79.5% had not received either tertiary level diplomas or university degrees; nevertheless, the extent of knowledge about hydatidosis was independent of the educational level attained ($p > 0.05$). The Chubut hydatidosis control program has been in operation in that province since 1984. This program utilizes health education as a basic preventive strategy for implementation not only in the primary and preparatory schools but also within the general population. The above considerations could explain the greater extent of knowledge about hydatidosis with respect to toxoplasmosis and toxocarosis that we recorded as well as the independence of this parameter from educational level attained.

Of the owners of pets, 70% exhibited a medium level of responsibility regarding pet care with only 3% showing a high degree. Pet feeding with raw visceras carries with it a high risk of echinococcosis infection in dogs and *T. gondii* in cats [5, 25]. We documented that a little less than one third (9 out of 30) dog and cat owners utilized raw meat as food for their pets. Moreover, about half of the owners do not deparasitize their animals, and a little more than half allow their animals to go outside the house unsupervised.

Such practices could well have a lot to do with the IPs forms i.e., Taeniidae ova, nematode larvae, and *T. gondii* oocyts that we found in the soil samples: That those specimens were all collected from public places located in the self same neighborhoods where the people in question with lax animal care practices live would certainly support that contention.

From the parasite screening results in conjunction with the environmental study reported here, we can conclude with considerable certainty that the soil of the public squares we investigated was contaminated with canine and feline IPs. Some of those parasites are known human pathogens, such as *T. gondii*, *Toxocara* spp., and *Taenia* spp./*Echinococcus* spp. In the soil samples analyzed we moreover found a predominance of helminths over protozoa during all the seasons studied. The detection of *Entamoeba* spp. and *T. gondii* in these samples, however, proved dependent of the season of the year ($p < 0.05$). Finally, we report the presence of *Capillaria* spp. and *Spirocerca* spp. under cool desert climatic conditions.

The presence of IFIPs in soil samples was dependent on the soil pH ($p < 0.05$), with this relationship being moderately associated with the pH range of 6–8 ($Q = 0.5822$) and strongly so with the pH subintervals of 7–8 ($Q > 0.61$) and 8–9. The occurrence of IPs was independent of the RH of the soil samples ($p > 0.05$).

The population survey revealed that the square caretakers have certain job associated practices that place them in danger of the exposure to and infection with the IPs detected in those public places. These workers therefore need to develop primary and secondary measures to safeguard their health. In the general population investigated within the surrounding neighborhoods the extent of knowledge about parasitic zoonoses was an inconsistent characteristic, with toxocarosis and toxoplasmosis being the diseases associated with the highest degree of ignorance. Furthermore, the majority of pet owners there show little responsibility regarding the sanitary care of their animals. For this reason, a community wide educational program dealing with pet sanitation in addition to an implementation of the practice of controlling and treating canine and feline IPs infection within the community would definitely effect a reduction in soil contamination by IPs within the public places we studied.

We conclude that the approach of screening soil samples from public spaces for IFIPs with an aim at constructing a cartographic representation of data on the appearance frequencies of those organisms constitutes a simple method for generating an urban scale comprised of zones characterized by graded degrees of risk for the contraction of zoonotic diseases.

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