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An Epidemiological Assessment of the Infectious forms of Intestinal Helminths in School Children from Chad

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Abstract

Intestinal helminths constitute the primary cause of illnesses in pre and school age children in the less developed countries. Their importance has been disregarded for a long time because of their insidious and chronic nature. In order to assess the prevalence rate of intestinal helminths in Chadian children, a survey of intestinal worms was carried out from March 2010 to February 2011 in two ecological zones (Sahelian and Sudanian zones) in the Republic of Chad. 1002 children (541 boys and 461 girls) aged from 6 to 17 years were enrolled in our investigation. The coprological analysis carried out in this study included macroscopic examination, direct microscopic examination and two concentration techniques (the Kato method and the formalin-ether concentration technique). The results showed highly significant differences in the prevalence of intestinal helminths between the two ecological zones, the prevalence being generally higher in the Sudanian zone than in the Sahelian one. Among all the helminths identified in the two zones, *Ascaris lumbricoides* was the most common, followed by *Hymenolepis nana*. A regular deworming and improvement of the hygienic conditions in these zones could go a long way to prevent intestinal worm infections. The findings of the present study urgently call for an improvement in environmental hygiene, the sanitary education of the populations and the creation of a national program for the fight against intestinal helminths in Chad.

Keywords: Epidemiology, Intestinal helminths, Children, School environment, Sudanian zone, Sahelian zone, Chad.

1. Introduction

Infections by intestinal helminths are the leading cause of illnesses among young people worldwide (OMS, 2004). High prevalence was observed in developing countries in tropical regions where poor sanitation, poor climatic conditions and low socio-economic status causes these parasites to pose a serious public health problem (Menan *et al.*, 1997; Perez, 2000; Savioli *et al*., 2002; Tchuem Tchuenté, 2011 & 2012). Consequently they induce diseases that should neither be neglected nor put in the background (Menan *et al*., 1997). The importance of the problem has long been neglected because these diseases are responsible for infant mortality due to their insidious and chronic nature (Tchuem Tchuenté, 2011). According to OMS (2001) and Brooker *et al.* (2002a), 2 billion people worldwide were infected with schistosomasis and soil-transmitted helminths (STH) with 300 million being severely affected and an increasingly high prevalence people living in less developed countries. It is often among preschool (2-5 years) and school aged children that infection rates are highest or ≥ 35% (Edwin, 2004). Using a probabilistic model to predict the prevalence and the number of children with helminthiasis in Africa, Tchuem Tchuenté (2011) estimated that more than 30.7 million school children are infected with *Ascaris lumbricoides*, 36.5 million with *Trichuris trichiura* and 50 million with hookworms. Children are particularly exposed to helminths for behavioral, hygienic and recreational reasons. 400 million school age infected subjects undergo frequent physical and mental suffering due to anemia, which results in a lack of attention, inability to assimilate knowledge and contributes to absenteeism and school dropouts (Drake *et al.*, 2000; Dreyfuss *et al.*, 2000; Stephenson *et al.*, 2000; Hall *et al.*, 2001; WHO, 2002; Hotez *et al.*, 2004; OMS, 2004). In Africa, the species such as *Schistosoma mansoni*, *Ankylostoma sp*., *T. trichiura* and *A. lumbricoides* respectively affect 25 million, 239 million, 233 million and 320 million children (Bundy *et al.*, 1997; Van der Werf, 2003). Intestinal worms are responsible for a decreased immunity of children towards malaria, which further increases the anemia caused by hookworms (OMS, 2005). In these subjects, intestinal helminths are the principal isolated leading cause of diseases and represent up to 12% of the total burden nosology (UNICEF, 2007). Morbidity due to schistosomiasis and STH is enormous in tropical countries (Savioli *et al*., 2002).

In Chad, very little studies have been done on intestinal parasites. According to Brooker *et al*. (2002b), 32.7% of Chad's rural population is infected with hookworm; Kostoingue *et al*. (2002) found that 57.7% of children harbor intestinal parasites in the city of N’Djamena. Recent studies showed that 60% of nomadic children in Chad are carriers of at least one intestinal parasite (Bechir *et al*., 2011) while Hamit *et al*. (2008) reported that 51% of the inhabitants of N’Djamena city are bearers of at least one intestinal parasites.

Within this context, the present study aims at determining the prevalence of intestinal helminths among chadian children aged from 6 to 17 years. Epidemiological data of this work will serve on the one hand as an advocacy tools for better personal and collective hygiene, a prerequisite in the fight against intestinal helminths and, on the other hand, will enable the implementation of a national program to fight against these parasites.

2. Materials and Methods

2.1 Study Area

Chad is a Sahelian country and land locked country in Central Africa with no coastline (Figure 1); it covers an area of 1,284,000 km ^{2} with an estimated population of 11,679,974 inhabitants (INSEED/RGPH2, 2010).

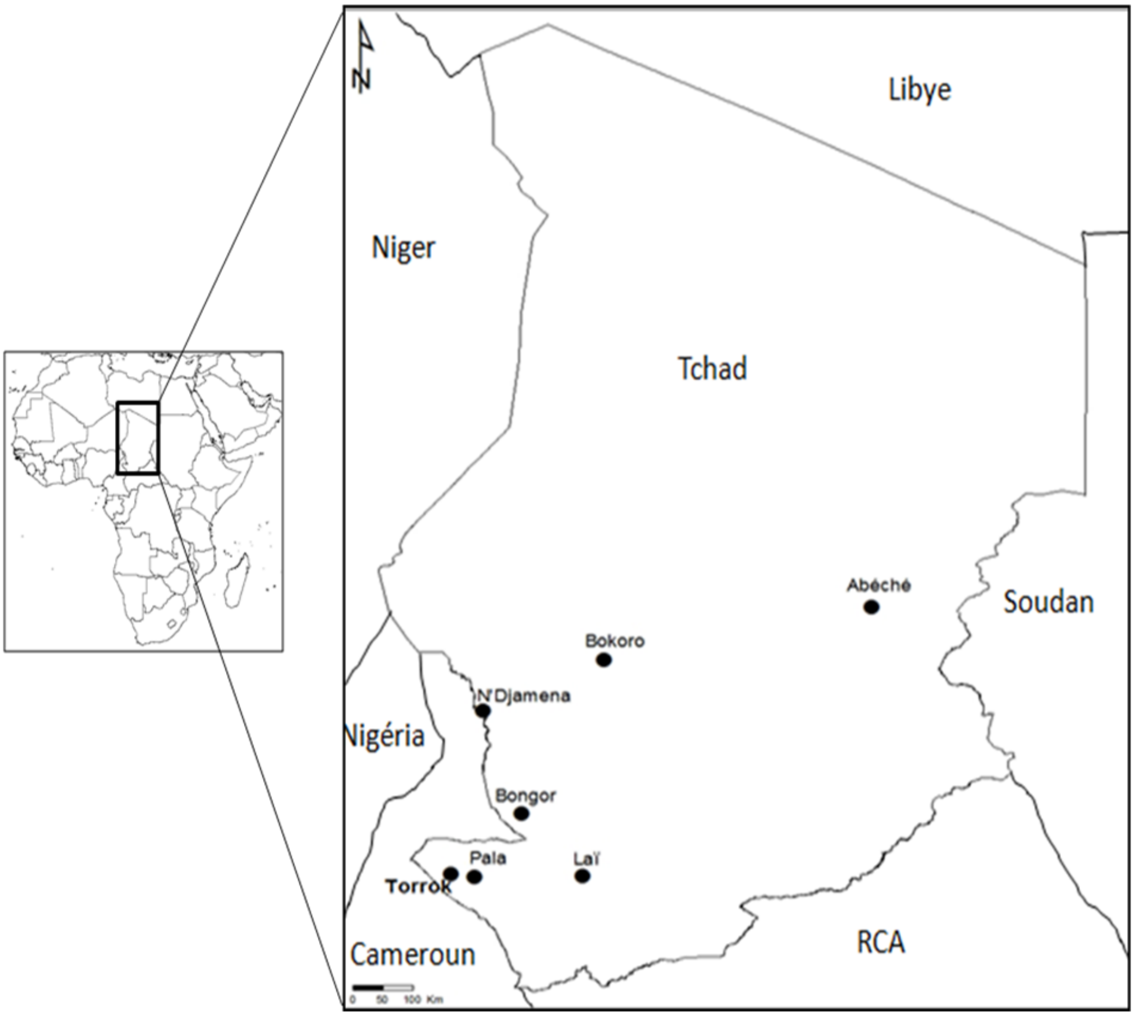

Figure1. Location of Chad and presentation of study sites (CNAR, 2012 amended)

With a growth rate of 3.1% in 2010, this population is characterized by an uneven distribution on the national territory, abundant youth, a high concentration of people in rural areas, a high ethnical diversity (256 tribes), many religions (Islam, Christianity, traditional), and a 52% representation of women (INSEED/RGPH2, 2010). Since 2003, the recurrent crisis in Darfur has forced more than 200,000 Sudanese to flee to Chad, in addition, tens of thousands of people were displaced within the country. On the economic front, Chad remains a very poor country despite the exploitation of oil in Doba (South) and in Chari-Baguirmi (Center) that has a refinery. The national health system is inefficient mainly because of the lack of qualified human resources, health facilities and medical equipment (OMS, 2010). Chad is divided into six ecological zones: Saharan, Sahel-saharan, Sahelian, Sudano-sahelian, Sudanian and Guinean (CNAR, 1998). This study was conducted in the Sahelian (Abeche, N'Djamena and Bokoro) and the Sudanian (Bongor, Pala, Torrok and Lai) zones (Figure 1). N'Djamena, the political capital of Chad, has a sahelian climate characterized by two seasons: a rainy season (June to September) and a dry season (October to May). Many of its neighborhoods are flooded during the rainy season. It is the most populated city in the country (Adibord, 1998). The climate in Abeche and Bokoro is also sahelian; Bokoro has the same periods of rainy and dry seasons as N'Djamena; even Abeche located in the mountains of Ouaddaï has a short rainy season from August to September. Bongor, Pala, Torrok, and Lai belong to the southern region of the country which has a tropical climate with three distinct seasons: a hot season from March to July, a rainy season from August to October and a cold season from November to February of the following year (DREM, 2013). Geographical and climatic characteristics of the study sites are presented in Table 1.

Table 1. Geographic and climatic characteristics of the study sites

City	Population (inhabitants/City)	Rainfall (mm)	Longitude East(^{0})	Latitude North(^{0})	Elevation (m)
Abeche	138 684	100 to 400	20^0 85'	13^0 85'	545
Bokoro	114 050	300 to 700	17^0 05'	12^0 33'	300
Bongor	69 787	500 to 1300	15^0 40'	10^0 28'	320
Lai	94 695	700 to 1300	16^0 30'	9^0 40'	358
N'Djamena	951 418	500 to 700	15^0 03'	12^0 13'	294
Pala	108 374	500 to 1200	14^0 92'	9^0 37'	454
Torrok	49 981	500 to 1200	15^0 02'	9^0 67'	355

Source: DREM (2013) and INSEED/RGPH2 (2010)

2.2 Population under Study

This work is a cross-sectional and prospective study that is focused on 1002 children of male and female genders; primary school children aged from 6 to17 years constituted the sampled population, and were randomly selected from 10 schools in 7 cities of Chad from March 2010 to February 2011 (Table 2).

Table 2. Sampling period

Cities	Schools	Sampling period
N'Djamena	Darhira	22 to 31 March 2010
	Daralsalam	
	Mandjafa	
Abeche	Sultan Mahamat Ourada	20 to 27 April 2010
	Association of catholic sisters	
Pala	Centre A	18-19 January 2011
Torrok	Centre	20-21 January 2011
La ï	Centre A	22-23 January 2011
Bongor	Centre A	24-25 January 2010
Bokoro	Centre A	2-3 February 2011

The size of the sample was determined by the cluster sampling technique (Fleiss, 1981; Spiegel, 1989) using the following formula: $n = \frac{P(1-P)Z^2}{i^2}$

P = prevalence of the latest study (37.52%) in the region of southern Chad (Brooker *et al*., 2002b), n =sample size, Z = is a given value of 1.96, if the probability limit $\propto$=0.05, n > 30; i is error in percentage read in confidence limit table = 0.03.

2.3 Preparatory Activities for the Investigation

A week before the study was carried out in each of the selected schools, a preliminary visit was carried out with the objective of assessing the level of sanitation on the one hand, and to sensitize pupils, teachers and other stake holders on the importance and necessity of the study as well as to seek their massive participation on the other hand.

A Socio-economic and health questionnaire developed on a survey form to collect information on the identity of the pupils, their habitat and lifestyle, was presented to the learner who agreed to participate in our investigation. This survey identified the general and food hygiene problems of each child.

Sampling collection was done in the morning. During the process, pupil that validated the age criterion were randomly selected; each child was then given a code number. Each Petri dish contained 3 to 5 drops of formalin 10%; selected pupils were then sent to the toilets to fill their Petri dish with feces. Collected feces were transported to the laboratory for immediate examination.

2.4 Methodology

In the laboratory, 4 standard methods were used to evaluate the helminth load in each stool sampled; the 4 methods included a macroscopic examination, a direct microscopic examination, the Kato method and the formalin-ether concentration technique.

The Kato method is an approach used to estimate the helminthic load in a sample of prepared stool; the outline procedure of this method involves several stages. First, a small amount of fecal matter was placed on a hard surface; a sieve or screen was then pressed on top of the feces to it. The filtered part of the feces (on the upper surface of the screen) was scrapped using a spatula; the scraped feces collected was then transferred in the hole of the template until it is completely filled (Odongo-Aginya *et al*., 2007). The template was then removed carefully. The fecal material was covered with a cellophane strip which is initially soaked in glycerol solution for at least 24 hours. The microscopic slide was inverted and firmly pressed on the fecal sample against the cellophane strip on a smooth surface like tile such that the fecal material was evenly spread. Clarification was ensured by glycerol and the set up was kept for a couple of minutes. The smear was then examined systematically, and eggs of each helminth species were recorded. Macroscopic observations were made at magnifications of 100x and 400x to better appreciate the contrast of the different elements. The number of eggs obtained was multiplied by 24 because the template used has holes of diameter 6 mm and a thickness of 1.5mm and stool weight of 41.5 mg (Katz, 1972; OMS, 1983; OMS, 1993). For the formalin-ether concentration technique, a small stick was used to introduce a small amount of fecal matter in the test tubes initially containing 10 ml of 10% formalin. The test tube was stirred and agitated vigorously such that a homogenous suspension of fecal matter was obtained. The homogenous suspension was then passed through a 2-layered fine-mesh wire sieve directly into a centrifugation tube, formalin was added to the centrifuge tube to raise the volume of the homogenous suspension to 10 ml. 0.3 ml of ether was then added and homogenized for 10 seconds. The suspension was centrifuged for 2-3 minutes at 400-500g. After the process of centrifugation, 4 different layers were obtained as follows: (a) a layer of ether at the surface (top), (b) a layer of fatty debris adhered on the walls of centrifugation tubes, (c) a layer of formalin and finally (d) a layer of sediments at the bottom. The 3 upper layers were carefully decanted living only the sediments in the tube; the sediments were mixed with some physiological water and placed on macroscopic slides for examination. Slides were observed at 100x and 400x to better appreciate the contrast of elements (OMS, 1993). Data collected were analyzed using the EPI INFO 6.0 software. The effect of age and sex on parasite hostage, global and specific prevalence and parasitic association were particularly studied. The 1002 randomly selected pupils in our sample were grouped according to gender and 3 age groups which are: 6-9, 10-14 and 15-17 years old.

3. Results

This study reveals that out of the 1002 pupils sampled, 572 (52.1%) had intestinal helminths, boys having a higher percentage (63.2%) compared to 49.8 % infection in girls. In general, boys more often harbour ($P<0.05$) parasites than girls (χ^2 =18, 04, ddl=1, Table 3).

Table 3. Global percentage in both sexes harboring at least one parasite species

Sex	n	n’	(%)
Male	541	342	63.2
Female	461	230	49.9
Total	1002	572	57.1

Legend: n = number of children examined; n' = number of pupils harboring at least one helminth species; (%) = percentage of infection.

The prevalence of helminths was higher among children in urban schools in the Sudanian zone as compared to schools in Sahelian zone (Table 4).

Table 4. Numbers and proportions of children bearing at least one helminth species per school and Chadian town of both ecological zones

Ecological zones	Cities	Schools				Subtotal by city			Subtotal by ecological zone		
			n	n’	(%)	n	n’	(%)	n	n’	(%)
Sahelian Zone	Abeche	ASC	101	20	19.8	210	81	38.6	588	289	49.1
		SMO	109	61	56						
	Bokoro	BokA	109	76	69.7	109	76	69.7			
		Dah	100	54	54						

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	N'Djamena	Dar	105	55	52.3	269	132	49.1			
		Man	64	23	36						
Sudanian Zone	Bongor	BonA	102	73	71.5	102	73	71.5	414	283	68.4
	La ï	La A	109	71	65.1	109	71	65.1			
	Pala	Pa A	102	70	68.6	102	70	68.6			
	Torrok	Tor	101	69	68.3	101	69	68.3			

Legend: n = number of children examined; n' = number of pupils bearing at least one helminth species; (%) = percentage of infection; SMO = Sultan Mahamat Ourada school; ASC = Association of Catholic Sisters School; BokA = Bokoro School Centre A; Dah = Darhira School; Dar = Daralsalam School; Man = Mandjafa School; BonA = Bongor Centre A School; LaA = Centre A Lai School; PaA = Pala Centre A School; Tor = School Torrok Centre.

Intrazonal analysis revealed variations in infection rate within cities in the Sahelian zone at P< 0.05 and $\chi^2 = 27.87$, ddl = 2, contrarily to the Sudanian zone where the differences in infection rate were not significant (P> 0.05, χ^2 =1.01, ddl =3).

In this study, 8 species of parasites were identified, among which were 4 nematodes, 3 tapeworms and 1 trematode. *Ascaris lumbricoides* (33.7%) and *Hymenolepis nana* (20.5%) were the most common helminthes in Chad; they were followed by hookworms and *Strongyloides stercoralis* with prevalence of 12.5% and 12.4% respectively. Prevalence rate of the other parasites identified were: *T. solium* (0.7%), *T. trichiura* (2.6%), *S. mansoni* (3.4%) and *T. saginata* (5.7%) (Table 5).

Table 5. Prevalence of helminth species in both sexes and the general population

Parasites		Boys (n = 541)		Girls (n = 461)		Total (N =1002)	
		n'	(%)	n'	(%)	n'	(%)
Nematoda	*A. lumbricoides*	201	37.2*	137	29.7*	338	33.7*
	Ankylostomes	78	14.4*	47	10.2*	125	12.5
	T. trichiura	11	2	15	3.3	26	2.6
	S. stercoralis	80	14.8*	44	9.5*	124	12.4
Cestoda	*T. solium*	3	0.6	4	0.9	7	0.7
	T. saginata	48	8.9*	9	2*	57	5.7
	H. nana	108	20	97	21	205	20.5*
Trematoda	*S. mansoni*	15	2.8	19	4.1	34	3.4

Legend: n= number of children examined as a function of sex; n'= number of pupils carrying the helminth species; (%) = percentage of infection; N = total number of children sampling; * = the highest percentage.

Specific parasite indices were different (P <0.05) in both sexes (Table 5) for *A. lumbricoides*, hookworms, *S. stercoralis* and *T. saginata*, the prevalence being higher in males than in females (χ^2 values respectively equal to 6.16, 4.06, 6.31 and 22.2). Two species (*T. solium* and

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S. mansoni) were absent in the Sahelian zone (Table 6). Hookworms were only diagnosed in the town of N'Djamena while *T. trichiura* and *S. stercoralis* were not found in Bokoro.

Table 6. Number of children and prevalence rate of each parasite species as a function of the city and the ecological zone studies

Cities (n)	AL (%)	AN (%)	TT (%)	SS (%)	HN (%)	TA (%)	TO (%)	SM (%)
Ab(210)	33(15.7)	0	3(1.4)	2(1)	36(17.1)	21(10)	0	0
Bok(109)	45(41.2)	0	0	0	40(36.7)	18(16.5)	0	0
Nd(269)	104(3.6)	5(1.8)	1(0.3)	2(0.7)	63(23.4)	13(4.8)	0	0
Subtotal (Sahelian zone) (n= 588)	182(31)	5(0.8)	4(0.6)	4(0.6)	139(23.6)	52(8.8)	0	0
Bon(102)	34(33.3)	33(32.3)	0	27(26.4)	35(34.3)	0	0	1(1)
La(109)	48(44)	22(20.1)	1(1)	32(29.3)	16(14.6)	3(2.7)	1(1)	0
Pal(102)	46(45.1)	24(23.5)	0	29(28.4)	9(8.8)	2(2)	0	17(16.6)
Tor(101)	28(27.7)	41(40.6)	21(20.8)	32(31.6)	6(5.9)	0	6(5.9)	16(15.8)
Subtotal (Sudanian zone) (n= 414)	156(37.6)	120(29)	22(5.3)	120(29)	66(16)	5(1.2)	7(1.7)	34(8.2)

Legend: n = number of children examined; (%) = percentage of infection; Ab =Abeche; Bok = Bokoro; Nd =N'Djamena; Bon = Bongor; La = Lai; Pal = Pala; Tor = Torrok;. AL = *A. lumbricoides*; AN = hookworm; TT = *T. trichiura*; SS = *S. stercoralis*; HN = *H. nana*; TA = *T. saginata*; TO = *T. solium*; SM = *S. mansoni*.

The results also indicated that the most infected age group was "10-14", all the 8 parasites were diagnosed in this age group within which the infection rates were different among parasite species (Table 7).

Table 7. Prevalence rate of each parasite species as a function of the age group

Parasites		Age groups (years)					
		"6-9" (n=310)		"10-14" (n=612)		"15-17"(n=80)	
		n'	(%)	n'	(%)	n'	(%)
Nematoda	*A. lumbricoides**	89	28.7	216	35. 3	33	41.3
	hookworm *	25	8.1	93	15.2	7	8.8
	*T. trichiura**	2	0.6	23	3.8	1	1.3
	*S. stercoralis**	18	5. 8	103	16.8	3	3.8
Cestoda	*T. solium*	0	0	7	1.1	0	0
	*T. saginata**	0	0	35	5.7	22	27.5
	*H. nana**	143	46.1	59	9.6	3	3.8
Trematoda	*S. mansoni**	1	0.3	31	5.1	2	2.5

Legend: n = number of students examined, n' = number of students carrying the helminth species, (%) = percentage of infestation, infestation * = prevalence rate different between the three age classes rate.

Monoparasitism, and polyparasitism (up to 4 species) were observed in this study; the

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percentage of polyparasitism cases decreased significantly while the number of parasites species in the association increased (P <0.05, ddl =3; $\chi^2 = 454.01$; Table 8).

Table 8. Distribution of infected children according to parasite associations

Type of parasitism	Parasite species	n'	(%)
Monospecific	AL	144	14.4
	AN	5	0.5
	TT	4	0.4
	SS	13	1.3
	HN	84	8.4
	TA	33	3.3
	TO	6	0.6
	SM	1	0.1
	Subtotal	290	28.9
Bispecific	AL-HN	90	9
	AL-AN	15	1.5
	AL-SM	4	0.4
	AL–TA	22	2.2
	AL-TO	1	0.1
	AL-TT	9	0.9
	AL-SS	21	2.1
	AN-HN	7	0.7
	AN-SS	41	4.1
	AN-SM	10	1
	SS-HN	2	0.2
	SS-SM	1	0.1
	SS-TT	1	0.1
	HN-TT	1	0.1
	Subtotal	225	22.5
Trispecific	AL-AN-TT	1	0.1
	AL-AN-HN	2	0.2
	AL-AN-SS	12	1.2
	AL-AN-SM	2	0.2
	AL-TA-TT	1	0.1
	AL-TA-SS	1	0.1
	AL-SS-HN	1	0.1
	AL-SS-TT	2	0.2
	AL-SS-SM	4	0.4
	AL-TT-SM	1	0.1
	AN-SS-TT	3	0.3
	AN-SS-SM	6	0.6
	AN-SS-HN	14	1.4
	AN-SM-HN	2	0.2
	Subtotal	52	5.2
Quadrispecific	AL-AN-HN-SS	1	0.1
	AL-AN-HN-TT	1	0.1
	AL-AN-SM-SS	1	0.1
	AL-SM-TT-AN	2	0.2
	Subtotal	5	0.5

Legend: n'= number of pupils carrying the helminth species; (%) = percentage of infection; AL = *A. lumbricoides*; AN = hookworm; TT = *T. trichiura*; SS = *S. stercoralis*; HN = *H. nana*; TA = *T. saginata*; TO = *T. solium*; SM = *S. mansoni*.

A. lumbricoides was the most frequent parasite species found in these associations; it was diagnosed in 194 children who were enrolled in the study. It was followed by *H. nana* (121 children) and hookworms (120 children), while *T. solium* was found in association with *A. lumbricoides* only once.

Chadians use water from diverse sources like wells, boreholes or SNE (National Society of Water) for cooking (Table 9).The results revealed a direct relationship between the intestinal parasite infection rate and the source of water supply. Percentage of infection was low (35.5%) among children using water supplied by SNE, but high (up 88.2%) for children relying exclusively on well water. About 89.4 % chadian households stored drinking water in clay pot which is half buried in the ground, with a poor lid; intestinal worms were mostly acquired by consuming water stored in canaries and drums ($P < 0.05$, χ^2 =5.68 and ddl=1). 66.6% of the children sampled indicated that they had a water point close to their homes against 33.4% who did not; however, the proportion of hosting at least one pathogenic species was higher ($P < 0.05$, χ^2=39, 13) in the first group.

Out of all questionnaires filled, 99.5 % children did not wash their hands with soap before meals; among them, 57.1% bore intestinal parasites; in the remaining (0.5 %), 60% (pupils) hosted intestinal parasites. Children who wore open shoes (40.7 %) presented an infestation percentage of 70.3 %, different ($P < 0.05$, χ^2=49.38) from 48% for those who wore closed shoes. Children that lived in household alongside domestic animals (like cows, sheep, dogs, pigs, ducks) hosted more often (66.9%) intestinal worms compared to (47.5%), the infection rate of those who had no domestic animals in their homes ($P < 0.05$, χ^2=38.2, Table 9).

Table 9. Infection rate by considering the water source, wearing shoes or not and the presence or absence of domestic animals in households

Water supply source		n	n'	(%)
Cooking water	SNE	211	75	35.5
	SNE and manual pump drilling	57	23	40.3
	Manual pumps drilling	717	459	64
	Wells	17	15	88.2
Mode of water storage at home	Canaris	896	500	55.8
	Canaris and drums	106	72	67.9
Presence of a water point close to the concession	Yes	335	145	43.3
	No	667	427	64

Washing hands with soap before meals	No	997	569	57.1
	Yes	5	3	60
wearing of shoes	closed	594	285	48
	Open	408	287	70.3
Pets at home	Absence	507	241	47.5
	Presence	495	331	66.9

Legend: n = number of children examined; n' = number of pupils carrying the helminth species; (%) = percentage of infection.

4. Discussion

This study did not take into account the protozoan although these organisms also form an important part of intestinal pathogens observed in fecal matter that is assessed in hospital laboratories in Chad. In our sample, there is a predominance of boys' contribution compared to the findings of several similar works in Africa and in the world (Zakai, 2004; Ostan, 2005; Raso, 2005; El Kettani, 2006 and Balcioglu, 2007). Age interval in our sample are 6 and 17 years, while in several studies carried out the world, they are 4 and 15 years (Kassi *et al*., 2008; El-Kettani, 2006; Stephane *et al*., 2004). This age difference can be explained by the delay in the enrollment of Chadian children in primary school (Salé Hagam, 2012).

Our survey revealed that 57.1% of children, that is about one child over two, were infested with at least one intestinal helminths species (Table 3). This value seems to be low because we did not use a specific method for the detection of *Enterobius vermicularis*, a parasite which is fairly common in children due to its peculiar life cycle (Adou-Brin *et al*., 2001). Local conditions and logistical constraints did not allow us to implement other techniques. Nevertheless, both methods used have the advantage of being simple, rapid, and inexpensive, and are suited for low-income countries (OMS, 1983; Tchuem Tchuenté, 2012). The prevalence rate of 57.1% corroborates those already found: 57.7% in N'Djamena by Kostoingue *et al*. (2002), 51% also in N'Djamena by Hamit *et al*. (2008), 56 % in other tropical regions as in Gondar (Ethiopia) by Worku *et al*. (2009), 54.7% in the Delta state (Nigeria) by Egwunyenga *et al*. (2005), 60% in the region of Lake Chad by Bechir *et al*. (2011), and 60% in Makenene (Cameroon) by Tchuem Tchuenté *et al*. (2001). Our result does not tie with those of: Tchuem Tchuenté *et al*. (2003) who reported 90.3% in Loum (Cameroon), Nkengazong *et al*. (2010) in the South West region (Cameroon) with 42% and Brooker *et al*. (2002a) in Mayo Kebbi (Chad) with 37.5%. The level of infection in this work still shows that intestinal helminths infections remain a public health problem in Chad.

The rate of infection was higher in boys than in girls (Table 3). This observation has been reported by several authors such as: Kassi *et al*. (1989) in Aboisso, Menan *et al*. (1997) in Abidjan, Adou-Brin (2001) in Toumodi and Stephane *et al*. (2004) in Agboville (Ivory Coast), Tchuem Tchuenté *et al*. (2012) in the Center, East and West regions of Cameroon. However, Agbolade *et al*. (2004) in southwestern Nigeria, OMS (2005) in Cape Verde, Hamit *et al*. (2008) in N'Djamena (Chad) and Kassi *et al*. (2008) in Divo (Ivory Coast), found no difference in infection between both sexes. This difference in prevalence rates, which only concerned *A.*

lumbricoides, Ankylostoma sp., *S. stercoralis* and *T. saginata* (Table 5), can be explained by the fact that in Chad, the traditional education of girls is also different from that of boys. For example, during the days of rest, girls must stay at home to help their mothers with some household duties, while boys engage themselves in games and feed out of the homes. During these leisure activities, the risks of parasitic infections are higher (Hamit *et al*., 2008). Besides, this risk of contamination from street food had been highlighted by certain authors (Tidjani *et al*., 2006; Barro *et al.*, 2007). Eight species of helminth were diagnosed during our investigation: four nematoda (*A. lumbricoides*, *T. trichiura*, hookworms and *S. stercoralis*), three cestoda (*H. nana*, *T. solium* and *T. saginata*) and a trematoda (*S. mansoni*). In a similar analysis conducted in southwest region of Cameroon, Nkengazong *et al*. (2010) identified the same four nematoda and showed prevalence rates higher in females than in males. This difference seems mainly due to the technical analysis of fecal matter collected. In addition to the method used by Nkengazong *et al*. (2010) the Kato, the formalin/ether method of concentration was included in the present study. Among the identified species, three are blood sucking (hookworm, *T. trichiura* and *S. mansoni*). This profile includes a risk of iron deficiency which provokes anemia that has been reported to have a negative impact on children academic performance and growth (Drake *et al.*, 2000; Dreyfuss *et al.*, 2000; Stephenson *et al.*, 2000; Hall *et al*., 2001; WHO, 2002; Hotez *et al*, 2004; OMS, 2004; Tchuem Tchuenté *et al.*, 2012). The presence in this study of transcutaneous-acquired helminthes (*S. mansoni* and hookworm) demonstrates a lack of environmental sanitation and an unprotected contact with the milieu.

This research study showed that intestinal helminthiasis in primary school pupils in Chad are mainly due to *A. lumbricoides, H. nana*, hookworm and *S. stercoralis* (Table 5). A similar finding had been published for the first two species by Brooker *et al*. (2000) in Cameroon, Saathoff *et al*. (2005) in South Africa, Goodman *et al.* (2007) in Zanzibar, Hamit *et al*. (2008) in Chad, and Zephania *et al.* (2010) in Cameroon. Recently, Bechir *et al*. (2011) demonstrated the prevalence of hookworm in Chad. The higher rate of ascaridiasis (33.7%) in the present study confirms that this parasitosis is one of the most common in the world among geohelminthiases (Tchuem Tchuente *et al.*, 2001 & 2012; Montresor *et al.*, 2002; Miguel & Kremer, 2002, Ajeagah *et al*., 2013). However, trichuriasis is the first helminthiasis in some tropical areas; this is the case in Toumodi (Adou-Brin *et al.*, 2001.) and Agboville respectively in the northen and southern part of Ivory Coast (Stephane *et al.*, 2004), in the South-western (Nkengazong *et al.*, 2010) and in the coastal region (Sumo, 2012) of Cameroon. Tchuem Tchuente *et al*. (2012) also found that *A. lumbricoides* and *T. Trichuria* are the most common helminthes in Cameroon. Regarding the trematode *S. mansoni*, the short duration and the fickleness of egg migration into blood capillaries could explain its low prevalence (3.4%) obtained in this study. Hence, prevalence could be considered underestimated as some infected children did not have its eggs in their feces (Golvan, 1983; Theron *et al.*, 1992). However, the interest of our study was first to identify the parasite species among school children.

Among the helminthes diagnosed, only two were found in the sudanian zone (Table 6), namely *T. solium* and *S. mansoni*. Apart from *H. nana* and *T. saginata*, the prevalences of all species appeared higher in the cities of the sudanian zone than in the sahelian zone (Table 6). Indeed,

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the sudanian zone is a wet and rainy forest region which is suitable for the dissemination of eggs (Brooker *et al.*, 2002b; Savioli *et al.*, 2002; Tchuem Tchuenté, 2003 & 2011). Bokoro city, though found in the sahelian zone, also presented high infection rate with *A. lumbricoides, H. nana* and *T. saginata* (Table 6). This can be explained by the fact that in Bokoro, the schools visited lack toilets and a supply of pine-borne water; the low infection rate (19.8%) observed in Abeche Catholic Associated Sisters School (Table 4) can be attributed to the presence of toilets and a water closet system with the presence of a sink to wash hands after the usage of the toilets. No other school among those visited is equipped with sanitation facilities, not even common water supply, although the center A school in Bongor is one of the oldest in the Central Africa region (Salé Hagam, 2012). Yet, health facilities in schools have been reported to reduce parasitic infections (Egwunyenga *et al*., 2005).

The parasite species diversity was higher in the age group "10-14" years. This result is similar to those of Kassi *et al.* (2008) in Divo (Ivory Coast) for the age range of 8-9 years and Stephane *et al*. (2004) in Agboville (Ivory Coast) for age range of "12-15" years. Similarly, Agbolade (2007) in a related study in Southwestern Nigeria reported a significant infection rate from 6 to 12 years old. Our result differs from that of Tchuem Tchuenté *et al*. (2012) in the Central, Eastern and Western Cameroon, who found parasite prevalence higher in the age group ≤ 9 years, Nkengazong *et al*. (2010) in South West Cameroon with high infection in the class "1-5" age old, and Sumo (2012) in the Central region of Cameroon with the prevalence rate higher in the age group > 15 years.

In the Chadian school context, parasitism seems to be directly related to lack of water and sanitation facilities. This infrastructural deficit does not facilitate high rules of hygiene in the community. This observation was also made in Cape Verde (OMS, 2005). The high prevalence rate assessed in our study is also associated to the source of water supply or storage of water. A low rate of children infected is seen in those with potable water supply (SNE) at home (Table 9). In Chad, the water storage is generally done in local clay pots called "canaries". This method and the poor maintenance of these containers increase chances of the infection rates. In our study, 0.5% of the children surveyed reported washing hands with soap before eating but most of them (60%) hosted parasites; this result is explained by the fact that hands are washed in the same container, then wiped with the same towel (Hamit *et al*., 2008). Similarly, wearing closed shoes and having no pets in the house reduced the infection rates compared to wearing opened shoes (Table 9); several authors (Steinmann *et al.*, 2000; Traub *et al.*, 2004; Corrales *et al.*, 2006) also reported that living in close proximity with pets increases the prevalence rate of intestinal parasites.

Monoparasitism was found in 290 pupils (28.9% of the sample); quite the same percentage of polyparasitism was observed in 282 children who represent 28.14% of the sample. This proportion is lower than 76.7% recorded by Dancesco *et al*. (2005) in Ivory Coast but higher than 10.19% as indicated by Tchuem Tchuenté *et al*. (2012) in Cameroon. Three types of polyparasitism (by 2 to 4 species) were identified (Table 8) in contrast to Menan *et al*. (1997) in Ivory Coast, Buchy (2003) in Madagascar and Nkengazong *et al*. (2010) in Cameroon who reported the coexistence of 5, 8 and 3 species respectively. In our study, *A. lumbricoides* is the species mostly involved in parasitic associations and may thus be primarily responsible for malnutrition in school children.

Out of 121 pupils (12.1% of the sample population), *H. nana* was associated with 1 to 4 other geohelminthes (*A. lumbricoides*, hookworm, *S. stercoralis*, *T. trichiura*). Except *T. trichiura* whose adults live in the coeco-appendicular mucosa (ANOFEL, 2010), the other three species mentioned are found in the adult stage hooked to the intestinal mucosa (small intestine). This parasitic biodiversity suggests that the infection process probably occurs simultaneously.

No case of simultaneous parasitism by the tapeworms *T. saginata* and *T solium* was observed; this confirms the name solitary worms given to these species (Golvan, 1983; ANOFEL, 2010). *T. solium* was only found to be associated to *A. lumbricoides* in one child; *T. saginata* coexisted with the same nematode and/or *T. trichiura* and *S. stercoralis* in 24 children. As for *T. trichiura*, 21 pupils harbored it with each of the other parasite species, except *T. solium*. This observation suggests either the absence of competitive interactions between the soil-transmitted helminthes identified, or that their parasitic loads are relatively low. This scientific study that took place in the seven most prominent towns of Chad, was carried out for a period of 12 months which is a complete ecological cycle. The findings of these researches will go a long way to attract the public power on the sanitary impact of the intestinal helminthiasis on school children. At our level, we used Albendazole (Zentel) to take care of all children infested at the unique dose of 400mg/infected child. The food potentialities of Chadian children are basically made of cereal which is prepared in one form or the other, making it difficult to subdivide the samples into different nutritional status. The local conditions and the logistical constraints didn't permit us, to study the efficiency of the treatment and the dynamism of reinfestation of the helminths, even though a technical survey in this direction is planned for 2014.

5. Conclusion

The present study proofs that intestinal helminths are prominent among primary school children in Chad. *A. lumbricoides* and *H. nana* are higher in the two first places respectively among the helminths diagnosed in the two ecological zones. The overall prevalence of intestinal helminths in the Sudanian zone is higher than those obtained in the Sahelian region where worm biodiversity in the Sudanian zone is much higher with 8 parasites identified as opposed to 6 parasites in the Sahelian zone. School children in the age range of "10-14" are more often infected. The profile of the above-described intestinal parasitosis suggests that the success in the fight against these diseases passes through sanitation efforts of schools, health education of parents, improvement of personal hygiene, maintenance of transport and storage of water containers, regular and sustainable deparasitation in schools and in the general population. It is also important to ensure the hygiene and health conditions of pets. All these findings show that despite the significant increase in the standard of living and the current consolidation efforts in cities such as N'Djamena, Abeche and Bongor, intestinal helminth infections remain a major public health problem in Chadian primary schools. Considering the overall prevalence in this study (57.1%) and given the prevalence of over 60% in some cities, it is necessary to carry out a systematic deworming of the population at least once every three months. The medical authority in Chad has everything to gain by adopting a national program to fight against the spread of intestinal-helminths.

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