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Prevalence of soil-transmitted helminths in primary school playgrounds in Edo State, southern Nigeria

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Summary

Schoolchildren in primary schools are mostly at risk of acquiring soil-transmitted helminths (STHs) infections due to their habits (geophagy, onychophagy and playing with barefoot). Profiling soil parasites on school playgrounds is expected to provide an insight to an array of parasites schoolchildren are constantly at risk of acquiring; and this information could guide on intervention programmes. Soil samples from sixteen primary school playgrounds in Edo State (South-South, Nigeria) were collected over a six-month period both in the dry (January, February and March) and wet (May, June and July) seasons in 2018 and early 2019. Samples were processed and analysed following standard parasitological procedures. Of the 576 soil samples collected, 318(55.2 %) were positive with one or more soil parasites. Generally, the predominant parasites recovered from the total number of soil samples collected were: *Ascaris* 127(22 %), *Strongyloides* 111(19.27 %) and hookworm 50(8.68 %). *Ascaris* was most preponderant in the dry season, while *Strongyloides* was the most occurring in the wet season. The mean differences in the parasite load for *Ascaris* and hookworm between dry and wet seasons were not significant; while for *Strongyloides,* it was higher in the wet than dry season. These results could be a consequence of observed poor state of toilet/sanitary facilities as well as the lack or poor state of basic infrastructure like proper drainage and waste disposal systems in the host communities. There is therefore urgent need to interrupt the STHs transmission cycles in the environment and possibly in schoolchildren by instituting sustainable intervention programmes within schools located in STHs endemic regions like southern Nigeria.
Keywords: Schoolchildren; soil-transmitted helminths; seasons, Edo State; southern Nigeria

Introduction

Soil-transmitted helminths (STHs) are a group of intestinal nematode-causing diseases in man. These are roundworm (*Ascaris lumbricoides*), whipworm (*Trichuris trichiura*) and hookworms (*Necator americanus*, *Ancylostoma duodenale* and *A. ceylanicum*). These aforementioned parasites are among the 20 major neglected tropical diseases (NTDs) identified by the World Health Organization (WHO, 2018). The threadworm (*Strongyloides stercoralis*) being an STH, is frequently considered separately because methods used for diagnosis as well as treatment regimen are different (Krolewiecki *et al*., 2013; Puthiyakunnon *et al*., 2014; Buonfrate *et al*., 2015; Forrer *et al*., 2018). STHs are estimated to affect more than 1.5 billion people worldwide (WHO, 2018) with the disability-adjusted life years (DALYs) for *A. lumbricoides* to be between 596, 000-1,290,000, *T. trichiura* (120,000 – 354,000) and hookworms infections (510,000 – 1,340,000) (Global Health Metrics, 2018). The morbidity caused by STHs is commonly asso-

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ciated with the intensity of infection as chronic and repeated infection could lead to malnutrition as well as physical and intellectual growth impairment particularly among school-age children (Bundy, 1995; Hotez *et al*., 2005). Clinical symptoms include: diarrhoea, abdominal pain, nausea, vomiting, cough, fever, dysentery and colitis (Bethony *et al*., 2006).

In addition to the STHs of humans, there are zoonotic STHs (*A. caninum*, *A. braziliense*. *A. suum*, *S. stercoralis*, *T. vulpis*) of domestic animal origin and infection with these parasites could be of public health concern (da Silva *et al*., 2016; Ma *et al*., 2018). For instance, in humans, *A. caninum* can present as eosinophilic enteritis, while *A. braziliense* can cause cutaneous larva migrans without intestinal infection (Prociv and Croese, 1990; Bowman *et al*., 2010). Primary school playgrounds without perimeter fencing in rural communities are likely to be contaminated with zoonotic STHs; and when acquired, these parasites are under-diagnosed due to sundry reasons such as the fact that medical personnel are largely unfamiliar with the identity of such parasites. Although symptoms of zoonotic STHs with human STHs often present very similar clinical pictures, they sometimes require different treatment approaches (Lloyd *et al*., 2014). The incidence of STH infections is dependent on several factors: sanitary, socio-demographic and environmental. The latter comprise the temperature of the soil surface, humidity and precipitation (Weaver *et al*., 2010; Schule *et al*., 2014). In the transmission cycle of STHs, infected humans and animals defecate in the soil, then eggs mature to the infective larvae stage; thereafter, infection could occur on contact with a new host by ingestion or through skin penetration (Schar *et al*., 2013, Hassan *et al*., 2017). In order to become infective, *Ascaris* egg must incubate at 5 to 38°C for 8 to 37 days, *Trichuris* at 5 to 38°C for 20 to 100 days, while for hookworms, it is 2 to 14 days at temperature under 40°C (Brooker *et al*., 2006). Past field studies have shown that soil contaminated with STHs in both rural and urban settings had significant geographic variability (Blaszkowska *et al*., 2011; Nwoke *et al*., 2013; Hassan *et al*., 2017; Oyebamiji *et al*., 2018).

Clearly, STH infections are prevalent in Nigeria and highest burden is seen in the South-West region (Ohiolei *et al*., 2017; Karshima *et al*., 2018). School-age children between ages 5 and14 are reportedly high risk group as a result of their habits (Nwaorgu *et al*., 1998). Many of these primary school children do pick up soil parasites mostly at break/lunch time because during this period, they are engaged in a range of activities that put them at high risk to acquiring infections (Geissler *et al*., 1998). Despite the possible risk of acquiring soil parasitic infections from public primary school playgrounds, there appear to be a dearth of information on the array of possible parasites seen in these areas within school premises in Nigeria. For the first time, we attempt to profile soil parasites in primary schools in Edo State, South-South, Nigeria; and we believe that the availability of these data may raise the level of consciousness/awareness towards understanding the degree to which schoolchildren are exposed and at risk of acquiring STH-infections. This may go a long way to possibly foster interven-

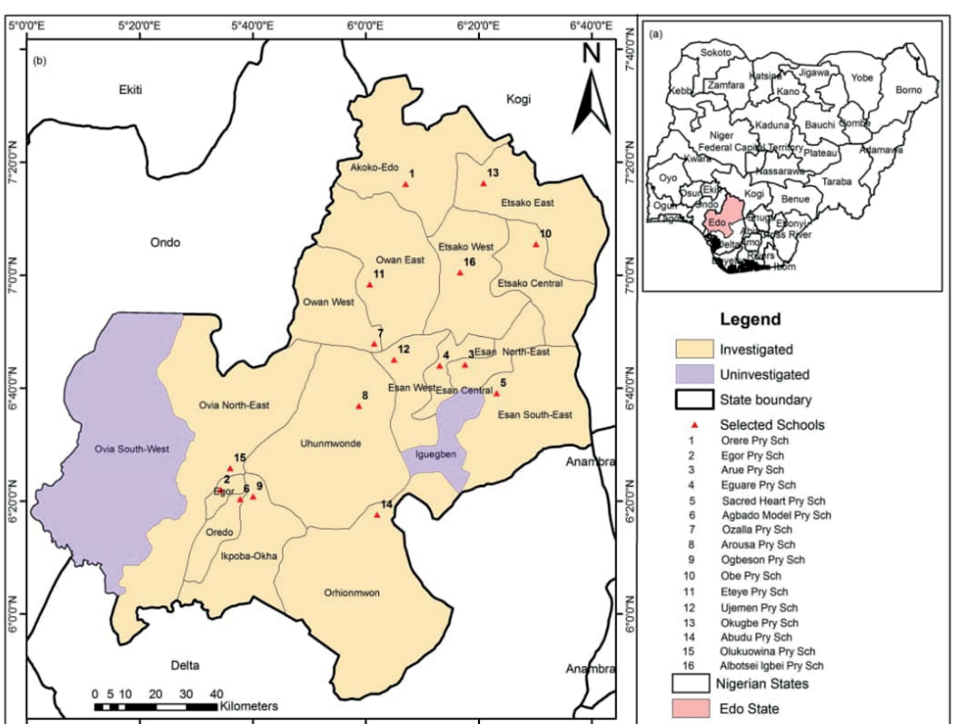

Fig. 1. Map of Edo State indicating study locations.

Table 1. Description of sampled primary schools.

Local Government Area	Primary School	Location	Population size	State of perimeter fencing	Water facility	Toilet facility
Oredo	Agbado pry sch	Urban	1240	Fenced	Borehole	Present
Orhionmwon	Abudu pry sch	Rural	918	Not fenced	Absent	Present
Ovia-North-East	Olukuowina pry sch	Semi-urban	877	Not fenced	Absent	Present
Owan East	Eteye pry sch	Semi-urban	950	Not fenced	Absent	Present
Owan West	Ozalla pry sch	Rural	1294	Not fenced	Absent	Absent
Uhunwonde	Arousa pry sch	Rural	968	Fenced	Present	Present
Etsako West	Albotse Igbei pry sch	Semi-urban	690	Not fenced	Absent	Absent
Ikpobaokha	Ogbeson pry sch	Urban	1099	Fenced	Borehole	Present
Esan North-East	Arue pry sch	Semi-urban	755	Partial fencing	Well	Present
Esan Central	Eguare pry sch	Semi-urban	940	Fenced	Well	Present
Esan South-East	Sacred heart pry sch	Rural	885	Not fenced	Absent	Present
Esan West	Ujemen pry sch	Rural	939	Not fenced	Absent	Present
Etsako Central	Obe pry sch	Semi-urban	978	Fenced	Well	Present
Etsako East	Oghe-Okugbe pry sch	Rural	720	Fenced	Absent	Present
Akoko Edo	Orere pry sch	Urban	1000	Not fenced	Absent	Present
Egor	Egor pry sch	Urban	844	Fenced	Absent	Present

tion programmes. Hence, we collected and analysed soil samples in the months of the year (dry and wet seasons) in which schools were opened for academic activities; and as such, the prevalence and burden of soil parasites in sixteen primary schools were estimated and are thus presented.

Materials and Methods

Study area

Edo State being located in the South-South region of Nigeria comprises 18 local government areas (LGAs) (Fig. 1) with population size of approximately 3,233,366. Its vegetation type is largely rainforest with two seasons: dry (November to March) and wet (April to October). Different communities make up each LGA as each community is likely to have at least one primary school. So, by random selection, one public primary school from each LGA was picked for this study. The settings (urban, semi-urban or rural) where these schools are located, population size, state of water and toilet facilities as well as the state of perimeter fencing around each primary school were noted (Table 1).

Sample collection and processing

In this study, purposive sampling (Jarosz *et al*., 2010) was adopted in selecting areas for soil collection; and as such before any decision on points of soil collection within school premises, we closely inspected these schools at periods when there were breaks from classroom activities which provides for pupils to play around. So, for each school, three locations in which children frequents either to play or carry out other activities were considered for soil collections. Soil samples were collected at three points within each primary school premises twice a month (first and last week of the month) for a six-month period in both dry (January, February and March) and wet (May, June and July) seasons in 2018 and early 2019. We ensured that all-through the period of collection, 100 – 200 g of samples were obtained on same spots within a 5 m radius at 2 – 3 cm depth and preserved at room temperature until needed for parasitological investigation. Soil samples were dried, filtered and weighed to obtain 2 g. Different techniques were used: modified Baermann's (soil samples were suspended in distilled water for 24hrs before examination) and flotation (sucrose solution) methods to obtain eggs and larvae. For the sucrose solution method, faecal samples were first mixed with distilled water, and sieved into tubes to remove large particulates before they were concentrated by centrifugation and decanted. Thereafter, tubes containing the concentrates were refilled with sucrose solution and cover slips placed on the surface of the tubes. Floated eggs/larvae sticks to the surface of the cover slips and these slips are then placed on slides and examined under the microscope (Foreyt, 2001). Using appropriate keys, recovered parasites were identified and also quantified (number of parasites per 2 g of soil) (Horiuchi & Uga, 2013).

Statistical analysis

ANOVA was applied to test differences in monthly variation, while student *t*-test compared variations between seasons for prevalence and parasite density data. Post hoc analysis using Newman-Keuls multiple comparison test was applied to the data on monthly *Strongyloides* density for the dry season. Differences in

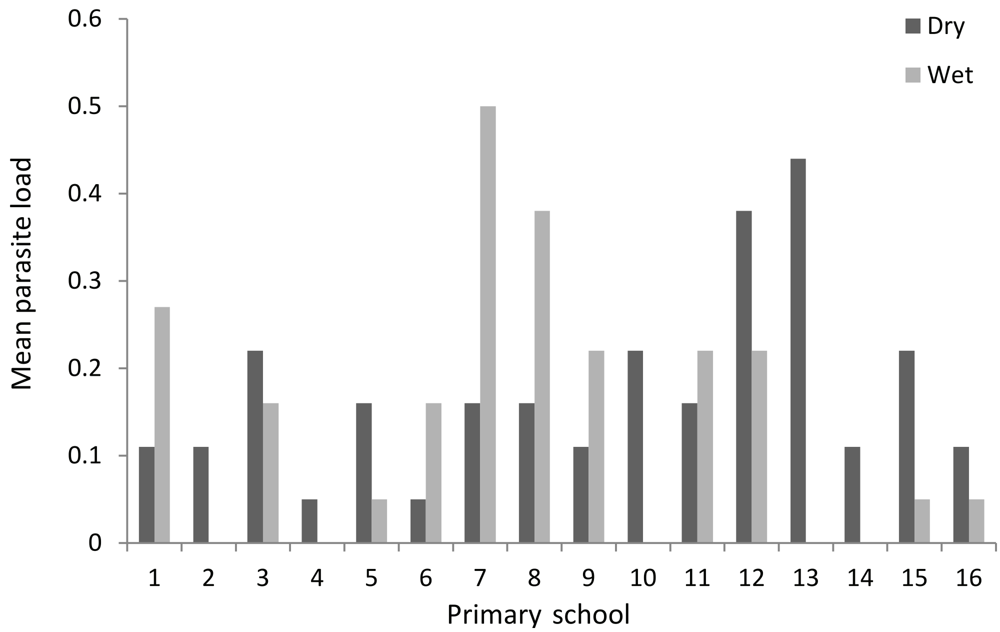

Fig. 2. Seasonal variations with *Ascaris* density.

mean values were significant at $p<0.05$. All analysis was done using GraphPad Prism version 5.01.

Ethics approval and/or Informed Consent

Not applicable.

Results

A total of 576 soil samples were collected in both dry and wet seasons. Four soil parasites were recovered with the following prevalence: *Ascaris* 127(22 %); *Strongyloides* 111(19.27 %); hookworm 50(8.68 %) and *Trichuris* 5(0.86 %). In the dry season, mean values of positive samples was lowest in January (1.87 ± 0.38) and

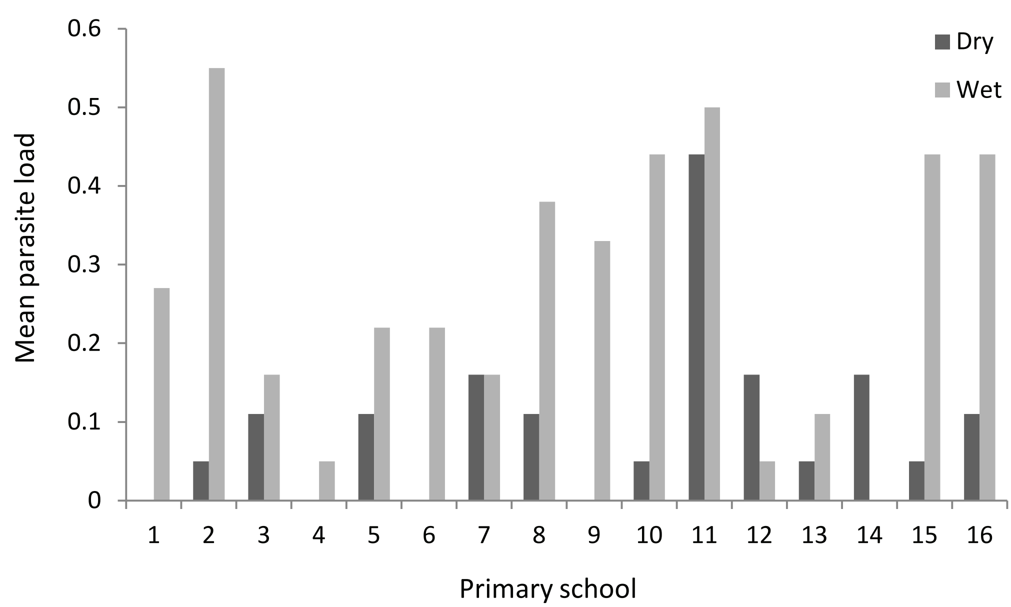

Fig. 3. Seasonal variations with *Strongyloides* density.

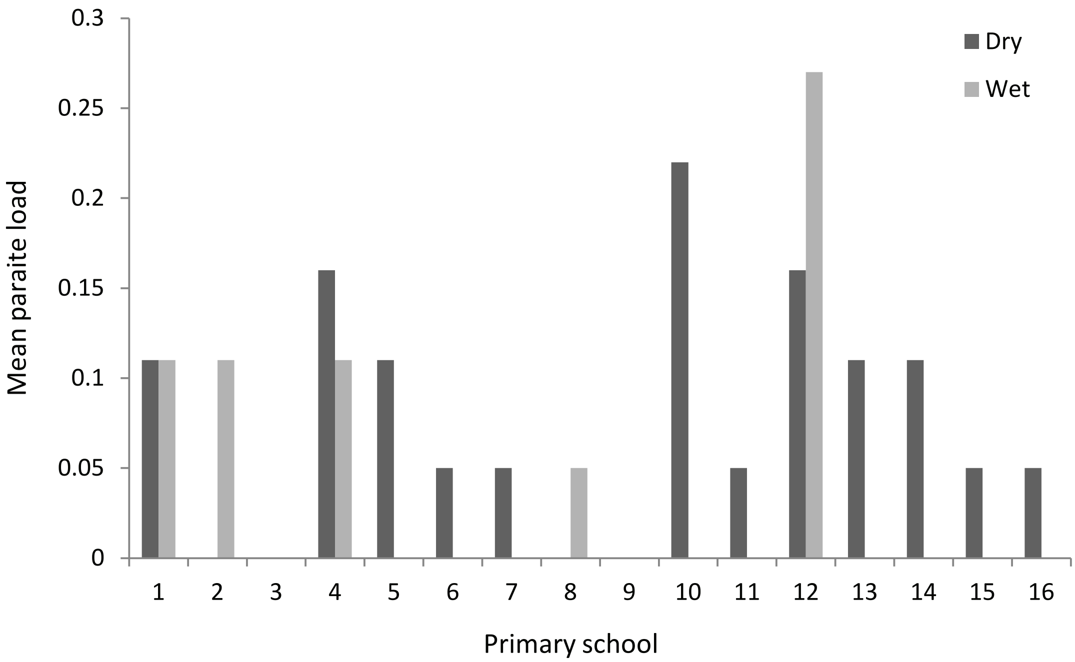

Fig. 4. Seasonal variations with hookworm density.

highest in February (3.75 ± 051) as difference in mean values was significant (F=3.65; p<0.05). In contrast, mean values for the wet season months was not significant (F=0.73; p>0.05). The frequency of positive samples in the dry (2.95 ± 0.3) season was higher than in the wet (3.66 ± 0.29) but mean difference not significant (t=1.61; p>0.05). Of note is the highest number of positive samples recorded in Esan Central and lowest in Owan East. More than 50 % of the total numbers of soil samples were parasite-positive. The least number of positive soil samples were recorded in the month of January, while July samples had the highest number of positives (Table 2).

A total of six parasites were recovered from soil sampled in both seasons, with *Ascaris* being most preponderant in the dry followed by *Strongyloides* and hookworm (Table 3). Meanwhile, in the wet season, *Strongyloides* was the most frequently seen followed by *Ascaris* and hookworm (Table 4). The frequency of occurrence of hookworm in the wet season was higher than in the dry. *Trichuris* parasites were relatively scanty in both seasons.

Nine schools had higher *Ascaris* load in the dry than wet, while seven schools were higher in the wet. Specifically, *Ascaris* density was highest in Etsako Central (0.5 parasite/2 g soil), while in the dry, Etsako West was highest (0.44 parasite/2 g soil) (Fig. 2). The overall mean difference in the *Ascaris* ova density between dry (0.166 ± 0.027/2 g soil) and wet (0.14 ± 0.037/2 g soil) was marginal (95 % CI: -0.078 to 0.11; t=0.36; p>0.05). For *Strongyloides*, twelve of the sites had higher load in the wet than dry season. So far, no positive sample was recorded in one of the primary schools in the wet, while in one study location, the parasite load was same. Only two study locations recorded higher load in the dry than wet (Fig. 3). During the wet season, parasite larvae load was highest in Orhionmwon (0.55 parasite/2 g soil), while in the dry, it was highest in Esan South-East (0.44 parasite/2g soil) (Fig. 2). In the dry season, parasite load was significantly reduced in the month of January; and by post hoc analysis, significant difference was between January and February (q=3.69). The overall mean difference between dry (0.1 ± 0.027/2g soil) and wet (0.26 ± 0.44/2g soil) was significant (95 %CI: -0.27 to -0.059; t=3.19; p<005). For hookworm, of the sixteen (16) sites sampled, only five (5) were positive in the wet season, while twelve (12) sites were positive in the dry. Hookworm ova density in the wet season was highest in Esan West (0.27parasite/2g soil), while in the dry, it was highest in Esan North-East (0.22 parasite/2g soil) (Fig. 4). Meanwhile, overall mean difference between dry (0.076 ± 0.016/2g soil) and wet (0.04 ± 0018/2g soil) was not significant (95 %CI=-0.015 to 0.087; t=1.44; p>005).

Discussion

Most of the efforts by WHO to break the cycles of STH transmission is primarily focused on mass drug administration but has posited that this goal is not achievable without deploying environmental measures to interrupt acquisition of new infections (Anderson *et al*., 2014; Truscott *et al*., 2014). Identification and estimating soil parasites burden could be in part the first step towards achieving this goal as information on the profile of dominant soil parasites in any locality could be useful in a complementary manner in planning an effective and sustainable preventive and control programme. More than half of the samples collected were positive of

Table 2. Frequency of occurrence of parasite-positive soil samples across primary school playground during the dry and wet seasons.

Local Government Area	Primary school	Positive soil sample (dry season)			Total	Positive soil sample (wet season)			Total	Grand total
		January	February	March	n(%)	May	June	July	n(%)	N(%)
Oredo	Agbado pry sch	2	0	6	8(44.44)	6	4	6	16(88.88)	24(66.66)
Orhionmwon	Abudu pry sch	0	6	2	8(44.44)	6	6	2	14(66.66)	22(61.11)
Ovia-North East	Olukuowina pry sch	2	6	0	8(44.44)	2	4	6	12(66.66)	20(55.55)
Owan East	Eteye pry sch	2	4	0	6(33.33)	4	0	2	6(33.33)	12(33.33)
Owan West	Ozalla pry sch	4	6	2	12(66.66)	4	0	6	10(55.55)	22(61.11)
Uhunwonde	Arousa pry sch	0	0	2	2(11.11)	2	6	2	10(55.55)	12(33.33)
Etsako West	Albotse Igbei pry sch	2	4	4	10(55.55)	4	4	4	12(66.66)	22(61.11)
Ikpobaokha	Ogbeson pry sch	0	4	6	10(55.55)	4	2	6	12(66.66)	22(61.11)
Esan North- East	Arue pry sch	2	4	0	6(33.33)	6	2	6	14(77.77)	20(55.55)
Esan Central	Eguare pry sch	4	4	6	14(77.77)	6	4	4	14(77.77)	28(77.77)
Esan South-East	Sacred heart pry sch	2	6	2	10(55.55)	2	4	6	12(66.66)	22(61.11)
Esan West	Ujemen pry sch	4	4	2	10(55.55)	2	4	6	12(66.66)	22(61.11)
Etsako Central	Obe pry sch	4	4	6	14(77.77)	0	4	2	6(33.33)	20(55.55)
Etsako East	Oghe-Okugbe pry sch	0	4	6	10(55.55)	0	0	0	0	0
Akoko Edo	Orere pry sch	2	0	2	4(22.22)	6	6	4	16(88.88)	20(55.55)
Egor	Egor pry sch	0	4	6	10(55.55)	4	2	4	10(55.55)	20(55.55)
Total		30(31.25)	60(62.5)	52(54.16)	142(49.3)	58(60.41)	52(54.16)	66(68.75)	176(61..11)	318(55.2)

[n(%); n= number of positive samples by season; %= percentage of positive samples against total number of collected samples by season]; [N(%); N=total number of positive samples for both wet and dry seasons; %=percentage of positive samples against total number of collected samples in both dry and wet seasons]

Table 3. Prevalence of soil parasites in the dry season.

Local Government Area	Primary school		Positive soil sample			Parasites			
			January	February	March	*Ascaris* (ova) n(%)	*Strongyloides* (larvae)	Hookworm (ova) n(%)	*Trichuris* (ova) n(%)
		1	-	-	Hookworm				
Oredo	Agbado pry sch	2	-	-	*Ascaris*	2(11.11)	-	4(22.22)	-
		3	-	-	Hookworm; *Ascaris*				
		1	-	*Ascaris*	-				
Orhionmwon	Abudu pry sch	2	-	-	*Ascaris*	3(16.66)	3(16.66)	-	-
		3	-	*Strongyloides*	-				
		1	-	*Strongyloides*	-				
Ovia North-East	Oluku Owina pry sch	2	-	*Strongyloides*; *Ascaris*	-	4(22.22)	4(22.22)	-	-
		3	*Ascaris*	*Ascaris*	-				
		1	Hookworm	Hookworm	-				
Owan East	Eteye pry sch	2	-	-	-	2(11.11)	-	4(22.22)	-
		3	-	*Ascaris*; Hookworm	-				
		1	-	*Strongyloides*; Hookworm	-				
Owan West	Ozalla pry sch	2	*Ascaris*	Hookworm	-	5(27.77)	3(16.66)	2(11.11)	-
		3	*Ascaris*	*Ascaris*; *Strongyloides*	*Ascaris*				
		1	-	-	-				
Uhunwonde	Arousa pry sch	2	-	-	-	1(5.55)	-	1(5.55)	-
		3	-	-	*Ascaris*; Hookworm				
		1	-	-	-				
Etsako West	Aibotse Igbei pry sch	2	-	*Ascaris*	*Strongyloides*;Hookworm	4(22.22)	4(22.22)	2(11.11)	-
		3	*Ascaris*	*Ascaris*	*Strongyloides*				
		1	-	*Ascaris*	*Strongyloides*				
Ikpobaokha	Obeson pry sch	2	-	*Ascaris*	*Ascaris*	7(38.88)	3(16.66)	-	-
		3	-	-	*Ascaris*				
		1	-	*Trichuris*	-				
Esan North- East	Arue pry sch	2	-	*Ascaris*	-	4(22.22)	-	-	2(11.11)
		3	*Ascaris*	-	-				

		1	Hookworm	Hookworm	*Strongyloides*				
Esan Central	Eguare pry sch	2	-	Hookworm	*Ascaris*	7(38.88)	3(16.66)	4(22.22)	-
		3	*Ascaris*	-	*Ascaris*				
		1	Hookworm	*Strongyloides*	-				
Esan South-East	Sacred heart pry sch	2	-	*Strongloides*	-	4(22.22)	4(22.22)	2(11.11)	-
		3	-	*Ascaris*	*Ascaris*				
		1	*Ascaris; Strogyloides*	-	-				
Esan West	Ujemen pry sch	2	-	*Strongyloides*	-	4(22.22)	3(16.66)	3(16.66)	-
		3	*Ascaris*	Hookworm	Hookworm; *Ascaris*				
		1	-	Hookworm	*Strongyloides*				
Etsako Central	Obe pry sch	2	*Ascaris*	*Ascaris*	*Ascaris*	10(55.55)	2(11.11)	2(11.11)	-
		3	*Ascaris*	-	*Ascaris*				
		1	-	Hookworm	*Strongyloides*				
Etsako East	Oghe-Okgbe pry sch	2	-	-	*Strongyloides*	2(11.11)	5(27.77)	3(16.66)	-
		3	-	*Ascaris*; Hookworm	*Strongyloides*				
		1	-	-	-				
Akoko-Edo	Orere pry sch	2	Hookworm; *Ascaris*	-	*Strongyloides*	1(5.55)	2(11.11)	1(5.55)	-
		3	-	-	-				
		1	-	*Strongyloides*	*Ascaris*				
Egor	Egor pry sch	2	-	*Strongyloides*	Hookworm	3(16.66)	5(27.77)	2(11.11)	-
		3	-	-	*Ascaris*; *Strongyloides*				
			Total N(%)			70(24.3)	41(14.26)	30(1.04)	1(0.34)

[n(%); n=number of samples positive for respective parasite in each primary school; %=percentage of samples positive for respective parasites in each primary school against total number of collected samples in the surveyed primary school); [N(%); N=total number of samples positive for respective parasite across the sixteen primary schools; %= percentage of samples positive for respective parasite across the sixteen primary schools against the total number of collected soil samples in the sixteen primary schools]

Table 4. Prevalence of soil parasites in the wet season.

Local Government Area	Primary school	Positive soil sample				Parasites			
			May	June	July	*Ascaris* (ova) n(%)	*Strongyloides* (larvae)	Hookworm (ova) n(%)	*Trichuris* (ova) n(%)
		1	*Ascaris*; *Strongyloides*	*Ascaris*	*Strongyloides*				
Oredo	Agbado pry sch	2	Hookorm	*Strongyloides*	Hookworm	3(16.66)	7(38.88)	6(33.33)	-
		3	Hookworm	-	*Strongloides*; *Ascaris*				
		1	*Strongyloides*; Hookworm	*Strongyloides*	-				
Orhionmwon	Abudu pry sch	2	*Strongyloides*	Hookworm	*Strongyloides*	-	10(55.55)	2(11.11)	-
		3	*Strongloides*	*Strongyloides*	-				
		1	-	-	*Strongyloides*; *Ascaris*				
Ovia North-East	Oluku Owina pry sch	2	*Ascaris*	*Ascaris*	-	5(27.77)	2(11.11)	2(11.11)	-
		3	-	-	Hookworm				
		1	-	-	-				
Owan East	Eteye pry sch	2	Hookworm	-	-	-	2(11.11)	1(5.55)	-
		3	*Strongyloides*	-	-				
		1	*Ascaris*	-	*Strongyloides*				
Owan West	Ozalla pry sch	2	*Strongyloides*	-	*Strongyloides*	3(16.66)	5(27.77)	-	-
		3	-	-	-				
		1	-	*Ascaris*	-				
Uhunwonde	Arousa pry sch	2	-	*Ascaris*	-	4(22.22)	4(22.22)	-	-
		3	-	*Strongyloides*	*Strongyloides*				
		1	-	*Strongyloides*	*Ascaris*				
Etsako West	Aibotse Igbei pry sch	2	*Ascaris*	-	*Ascaris*	5(27.77)	3(16.66)	-	-
		3	*Ascaris*	*Strongyloides*	-				
		1	*Ascaris*	-	*Ascaris*; *Strongyloides*				
Ikpobaokha	Obeson pry sch	2	*Ascaris*	*Ascaris*	*Strongyloides*; Hookworm	7(38.88)	4(22.22)	1(5.55)	-
		3	-	Ascaris	-				

		1	*Strongyloides*; *Ascaris*	-	*Strongyloides*; *Ascaris*				
Esan North- East	Arue pry sch	2	*Ascaris*	*Trichuris*; *Strongyloides*	*Strongyloides*; *Ascaris*	7(38.88)	6(33.33)	-	1(5.55)
		3	*Ascaris*	-	*Strongyloides*				
		1	*Strongyloides*	*Strongyloides*	-				
Esan Central	Eguare pry sch	2	*Strongyloides*; Hookworm	-	*Strongyloides*	2(11.11)	7(38.88)	2(11.11)	3(16.66)
		3	*Trichuris*; *Ascaris*	*Trichuris*	*Strongyloides*				
		1	-	-	*Strongyloides*				
Esan South-East	Sacred heart pry sch	2	*Ascaris*	*Ascaris*	*Strongyloides*	6(33.33)	4(22.22)	2(11.11)	-
		3	-	*Ascaris*	*Strongyloides*				
		1	-	*Strongyloides*	*Ascaris*; Hookworm				
Esan West	Ujemen pry sch	2	-	-	*Ascaris*	5(27.77)	3(16.66)	4(22.22)	-
		3	Hookorm	Hookworm	*Ascaris*				
		1	-	-	-				
Etsako Central	Obe pry sch	2	-	*Strongyloides*	-	2(11.11)	3(16.66)	-	-
		3	-	*Ascaris*	-				
		1	-	-	-				
Etsako East	Oghe-Okgbe pry sch	2	-	-	-	-	-	-	-
		3	-	-	-				
		1	*Ascaris*	*Ascaris*	-				
Akoko-Edo	Orere pry sch	2	-	*Strongyloides*	*Strongyloides*	6(33.33)	8(44.44)	-	-
		3	*Strongyloides*	*Strongyloides*	*Strongyloides*				
		1	-	-	-				
Egor	Egor pry sch	2	-	-	-	2(11.11)	2(11.11)	-	-
		3	*Ascaris*	-	*Strongyloides*				
			Total N(%)			57(19.79)	70(24.3)	20(6.94)	4(1.38)

[n(%); n=number of samples positive for respective parasite in each primary school; %=percentage of samples positive for respective parasites in each primary school against total number of collected samples in the surveyed primary school); [N(%); N=total number of samples positive for respective parasite across the sixteen primary schools; %= percentage of samples positive for respective parasite across the sixteen primary schools against the total number of collected soil samples in the sixteen primary schools] one or more parasites as this could be an indication of the level of soil contamination. In January, positive samples were at the lowest but increased in subsequent months. In the state, usually in the month preceding January (December), there are no rains, while in February and March, the state experiences both its first and in some areas, the second rainfall for the year. Meanwhile, by May, the rainy season fully commences and peaks in July. Rainfall comes with high humidity and lower temperatures (23 and 30°C) and these conditions favour the presence and development of soil parasites (Brooker *et al*., 2006), while temperatures from 35°C and above which is often the case in December and January could potentially disintegrate parasites (Rocha *et al*., 2011; Steinbaum *et al*., 2016). Further, in these areas, improper disposal of human and animal faeces is common practice because a majority of these communities where these schools are located lack proper drainage and waste disposal systems. Therefore, when it rains and get flooded, most of these playgrounds could receive faecal-contaminated water from the surrounding environment, partly influencing the rise in the prevalence of STH eggs and larvae on playgrounds (Echazu *et al*., 2015).

The predominant parasites in these areas were *Ascaris*, *Strongyloides* and hookworm, while the occurrence of *Trichuris* was relatively scanty. So we believe that one of the sources of soil contamination with STHs in these playgrounds may have been through open defecation from pupils and inhabitants of respective host communities living close to the school premises. Pit-toilet type was seen in all the schools and shared by pupils. Many pupils have apathy towards the use of a common toilet facility due to it often unhygienic state as they are poorly managed. A report has shown that shared latrines are likely to be dysfunctional, less clean and have flies and faeces littered; and that people who shared latrines were more likely to practice open defecation (Heijnen *et al*., 2015). Another source of contamination could be as a result of lack/partial perimeter fencing, whereby animals could freely move into and out of the school premises and defecate. Coprophagia of human faeces by dogs increases the possibility of transporting STH eggs into the playground as sticky-coated *Ascaris* egg might adhere to the dog's coat for relatively longer period (Nonaka *et al*., 2011; Traub *et al*., 2002). Aside being reservoir hosts, the role of dogs in the transmission cycle of *Ascaris* has been suggested (Shalaby *et al*., 2010). However, it is difficult to differentiate *S. steroralis* larvae, hookworm eggs and larvae as well as *T. vulpis* eggs from the human-infecting STH species deposited possibly by dogs on the playgrounds. Whichever the case, any of these parasites can potentially cause human infection. Meanwhile, a survey of the intestinal parasites of sheep, goat, cattle and dogs across the states possibly indicate high incidence of zoonotic parasites and these could be of public health importance to these children (unpublished data) as reported elsewhere (Shalaby *et al*., 2010; Areekul *et al*., 2010; Steinbaum *et al*., 2019; Pipikova *et al*., 2017).

The prevalence and load of *Ascaris* and hookworm between the dry and wet seasons were similar; while for *Strongyloides*, positive samples were higher in the wet than dry. So seasonal variation in parasite's prevalence and burden demonstrates period of higher or lower risk of infections as well as changes that may have occurred to the source(s) of contamination over time (Wong & Bundy, 1990). The optimal conditions for *S. stercoralis* to thrive in an environment include soil temperatures between 20 to 28ºC and high moisture; which is likely the case during the wet seasons in most parts of southern Nigeria as larvae dies rapidly under unfavourable conditions. However, evidence has shown that geographical and climatic conditions are not the primary factors determining the disease presence but rather the level of infrastructural facility, sanitation and socioeconomic status; and as such, strongyloidiasis is recently referred to as: ''a disease of disadvantage and poor sanitation'' (Beknazarova *et al*., 2016). The overall sanitary conditions as well as the state of the infrastructural facilities in most of the schools are poor; but specifically, these primary schools (Abudu and Sacred heart) with relatively high load of *Strongyloides* lacked perimeter fencing.

Detection of STHs in children playground suggests that children exposure to the soil poses substantial health risk. Geophagy is widespread among school children and not limited to toddlers, infants and pregnant women; and this habit has been associated with STH infections (Wong *et al*., 1991; Geissler *et al*., 1998; Saathoff *et al*., 2002; Nchito *et al*., 2004). In a study, 46 % of geophagus school children carried out this activity at break hours in school (Geissler *et al*., 1998). Regardless of the season, by the mean parasite load for *Ascaris* and *Strongyloides*, children who practise geophagy are likely to ingest STH eggs/larvae; but infection may not be as frequent as when a higher parasite load is recorded (Steinbaum *et al*., 2016). In addition, some children that are not habitually geophagous, are equally at risk of infection because often time after play they were seen eating their snacks or other food items without strictly observing hand hygiene (personal observation). Further, in all the schools during break period, many of the boys often play in the open field (mainly football) without footwear so as to ease movement. Therefore, this risk behaviour further exposes these children to hookworm and *Strongyloides* infections.

The soil parasites recovered from designated points in the study locations may not be a complete reflection of the reported parasite profile as soil texture could affect egg recovery efficiency (Steinbaum *et al*., 2017). The flotation technique (sugar solution) used in this study is known to distort STH eggs and make microscopic identification difficult (Ayres & Mara, 1996). Also, identifying eggs in soil samples is challenging as soil contain different life stages of STH eggs. Worthy of note is that the rhabditiform larvae of *S. stercoralis* are morphologically similar to those of some free-living nematodes and it is possible that in some cases misidentification may have occurred. In future, molecular techniques should be used so that parasites are identified at species level as this could determine the extent to which these playgrounds are contaminated with human or zoonotic parasites.

Of the four soil parasites isolated (*Ascaris, Strongyloides*, hookworm and *Trichuris*), *Ascaris* was most dominant in the dry season while *Strongyloides* in the wet. The intensity of *Strongyloides* was higher in the wet than dry but not significant for other parasites. Clearly, schoolchildren in all the sampled areas across the state are substantially at risk of acquiring soil parasites; and we believe that the profile of parasites in Edo State public primary schools may be similar to other states in southern Nigeria as they have similar climatic conditions and possibly similar sanitary status. If sanitary conditions and the state of infrastructure remain unchanged, interrupting the cycle of infection would be daunting. To our knowledge, intervention programmes like preventive chemotherapy (WHO, 2006) within the context of mass drug administration has not been organised or implemented for Edo State and effectively in many parts of southern Nigeria. We cannot evidently provide reasons why such schemes have not been stepped down to heavily endemic regions like Edo State; but we sense a lack of political-will to push for this kind of programme. In any case, by this communication, we strongly advocate that relevant authorities and agencies should make efforts to implement this laudable project within the state and indeed in southern Nigeria as there are huge benefits (Bleakley, 2009). We also recommend that there should be significant improvement in the sanitary/water facilities in public primary schools including engaging in continuous education/enlightenment programme that strongly emphasise strict compliance to personal and environmental hygiene.

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Authors' contributions

CI designed the study; NPT, UCI, SAE, HOA, collected and processed samples; CI and AJO wrote the manuscript; while all read and approved the final version of the manuscript.

Conflict of Interest

The authors declare that they have no competing interests.

References

Anderson, R., Truscott, J., Hollingsworth, T.D. (2014): The coverage and frequency of mass drug administration required to eliminate persistent transmission of soil-transmitted helminths. *Philos. Trans. R. Soc. Lond. B. Biol. Sci.*, 369 (1645): 20130435. DOI: 10.1098/rstb.2013.0435

Areekul, P., Putaporntip, C., Pattanawong, U., Sitthicharoenchai, P., Jongwutiwes, S. (2010): *Trichuris vulpis* and *T. trichiura* infections among schoolchildren of a rural community in northwestern Thailand: the possible role of dogs in disease transmission. *Asian Biomed.*, 4: 49 – 60. DOI: 10.2478/abm-2010-0006

Ayres. R.M., Mara, D.D. (1996): Analysis of wastewater for use in Agriculture – A laboratory manual of parasitological and bacteriological techniques, WHO 1996.

Beknazarova, M., Whilley, H., Ross, K. (2016): Strongyloidiasis: a disease of socioeconomic disadvantage. *Int. J. Environ. Res. Public Health,* 13: 517. DOI: 10.3390/ijerph13050517

Bethony, J., Brooker, S., Albonico, M., Geiger, S.M., Loukas, A., Diemert, D., Hotez, P.J. (2006): Soil-transmitted helminth infections: ascariasis, trichuriasis, and hookworm. *Lancet,* 36: 1521 – 1532. DOI: 10.1016/S0140-6736(06)68653-4

Blaszkowska, J., Kurnatowski, P., Damiecka, P. (2011): Contamination of the soil by eggs of geohelminths in rural areas of Lodz District (Poland). *Helminthologia,* 48: 67 – 76. DOI: 10.2478/s11687-011-0012-8

Bleakley, H. (2007): Disease and development: evidence from hookworm eradication in the American South. *Q. J. Econ.,* 122: 73 – 117. DOI: 10.1162/qjec.121.1.73

Bowman, D.D., Montgomery, P.S., Zajac, M.A., Eberhard, L.M., Kazacos, R.K. (2010). Hookworms of dogs and cats as agents of cutaneous larva migrans. *Trends Parasitol.*, 26: 162 – 167. DOI: 10.1016/j.pt.2010.01.005

Brooker, S., Clements, A., Bundy, D. (2006): Global Epidemiolgy, ecology and control of soil-transmitted helminth infection. *Adv. Parasitol.*, 62: 221 – 261. DOI: 10.1016/S0065-308X(05)62007-6

Bundy, D.A. (1995): Epidemiology and transmission of intestinal helminths. In Farthing, M.J.G., Keusch, G.T., Wakelin, D. (Eds) *Enteric Infection 2, Intestinal Helminths*, 5 – 24. London: Chapman & Hall Medical.

Buonfrate, D., Formenti, F., Perandin, F., Bisoffi, Z. (2015): Novel approaches to the diagnosis of *Strongyloides stercoralis* infection. *Clin. Microbiol. Infect.*, 21: 543 – 552. DOI: 10.1016/j.cmi.2015.04.001.

Da Silva Alves, E.B., Conceição, M.J., Leles, D. (2016): *Ascaris lumbricoides*, *Ascaris suum*, or '*Ascaris lumbrisuum*'? *J. Infect. Dis.* 213: 1355. DOI: 10.1093/infdis/jiw027

Echazu, A., Bonanno, D., Juarez, M., Cajal, S.P., Heredia, V., Caropresi, S., Cimino, R.O., Caro, N., Vargas, P.A., Paredes, G. (2015): Effect of poor access to water and sanitation as risk factors for soil-transmitted helminth infection: selectiveness by the infective route. *PLos. Negl. Trop. Dis.,* 9: e0004111. DOI: 10.1371/journal.pntd.0004111

Foreyt , W.J. (2001): *Veterinary Parasitology Reference Manual*. 5th ed. Ames, Iowa. Blackwell Publishing Professional, pp 45 – 222.

Forrer, A., Khieu, V., Schär, F., Vounatsou, P., Chammartin, F., Marti, H. (2018): *Strongyloides stercoralis* and hookworm co-infection: spatial distribution and determinants in Preah Vihear Province,

Cambodia. *Parasit. Vectors.,* 11: 33. DOI: 10.1186/s13071-017-2604-8.
Geissler, W.P., Mwaniki, D., Thiong'o, F., Friss, H. (1998): Geophagy as a risk factor for geohelminth infections: a longitudinal study of Kenyan primary schoolchildren. *Trans. R. Soc. Trop. Med. Hyg.*, 92: 7 – 11. DOI: 10.1016/s0035-9203(98)90934-8
Global Health Metrics (2018): Global, Regional, and national disability-adjusted life-years (DALYs) for 359 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990 – 2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet*, 392: 1859 – 922. DOI: 10.1016/S0140-6736(18)32335-3
Hassan, A.A., Oyebamiji, D.A., Idowu, O.F. (2017): Spatial patterns of soil transmitted helminths in soil environment around Ibadan, an endemic area in south-west Nigeria. *Nig. J. Parasitol.,* 38: 179 – 184. DOI: 10.4314/njpar.v38i2.9
Heijnen, M., Routray, P., Torondel, B., Clasen, T. (2015): Shared Sanitation versus Individual Household Latrines in Urban Slums: A Cross-Sectional Study in Orissa, India. *Am. J. Trop. Med. Hyg.*, 93: 263 – 268. DOI: 10.4269/ajtmh.14-0812
Horiuchi, S., Paller V.G., Uga, S. (2013): Soil contamination by parasite egg in rural village in the Phillipines. *Trop. Biomed*., 30: 495 – 503
Hotez, P.J., Bethony, J., Bottazzi, M.E., Brooker, S., Buss, P. (2005): Hookworm: 'the great infection of mankind'. *PLoS Med.,* 2: e67. DOI: 10.1371/journal.pmed.0020067
Hotez, P.J, Bundy, D.A.P., Beegle, K., Brooker, S., Drake, L., De Silva, N., Montressor, A., Engels, D., Jukes, M., Chitsulo, L., Chow, J., Laxminarayan, R., Michaud, C., Bethony, J., Correa-Oliveira, R., Shuhua, X., Fenwick, A., Savioli, L. (2006): Chapter 24 – Helminth infections: Soil-transmitted helminth infections and schistosomiasis. In: Jamison, D.T., Breman, J.G., Measham, A.R., Alleyne, G., Claeson, M., Evans, D.B., Jha, P., Mills, A., Musgrove, P. (Eds) *Disease control priorities in developing countries*. 2nd edition. Washington (DC): World Bank, 2006. pp. 467
Jarosz, W., Mizgajska-Wiktor, H., Kirwan, P., Konarski, J., Rychlicki, W., Wawrzyniak, G. (2010): Developmental age, physical fitness and Toxocara seroprevalence amongst lower secondary students living in rural areas contaminated with *Toxocara* eggs. *Parasitol*., 137: 53 – 63. DOI: 10.1017/s0031182009990874
Karshima Ns, Maikai B, Kwaga Pkj (2018). Helminths of veterinary and zoonotic importance in Nigerian ruminants: a 46-year meta-analysis (1970 – 2016) of their prevalence and distribution. *Infect. Dis. Poverty.* 7: 52. DOI: 10.1186/s40249-018-0438-z
Ma, G., Holland, C.V., Wang, T., Hofmann, A., Fan, C.K., Maizels, R.M. (2018): Human toxocariasis. *Lancet Infect. Dis*., 18: e14 – e24. DOI: 10.1016/S1473-3099(17)30331-6
Montresor, A., Trouleau, W., Mupfasoni, D., Bangert, M., Joseph, S.A., Mikhailov, A., Fitzpatrick, C. (2017): Preventive chemotherapy to control soil-transmitted helminthiasis averted more than 500 000 DALYs in 2015. *Trans. R. Soc. Trop.Med. Hyg*., 111: 457 – 463. DOI: 10.1093/trstmh/trx082
Lloyd, E.A., Honey, L.B., John, M.B., Condrem, M. (2014): Treatment options and considerations for intestinal helminthic infections. *J. Pharm. Tech.,* 30: 130 – 139. DOI: 10.1177/8755122514533667
Nchito, M., Geissler, P.W., Mubila, L., Friis, H., Olsen, A. (2004): Effects of iron and multimicronutrient supplementation on geophagy: a two-by-two factorial study among Zambian schoolchildren in Lusaka. *Trans. R. Soc. Trop. Med. Hyg.,* 98: 218 – 227. DOI: 10.1016/s0035-9203(03)00045-2
Nonaka, N., Nakamura, S., Inoue, T., Oku, Y., Katakura, K., Matsumoto, J., Mathis, A., Chembesofu, M., Phiri, I.G. (2011). Coprological survey of alimentary tract in dogs from Zambia and evaluation of a coproantigen assay for canine echinococcosis. *Ann Trop. Med. Parasitol.,* 105: 521 – 531. DOI: 10.1179/2047773211Y.0000000001
Nwaorgu, O.C., Okeibunor, J., Madu, E., Amazigo, U., Onyegegbu, N., Evans, D. (1998): A school-based schistosomiasis and intestinal helminthiasis control programme in Nigeria: acceptability to community members. *Trop. Med. Int. Health,* 3: 842 – 849. DOI: 10.1046/j.1365-3156.1998.00313.x
Nwoke, E.U., Ibiam, G.A., Odikamnoro, O.O., Umah, O.V., Ariom, O.T., Orji, I. (2013): Examination of soil samples for the incidence of geohelminth parasites in Ebonyi norh-central area of Ebonyi State, South-East of Nigeria. *A. App. Sci. R.,* 5: 41 – 48
Ohiolei, J.A., Isaac, C., Omorodion, O.A. (2017): A review of soil transmitted helminthiasis in Nigeria. *Asian Pac. J. Trop. Dis.* 7: 930 – 937. DOI: 10.12980/apjtd.7.2017D7-235
Oyebamiji, D.A., Ebisike, A.N., Egede, J.O., Hassan, A.A. (2018): Knowledge, attitude and practice with respect to soil contamination by soil-transmitted helminths in Ibadan, Southwestern Nigeria. *Parasite Epidemiol. Control,* 3: e00075. DOI: 10.1016/j.parepi.2018.e00075
Pipikova, J., Papajova, I., Soltys, J., Schusterova, I., Kocisova, D., Tohathyova, A. (2017). Segregated settlements present an increased risk for parasite infections spread in Northeastern Slovakia. *Helminthologia*, 54: 199 – 210. DOI: 10.1515/helm-2017-0026
Prociv, P., Croese J. (1990). Human eosinophilic enteritis caused by dog hookworm, *Ancylostoma caninum. The Lancet,* 335: 1299 – 1302. DOI: 10.1016/0140-6736(90)91186-E
Puthiyakunnon, S., Boddu, S., Li, Y., Zhou, X., Wang, C., Li, J., Chen, X. (2014): Strongyloidiasis—an insight into its global prevalence and management. *PLoS. Negl. Trop. Dis.* 8: e3018. DOI: 10.1371/journal.pntd.0003018
Rocha, S., Pinto, R.M.F., Floriano, A.P., Teixeira, L.H., Bassili, B., Martinez, A., Da Costa, S.O.P., Caseiro, M.M. (2011): Environmental analyses of the parasitic profile found in sandy soil from the Santos municipality beaches SP, Brazil. *Rev. Inst. Med. Trop. S. Paulo,* 53: 277 – 281. DOI: 10.1590/s0036-46652011000500007
Saathoff, E., Olsen, A., Kvalsvig, J.D., Geissler, P.W. (2002): Geophagy and its association with geohelminth infection in rural schoolchildren from northern Kwazulu-Natal South Africa. *Trans. R. Soc. Trop. Med. Hyg.,* 96: 485 – 490. DOI: 10.1016/s0035-9203(02)90413-x
Shalaby, H.A., Abdel-Shafy, S., Derbala, A.A. (2010). The role of

dogs in transmission of *Ascaris lumbricoides* for humans. *Parasitol. Res.,* 106: 1021 – 1026. DOI: 10.1007/s00436-010-1755-8
Schar, F., Trostdorf, U., Giardina, F., Khieu, V., Muth, S., Marti, H., Vounatsou, P., Odermatt, P. (2013): *Strongyloides stercoralis*: global distribution and risk factors. *PLoS Negl. Trop. Dis.* 7: e2288. DOI: 10.1371/journal.pntd.0002288
Schule, S.A., Clowes, P., Kroidl, I., Kowuor, D.O., Nsojo, A., Mangu, C., Riess, H., Geldmacher, C., Laubender, R.P., Mhina, S., Maboko, L., Loscher, T., Hoelscher, M., Saathoff, E. (2014): *Ascaris lumbricoides* infection and its relation to environmental factors in the Mbeya Region of Tanzania, a cross-sectional population-based study**.** *PLoS One*, 9: e92032. DOI: 10.1371/journal.pone.0092032
Steinbaum, L., Njenga, S.M., Kihara, J., Boehm, A.B., Davis, J., Null, C., Pickering, A.J. (2016): Soil-transmitted helminth eggs are present in soil at multiple locations within households in rural Kenya. *PLoS One,* 11: 1 – 10. DOI: 10.1371/journal.pone.0157780
Steinbaum, L., Mboya, J., Mahoney, R., Njenga, S.M., Null, C., Pickering, A.J. (2019): Effect of a sanitation intervention on soil-transmitted helminth prevalence and concentration in household soil: A cluster-randomized controlled trial and risk factor analysis. *PLoS Negl. Trop. Dis.,* 13(2): e0007180. DOI: 10.1371/journal.pntd.0007180
Steinbaum, L., Kwong, L.H., Eroumen, A., Negash, S.M., Lovely, J.A., Njenga, M.S., Boehm, B.A., Pickering, J.A., Nelson, L.K. (2017): Detecting and enumerating soil-transmitted helminth eggs in soil: New method development and results from field testing in Kenya and Bangladesh. *PLoS Negl. Trop. Dis.,* 11: e0005522. DOI: 10.1371/journal.pntd.0005522
Traub, R.J., Robertson, I.D., Irwin, P., Mencke, N., Thompson, R.C. (2002). The role of dogs in transmission of gastrointestinal parasites in a remote tea-growing community in northeastern India. *Am. J. Trop. Med. Hyg.* 67: 539 – 545. DOI: 0.2105/AJPH.92.11.1841
Truscott, J.E., Hollingsworth, T.D., Brooker, S.J., Anderson, R.M. (2014): Can chemotherapy alone eliminate the transmission of soil transmitted helminths? *Parasit. Vectors.* 7: 266. DOI: 10.1186/1756-3305-7-266
Weaver, H.J., Hawdon, J.M., Hoberg, E.P. (2010): Soil-transmitted helminthiases: implications of climate change and human behavior. *Trends in Parasitol*., 26: 574 – 581. DOI: 10.1016/j.pt.2010.06.009
WHO (2006): *Preventive chemotherapy in human helminthiasis*. Geneva, Switzerland: World Health Organisation
WHO (2018): *Soil-transmitted helminth infections*. Retrieved 22 May, 2018, from http: //www.who.int/news-room/fact-sheets/detail/soil-transmitted-helminth-infections
Wong, M.S., Bundy, D.A. (1990): Quantitative assessment of contamination of soil by the eggs of *Ascaris lumbricoides* and *Trichuris trichiura*. *Trans. R. Soc. Trop. Hyg.,* 84: 567 – 70. DOI: 10.1016/0035-9203(90)90043-E
Wong, M.S., Bundy, D.A.P., Golden, M.H.N. (1991): The rate of ingestion of *Ascaris lumbricoides* and *Trichuris trichiura* eggs in soil and its relationship to infection in two children's homes in Jamaica. *Tran. R. Soc. Trop. Med. Hyg.,* 85: 89 – 91. DOI: 10.1016/0035-9203(91)90172-U