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Soil-transmitted Helminth Infections in Schoolchildren of Laguna de Perlas (Nicaragua)

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ABSTRACT

Soil-transmitted helminth (STH) prevalence, intensity, polyparasitism and co-infections in 425 children from 3 schools of Laguna de Perlas (Nicaragua) were investigated. Single stool samples were analysed by the formalin-ether method and the Kato-Katz. A total of 402 (94.6%) children were infected. *Trichuris trichiura* 308 (72.4%), *Ascaris lumbricoides* 115 (27.1%) and Hookworms 54 (12.7%) were the most prevalent STHs. Polyparasitism (322; 75.8%) with two species was most prevalent (109; 25.6%). *T. trichiura* with *A. lumbricoides* (19.3%) and *T. trichiura* with Hookworm (6.8%) were the most common combinations. Positive associations were observed between *T. trichiura* and *A. lumbricoides* and *T. trichiura* and Hookworm ($p = 0.0001$). Highest Hookworm intensities appeared when three STH co-infections occurred. Moderate- heavy STH intensities appear in up to 42.1% in trichuriasis, 57.5% in ascariasis and 11.1% in Hookworm infections. Integrated control interventions covering children need to be implemented mainly in a rural environment.

INTRODUCTION

Soil-transmitted helminths (STHs) are the most prevalent afflictions in children[1]. *Ascaris lumbricoides* (affecting 1.221 billion people), *Trichuris trichiura* (800 million), *Necator americanus* and *Ancylostoma duodenale* (740 million) are the four most common STHs[2], found in poor areas in the developing countries of the Americas, in China and East Asia, as well as Sub-Saharan Africa[1–4]. These helminths affect the physical, intellectual and cognitive development of children [5–9].

In Latin America and the Caribbean region, there are 30 STH-endemic countries and there were 49.3 million pre-school and school-age children at risk of infection in the region [10,11]. Currently, more than 1.8 million of these children with STH infections are found in Nicaragua, a low-middle income Central American country in which 42.5% of the population live in poverty [12,13].

Nicaragua is made up of three regions: the Pacific with seven departments; the centre with eight departments; and the Atlantic/Caribbean including the

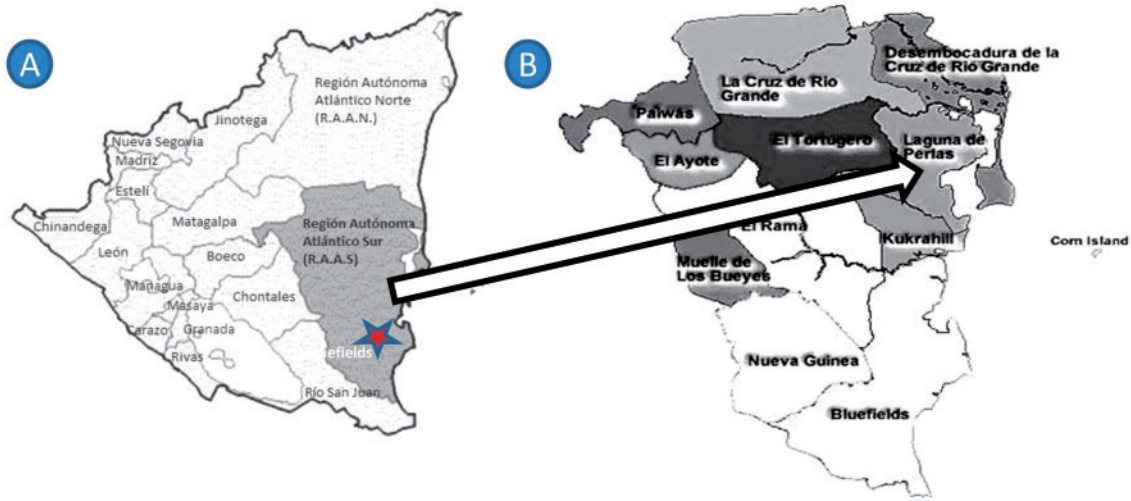

Fig.1. Maps showing the (**A**) different departments of Nicaragua, with the Region Autónoma del Atlántico Sur—RAAS— and (**B**) the different municipalities of this region, highlighting Laguna de Perlas.

Autonomous North Atlantic Region (RAAN) and the Autonomous South Atlantic Region (RAAS) (Fig. 1A). In general, urban and rural areas normally are not very different. However, houses in rural RAAS areas tend to be more dispersed, being surrounded by grassland, without any urbanization and without sanitation.

PAHO[14] reported that Nicaragua presented STH prevalence rates above 20% in several departments, with *T. trichiura* (84.4%) and *A. lumbricoides* (34.2%) topping the list. However, for the Central American isthmus, the data published revealed a STH intensity only in Guatemala and Honduras.[15–19] Moreover, multiple helminth infections are extremely widespread in tropical countries, and some studies have reported that even light infections may pose a threat to children's health[20,21], especially when living in endemic communities with a poor nutritional status[21–23]. The relationship between parasite-infection and malnutrition induces problems in the normal physical and cognitive development of children.[7]

The aim of this study was to investigate STH prevalence and intensity, polyparasitism and co-infections in the context of intestinal parasites, in a sample of children of the municipality of Laguna de Perlas on the Caribbean coast of Nicaragua, so far without any previous data on intestinal parasite infections.

MATERIALS AND METHODS

Study area and population

This study was conducted in the municipality of Laguna de Perlas (12°21'N—83°40'O), one of the twelve municipalities forming the RAAS (Fig. 1B), where there is a town of the same name, Laguna de Perlas on the coast, and several rural communities, covering some 2000 km^2, with a population of 10 700 inhabitants. The town can be reached by boat from the bay of the town of Bluefields, the capital of RAAS. There are about 2000 children of different age-groups in the town of Laguna de Perlas. The survey was carried out in a total of three schools: the only two schools of the town Laguna de Perlas and in a third school in Haulover, a small rural community with about 1500 inhabitants, at 5 km south of the town of Laguna de Perlas (Fig. 1C). The three schools were selected to focus on the schoolchildren of the municipality differentiating both, urban and rural areas. The sample size was representative of the pupil enrolment in each school (at least 85%) and the inclusion criteria was the children present on the day of the survey (95%). All the children participants were asymptomatic.

Sampling and laboratory methods

In March 2012, the coprological survey involved 425 children (176 males and 249 females) aged 2–15

Table 1. Prevalence of intestinal parasite species in the 425 children studied in urban and rural areas of the municipality of Laguna de Perlas (RAAS, Nicaragua)

Parasites	Municipality of Laguna de Perlas					
	Laguna de Perlas (urban)		Haulover (rural)		Total	
	$N^d = 228$		$N = 197$		$N = 425$	
	n^e	% (95% CI)[f]	n	% (95% CI)	n	% (95% CI)
Protozoa	180	78.9 (73.3–83.9)	152	77.2 (70.9–82.6)	332	78.1 (74–81.8)
Entamoeba histolytica[a]	25	10.9 (7.4–15.5)	7	3.6 (0–17.3)	32	7.5 (0–16.7)
Entamoeba coli	60	26.3 (20.9–32.3)	46	23.4 (11.1–35.6)	106	24.9 (16.7–33.2)
Entamoeba hartmanni	59	25.9 (20.5–31.9)	37	18.8 (6.2–31.4)	96	22.5 (14.2–30.9)
Endolimax nana	55	24.1 (18.9–30)	43	21.8 (9.5–34.2)	98	23.1 (14.7–31.4)
Iodamoeba buetschlii	1	0.4 (0.02–2.1)	7	3.6 (0–17.3)	8	1.8 (0–11.3)
Chilomastix mesnili	8	3.5 (1.6–6.6)	6	3.1 (0–16.8)	14	3.2 (0–12.6)
Giardia intestinalis	32	14.1 (9.9–19)	42	21.3 (8.9–33.7)	74	17.4 (8.8–26)
Blastocystis hominis	131	57.5 (50.9–63.8)	116	58.9 (49.9–67.8)	247	58.1 (53.4–62.8)
Helminths	162	71.1 (64.9–76.7)	164	83.2 (77.5–87.9)	326	76.7 (72.5–80.5)
Hymenolepis diminuta	1	0.4 (0.02–2.1)	0	–	1	0.2 (0–9.6)
Enterobius vermicularis[b]	2	0.9 (0.1–2.9)	1	0.5 (0.02–2.5)	3	0.7 (0.2–1.9)
Trichiuris trichiura	150	65.8 (59.5–71.7)	158	80.2 (74.0–86.4)	308	72.4 (67.5–77.5)
Ascaris lumbricoides	69	30.3 (24.6–36.5)	46	23.4 (11.1–35.6)	115	27.1 (18.9–35.2)
Hookworm[c]	23	10.1 (6.7–14.5)	31	15.7 (2.9–28.5)	54	12.7 (3.8–21.6)
TOTAL	213	93.4 (89.6–96.1)	189	95.9 (93.1–98.7)	402	94.6 (92.4–96.8)

[a]And/or *Entamoeba dispar/E. moshkovskii.*
[b]Detected in stool samples.
[c]*Ancylostoma duodenale* and/or *Necator americanus.*
[d]Number of schoolchildren studied.
[e]Number of schoolchildren parasitized.
[f]95% confidence interval.

years (mean ± SD = 9.8 ± 3.4): 228 children (86 males and 142 females) attending urban schools and 197 children (90 males and 107 females) attending a rural school. A clean, plastic, wide-mouthed, numbered container with a snap-on lid was given to every child. With the help of parents/guardians, when needed, one stool sample per child was collected and personal data (name, sex and age) were recorded on delivery of the container the following day. A Kato-Katz slide was made from each stool sample and examined within 1 h after preparation to avoid over-clarification of some helminth eggs (*Hymenolepis*, hookworms). One aliquot was preserved in 10% formalin solution (1:3). All the material was finally transported to the laboratory of Instituto Politécnico de la Salud (IPS) in Managua, and then shipped to the Department of Parasitology (Valencia, Spain). In Spain, the Nicaraguan co-author (A.P.) helped with the sample analysis. Each faecal sample was microscopically examined with a wet iodine mount and concentrated with the formalin-ether method. Two drops of sediment obtained with this technique were stained using a modified Ziehl-Neelsen technique[24]. Every Kato-Katz slide was examined to count the number of eggs of *T. trichiura* and *A. lumbricoides.*

Data analysis

Statistical analyses were done using 'Open Source Epidemiologic Statistics for Public Health, version 3.03a'. Statistical comparison was carried out with the X^2 test, Student's *t*-test and analysis of variance.

Table 2. Prevalence of STH species in the 425 children studied in urban and rural areas of the municipality of Laguna de Perlas (RAAS, Nicaragua) by sex and age-groups (95% confidence interval)

		Municipality of Laguna de Perlas					
		Laguna de Perlas (urban)		Haulover (rural)		Total	
		$N = 228$		$N = 197$		$N = 425$	
		n	% (95% CI)	*n*	% (95% CI)	*n*	% (95% CI)
Trichuris trichiura	Total	150	65.8 (59.5–71.7)	158	80.2 (74.0–86.4)	308	72.4 (67.5–77.5)
Sex	male	61	26,8(21,3–32,8)	73	37,1(30,5–43,9)		
	female	89	39(32,9–45,5)	85	43,1(36,4–50,1)		
Age-groups	2–5	8	3,5(1,6–6,6)	20	10,2(6,5–14,9)		
	6–11	61	26,8(21,3–32,8)	105	53,3(46,3–60,2)		
	12–15	81	35,5(29,5–41,9)	33	16,8(12–22,5)		
Ascaris lumbricoides	Total	69	30.3 (24.6–36.5)	46	23.4 (11.1–35.6)	115	27.1 (18.9–35.2)
Sex	male	23	10,1(6,7–14,5)	22	11,2(7,3–16,2)		
	female	46	20,2(15,3–25,8)	24	12,2(8,2–17,3)		
Age-groups	2–5	2	0,9(0,1–2,8)	3	1,5(0,4–4,1)		
	6–11	11	4,8(2,5–8,2)	28	14,2(9,8–19,6)		
	12–15	56	24,5(19,3–30,5)	15	7,6(4,5–11,9)		
Hookworm	Total	23	10.1 (6.7–14.5)	31	15.7 (2.9–28.5)	54	12.7 (3.8–21.6)
Sex	male	11	4,8(2,5–8,2)	18	9,1(5,7–13,8)		
	female	12	5,3(2,9–8,8)	13	6,6(3,7–10,8)		
Age-groups	2–5	0	–	1	0,5(0,02–2,5)		
	6–11	6	2,6(1,1–5,4)	25	12,7(8,6–17,9)		
	12–15	17	7,5(4,5–11,4)	5	2,5(0,9–5,5)		

Notes. $N = 1/4$ number of schoolchildren studied; $n = 1/4$ number of schoolchildren parasitized.

Associations between STH infections were investigated by 2×2 contingency tables. OR (95% IC) and significance levels were assessed. All results were considered significant if the *p*-value was <0.05.

Ethical considerations

IPS as well as University of Valencia granted the ethical approval of the study. Informed consent was obtained on the day of delivery from the parents/guardians of pupils enrolled. Diagnostic results were sent to IPS, which then informed the Nicaraguan Ministry of Health, being in charge of appropriate treatments.

RESULTS

Prevalence

In the 425 children included in the study, up to 8 protozoan and up to 5 helminth species were found (Table 1). In 402 (94.6%) of the children surveyed an infection with at least one parasite species, or protozoan 332 (78.1%) or helminth 326 (76.7%), was found. Although STHs were the subject of the study, *Blastocystis hominis* 247 (58.1%) was the most prevalent protozoan species. The only case of *Hymenolepis diminuta* (0.2%), together with the three cases of *Enterobius vermicularis* (0.7%), was not studied in detail. The analysis of the STH prevalence made it possible to detect differences in *T. trichiura*, resulting more prevalent in the rural school ($p = 0.0013$) (Table 1).

In Table 2, the prevalence of the 425 children studied in urban and rural areas is divided by sex and age-groups. Boys from the rural school were statistically more *T. trichiura* infected than boys from urban schools ($p = 0.029$), while girls from urban schools were statistically more *A. lumbricoides* infected than girls from the rural school ($p = 0.037$). Children of the

Table 3. Percentage (%) of mono- and polyparasitism species in the 425 children studied in urban and rural areas of the municipality of Laguna de Perlas (RAAS, Nicaragua)

	Municipality of Laguna de Perlas		
	Laguna de Perlas (urban) $N = 228$ $n(\%)$	Haulover (rural) $N = 197$ $n(\%)$	Total $N = 425$ $n(\%)$
Monoparasitism	45(19.7)	35(17.8)	80(18.8)
Polyparasitism	168(73.7)	154(78.2)	322(75.8)
Two species	51(22.4)	58(29.4)	109(25.6)
Three species	55(24.1)	36(18.3)	91(21.4)
Four species	39(17.1)	37(18.8)	76(17.9)
Five species	15(6.6)	12(6.1)	27(6.4)
Six species	5(2.2)	10(5.1)	15(3.5)
Seven species	2(0.9)	1(0.5)	3(0.7)
Eight species	1(0.4)	0	1(0.2)
Negative	15(6.6)	8(4.1)	23(5.4)

Notes. N = number of schoolchildren studied; n = number of schoolchildren parasitized.

6-11 age-group from the rural school appeared statistically more *T. trichiura* ($p = 0.0000001$), *A. lumbricoides* ($p = 0.001$) and Hookworm ($p = 0.0001$) parasitized than those from urban schools, while children of the 12–15 age-group from urban schools resulted statistically more *T. trichiura* ($p = 0.00002$), *A. lumbricoides* ($p = 0.000005$) and Hookworm ($p = 0.039$) parasitized than those from the rural school.

Polyparasitism and co-infections

Mono-infections were observed in 80 (18.8%) children, polyparasitism in 322 (75.8%) and 23 (5.4%) were negative (Table 3). The most frequent, both in urban and rural areas, was the co-infection with two species, 109 (25.6%), and gradually declined thereafter until reaching up to eight different species but only in one case (0.2%).

The prevalence of single and multiple helminth species infection is shown in Table 4. Of those infected with any single infection, 82 (35.9%) in urban and 95 (48.2%) in rural school harboured *T. trichiura* only, with significant differences ($p = 0.013$). The most common combination, with any double infection (111; 26.2%), was with *T. trichiura* and *A. lumbricoides* both in urban (48; 21.1%) and rural (34; 17.3%) schools, while *T. trichiura* and Hookworm were significantly more prevalent at the rural school (20; 10.2%) ($p = 0.019$).

It is possible to highlight the co-infection of *Giardia intestinalis* with *T. trichiura* in double infections (9.2%) and in triple infections with *T. trichiura* and *A. lumbricoides* (1.9%) or Hookworm (1.6%).

Significant positive associations were reached in the co-infection analysis of *T. trichiura* with respect to other STHs detected in this study ($p = 0.0001$), but no significant associations were observed between *A. lumbricoides* and Hookworm co-infections (Table 5). Moreover, *T. trichiura* presented a significantly positive association with *A. lumbricoides* and Hookworm in both sexes. In relation to age-groups, a significant association of *T. trichiura* was observed in co-infections with *A. lumbricoides* in the 6–11 and in the 12–15 year age-groups and with Hookworm in the 6–11 year age-group (Table 5).

STHs intensity

Intensity of infection, measured as eggs per gram (epg) of faeces, is shown in Table 6.

There were no significant differences in intensity between single and multiple infections for *T. trichiura* ($p = 0.456$), *A. lumbricoides* ($p = 0.293$) and Hookworm, ($p = 0.702$). Individuals co-infected with

Table 4. Prevalence of single and multiple soil-transmitted helminth species detected in the 425 children studied in urban and rural areas of the municipality of Laguna de Perlas (RAAS, Nicaragua)

	Municipality of Laguna de Perlas					
	Laguna de Perlas (urban)		Haulover (rural)		Total	
	$N = 228$		$N = 197$		$N = 425$	
	n	%	*n*	%	*n*	%
Any single infection	91	39.9	100	50.8	191	44.9
Trichuris trichiura only	82	35.9	95	48.2	177	41.6
Ascaris lumbricoides only	8	3.5	3	1.5	11	2.6
Hookworm only	1	0.4	2	1	3	0.7
Any double infection	57	25	54	27.4	111	26.2
T. trichiura + *A. lumbricoides*	48	21.1	34	17.3	82	19.3
T. trichiura + Hookworm	9	3.9	20	10.2	29	6.8
Triple infection	12	5.3	9	4.6	21	4.9
Any multiple infection	69	30.3	63	32	132	31.1

Notes. N = number of schoolchildren studied; n = number of schoolchildren parasitized; % = prevalence.

T. trichiura and *A. lumbricoides* had the highest intensities of both helminth species and those co-infected by the three STHs showed the highest Hookworm intensities (Fig. 2).

The stratification of STH egg intensity according to WHO guidelines[25] is expressed in order to quantify the severe consequences suffered by each individual (Table 7). Among the children positive for trichuriasis, the majority detected in urban (68.9%) and rural (57.9%) schools can be classified as light-intensity infections, although the percentages of moderate- and heavy-intensity infections stand out (31.1 and 42.1%). The results for ascariasis are rather different, with 48.3 and 42.5% showing light intensity infections, while 51.7 and 57.5% presented moderate- and heavy-intensity infections. With Hookworm light-intensity infections reached the highest percentages (88.9 and 95.5%) of the three STHs being compared and heavy infections were not detected.

No statistical differences were found with regard to sex ($p = 0.082$ *T. trichiura*; $p = 0.385$ *A. lumbricoides*) nor age-groups ($p = 0.474$ *T. trichiura*; $p = 0.749$ *A. lumbricoides*), in any of the heavy helminth infections (Fig. 3). Moderate intensity of ascariasis in 6–11 years old occurred in more than half the children (55.9%), with significant differences ($p = 0.0005$) to light and heavy infections in that age group.

DISCUSSION

The high overall prevalence of intestinal parasites (94.6%) is worth mentioning. This prevalence is higher than those encountered in the few studies carried out in other departments of Nicaragua: 92.9% in Rio San juan[26]; 77.1% in Corn Island[27]; 47.2% in León[28]; 46% in Chinandega, Estelí, Chontales and Granada[29]. The results of this study are particularly relevant, especially when considering the limitations of our study, such as the fact that only one faecal sample per child was analysed[30–34]. Another limitation of our study is the lack of clinical data to discuss the possible risk factors related to the parasitemia obtained. However, the great strength of our study is the fact that the Kato-Katz technique, recommended by WHO for epidemiological STH surveys, was applied[25].

Trichuris trichiura, the most prevalent intestinal helminth species (72.4%), confirms the dominance of this species constituting a serious health problem

Table 5. Association between soil-transmitted helminth species, sex and age-groups, respectively, detected in the schoolchildren of the municipality of Laguna de Perlas (RAAS, Nicaragua)

Parasite	Association		O.R.	95% CI	*p*-value
Ascaris lumbricoides	*Trichuris trichiura*		4.8	2.5–9.3	0.0001
Hookworm	*T. trichiura*		7.3	2.2–23.8	0.0001
A. lumbricoides	*T. trichiura*				
	Sex	Male	4.2	1.4–12.5	0.008
		Female	5.3	2.3–12.1	0.0001
Hookworm	*T. trichiura*				
	Sex	Male	5	1.1–22.2	0.017
		Female	11	1.5–83.4	0.002
A. lumbricoides	*T. trichiura*				
	Age groups	2–5	1.5	0.1–17.5	1
	(years)	6–11	1.3	1.2–1.4	0.0001
		12–15	3.2	1.4–7.2	0.005
Hookworm	*T. trichiura*				
	Age groups	2–5	0.6	0.4–0.7	1
	(years)	6–11	12.5	1.7–93.7	0.0001
		12–15	3.5	0.8–15.9	0.104

Table 6. Intensity (eggs per gram—epg—of faeces) of soil-transmitted helminth species detected in the 425 children studied in urban and rural areas of the municipality of Laguna de Perlas (RAAS, nicaragua)

	Municipality of Laguna de Perlas		
	Laguna de Perlas (urban) $N = 228$	Haulover (rural) $N = 197$	Total $N = 425$
Trichuris trichiura			
Range	24–17856	24–84888	24–84888
AM/GM	1425/NC	2558/NC	1819/459
Ascaris lumbricoides			
Range	24–92640	24–75912	24–92640
AM/GM	16748/4516	13977/3993	15638/4237
Hookworm			
Range	96–2400	96–2400	96–2400
AM/GM	362/145	327/201	343/174

Notes. N = number of schoolchildren studied; AM/GM = arithmetic mean/geometric mean; NC = not calculated.

in this area. This fact is similar with some previous studies in Nicaragua[26,27,29], as well as in the Latin America and Caribbean region[17–19,35–38], which contrasts with the dominance of *A. lumbricoides* and the Hookworm in other areas[15,16,28,39–44].

Considering that *Ascaris* and *Trichuris* have similar life-cycles and that they are transmitted by eggs which require optimum environmental conditions with a similar route of infection, i.e. faecal-oral, for both parasites, the difference found in the present

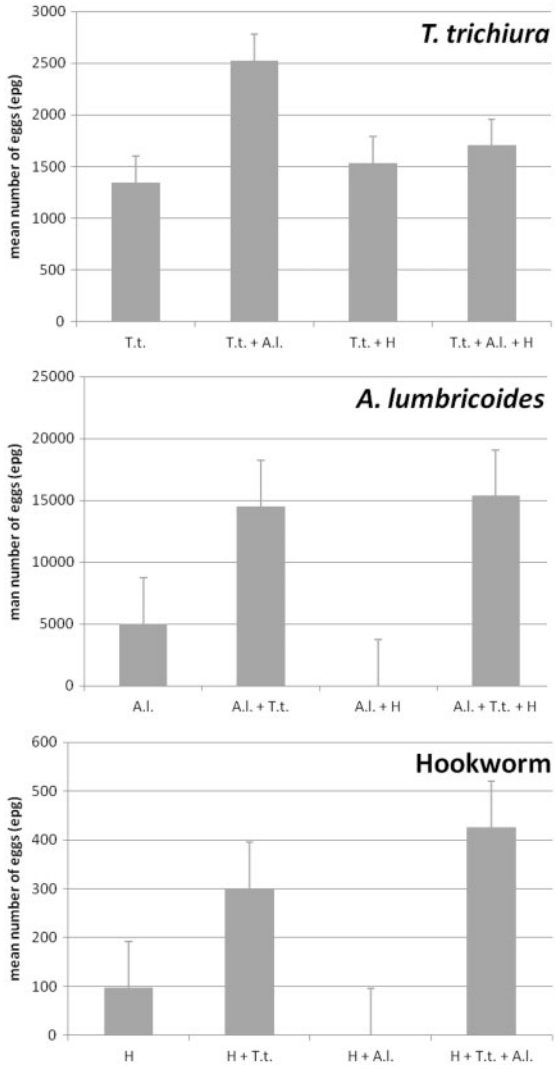

Fig.2. Mean intensity of individual helminth infections in the absence and presence of other co-infecting helminth species (T.t.= *Trichuris trichiura*; A.l.= *Ascaris lumbricoides* and H= Hookworm). Columns indicate mean number of eggs per gram (epg) of faeces and vertical bars indicate standard error.

study may perhaps be related to the different egg viability of these species[44]. In this sense, the more frequent contact of the children in the rural community of Haulover with wet and sandy soils, could also explain the elevated result obtained in *T. trichiura*.

No statistical differences of infection between sexes were detected, although girls from urban schools were highly *A. lumbricoides* infected and an increase of STH infection with age in urban schools could be associated with the relaxation in the protective measures among the oldest school aged children.

Table 7. Total percentages of schoolchildren with soil-transmitted helminth species of the municipality of Laguna de Perlas (RAAS, Nicaragua) classified by intensity

	Class of Intensity[a]		
	Light	Moderate	Heavy
Trichuris trichiura	%	%	%
Laguna de Perlas	68.9	28.8	2.3
Haulover	57.9	37.6	4.5
Ascaris lumbricoides			
Laguna de Perlas	48.3	41.7	10
Haulover	42.5	50	7.5
Hookworm			
Laguna de Perlas	88.9	11.1	0
Haulover	95.5	4.5	0

[a]According to Montresor *et al.* (1998). *Trichuris Trichiura*: light. 1–999 eggs per gram faeces—epg; moderate. 1000–9999 epg; heavy. ≥00 000 epg; *Ascaris Lumbricoides*: light. 1–4999 epg; moderate. 5000–49999 epg; heavy. ≥00 000 epg; hookworm: light. 1–1999 epg; moderate. 2000–3999 epg; heavy. ≥4000 epg.

Polyparasitism is a common phenomenon in the tropics[5,23,45], as evidenced by the fact that infection with up to eight different species of protozoan and STHs were detected: *Entamoeba coli, Entamoeba hartmanni, Endolimax nana, Chilomastix mesnili, B. hominis, T. trichiura, A. lumbricoides* and Hookworm. Particularly noteworthy is the absence of association between *A. lumbricoides* and Hookworm. The fact that some intestinal species may prompt infection with other intestinal species, modulate the immunological response, and thus different degrees of polyparasitism should be the objective of a future study[46,47].

Among children of the municipality of Laguna de Perlas, the most frequent class of infection found is of a light intensity of STH infections. However, the intensities of *A. lumbricoides* and Hookworm were significantly higher when they were associated with *T. trichiura* than when they were found as monoparasitism. This is especially remarkable in co-infections with the three STH species in which the intensity of Hookworm infection presented the highest values.

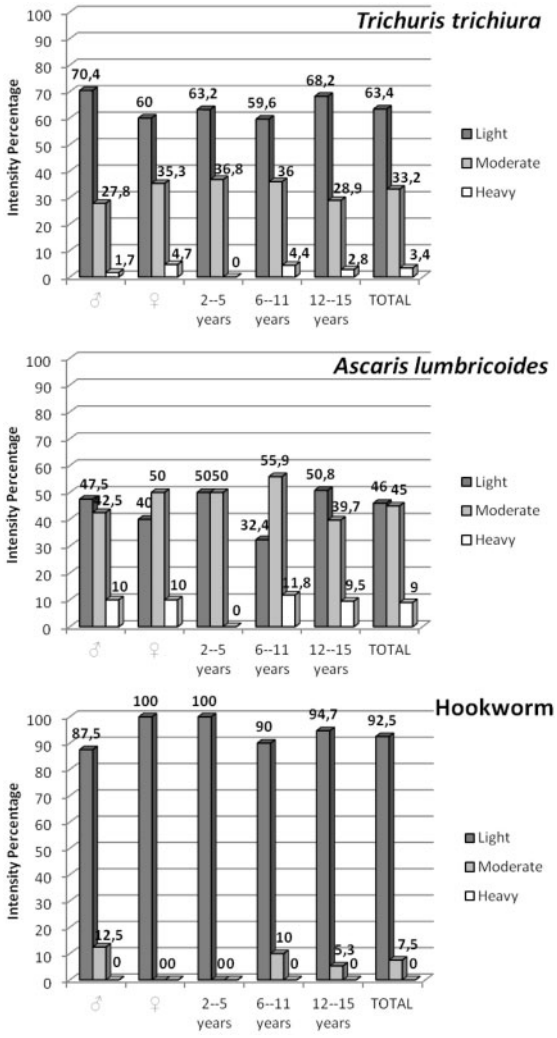

Fig.3. Comparison of categories of helminth infection intensities[a] in relation to sex and age-groups in the children of the municipality of Laguna de Perlas (RAAS, Nicaragua). Columns indicate percentage of intensity ([a]according to Montresor *et al.* (1998). *Trichuris trichiura*: light. 1–999 eggs per gram faeces—epg; moderate. 1000–9999 epg; heavy. ≥10000 epg; *Ascaris lumbricoides*: light. 1–4999 epg; moderate. 5000–49999 epg; heavy. ≥50000 epg; Hookworm: light. 1–1999 epg; moderate. 2000–3999 epg; heavy. ≥4000 epg).

Normally, in an endemic area, STHs are aggregated, with pupils harbouring low or moderate burdens, while only a few individuals harbour heavy burdens[48]. However, it has been clearly documented[7,49,50] that moderate and heavy intensity infections are of particular value from the public health point of view as the children in these categories are the ones who suffer most from the morbidity caused by these infections and are the target of the STH control activities aimed at eliminating these infections as a public health problem[51].

WHO recommends to carried out mass deworming programmes in communities when the cumulative STH prevalence is greater than or equal to 20% among school aged children[52]. Although Nicaragua supplies deworming drugs once per year for schoolchildren[53], our study indicates a helminth prevalence of 76.7%, even reaching up to 83.2% in the rural Haulover community, thus making a novel mass deworming programme highly recommendable in this area, treating all school-aged children at least twice a year, to reduce the rates of infection/reinfection. Moreover, it is vital to provide the necessary health education to parents,[54] so that children can be adequately protected from these STH infections.

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