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Soil Transmitted Helminths and Schistosomiasis in Adamawa Northern Senatorial District, Nigeria

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Abstract

Helminthiasis is a parasitic infection known to infect low-income population group and people with poor personal hygiene worldwide. Helminths (Worms) such as roundworm, hookworm, whipworm and the flat worms (schistosome) are among others that causes heminthiasis. Infections with these worms results to mild, chronic and severe illness especially in an endemic area. This study reports the prevalence of soil-transmitted helminthiasis and schistosomiasis in Adamawa Northern Senatorial District that are made up of five Local Areas namely, Maiha, Mubi North, Mubi South, Michika and Madagali Local Government Areas out of which two communities where sampled from each LGA. Normal saline direct wet preparation, formol-ether concentration and Polymerase Chain Reaction (PCR) techniques were used to analyze stool samples. Centrifugation and filtration technique were used for urine analysis, Out of 2,808 stool and urine samples examined from 1,404 participants, an overall prevalence of 565 (40.2%) were recorded. Out of these, soil-transmitted Helminthiasis account for 239 (17.0%) while Schistosomiasis infections was 326 (23.2%) respectively. The highest prevalence of Soil-transmitted helminthiasis by community was recorded in Bororo (23.6%) and lowest in Pakka (12.5%) communities. While highest and lowest prevalence of

Schistosomiasis were observed in Pakka and Kuda with 30.0% and 15.7% respectively and there was statistical significant difference ($p<0.05$) between the two infections. The study further revealed that farmers (27.1%) had highest infection with STH while students (38.2%) had more infections with Schistosomiasis and there was no significant statistical differences at ($p>0.05$). Differences were observed between STHs and Schistosomiasis in relation to occupation. The distribution of each parasite during the study also revealed that, high prevalence (18.5%) of *S. haematobium* was recorded while *Strongyloide stercoralis* had the lowest prevalence (2.9%) with significant differences at ($P<0.05$). Total co-infection of 5.2% was also recorded for STHs and Schistosomiasis. Similarly, analysis of stool sample using PCR further revealed the presence of *A. lumbricoides,* Hookworms and *T. trichiura*. Therefore, the findings has reveal the presence of helminthiasis to high among low income participants in the study area.

Keywords: Soil-transmitted, Helminths, Schistosomiasis, Infection, Parasite

INTRODUCTION

Soil-transmitted helminthiasis and Schistosomiasis represent the most common neglected tropical diseases and may cause acute and chronic illness (World Health Organization, 2019). Soil-transmitted helminths (STHs) infection and Schistosomiasis are responsible for intensive morbidity and mortality in sub-Saharan Africa. It has been estimated that more than 200 million persons are infected with Schistosomes worldwide, with 85% of the cases occurring in Africa, and more than 1.5 billion are infected with STHs (WHO, 2023; Chitsulo, Engels, Montresor and Savioli L, 2000). Both Schistosome and STHs infections tend to be highly aggregated in that a small percentage of infected persons have very high worm burdens (Chan, Medley, Jamieson and Bundy, 2014).

Eggs with lateral spine are of *S. mansoni*, eggs with terminal spine are of *S. haematobium* and *S. mokongi*. Oval shaped eggs are these of *S. japanicum* (WHO, 2003). According to the WHO (2010) only three of the five main species of schistosomes infecting man cause the major form of human Schistosomiasis, these are *S. mansoni* and *S. japanicum* which causes intestinal form of disease and *S. haematobium* causes the urinary form of the disease (WHO, 2010). However, these parasites may result to severe and mild conditions of illness; it is also considered as life threatening parasites depending on their load on the host.

MATERIALS AND METHODS

Study Area

The study was conducted in Adamawa Northern Senatorial District of Adamawa State. The state is located in the north eastern part of Nigeria and lies between latitude 7^0 and 11^0N of the equator and between longitude 11^0 and 14^0 east of Greenwich Meridian. Adamawa state shares a boundary with Taraba state in the south and west, Gombe state in the North West and Borno state to the North (Figure 1). Adamawa state has an international boundary with Cameroon Republic in the east. The state covers a land mass of about 38.741 square kilometers with mountainous land transverse by river Benue, Gongola and Yadzaram respectively. According to National Population commission [NPC] (2006), Adamawa has a total population of 3,178,950, with males (1, 607,270) and females (1,571,680) respectively.

The study was carried out in 10 communities in 5 selected LGAs o the zone in Adamawa State. The selection was based on population and proximity of the community to shores of river. In Maiha LGA, Belel and Pakka communities were selected. In Mubi South, Gilla and Dribishi were selected while Maduguva and Bahule were selected for this study in Mubi North LGA. Similarly, Garta and Bororo communities were selected in Michika while Yenagu and Kuda in Madagali LGAs respectively.

Research Design

Prior to this research, a preliminary survey was carried out across study area in the zone to determine people activities along River bank. Sites with high domestics, irrigation, fishing and recreational activities were taken into consideration. Urine and faecal samples were collected randomly in nearby communities with maximum proximity of 400m away from the river bank. Sample collection was done during the rainy season, from August to October, 2024 and in dry season, from January to March, 2025. Moreover, structured questionnaires were served and retrieved from subjects who consented to participate in this study. Sites were visited for sample collections every first week of the Month throughout the period of the study. Three different techniques (Direct wet normal Saline technique, Formal ether Concentration technique and PCR) were selected for stool analysis while sedimentation technique was used for Urine analysis.

Sampling of the Subjects

One thousand four hundred and four (1,404) volunteers from the ten communities in the five (5) LGAs consented to participate in this study. The sample size was determined using Yaro Yamane Revised Edition (2008), formula for finite population.

Sample Collection, Materials and Analysis

Ethical clearance was sought and obtained from Adamawa State Ministry of Health Yola before the commencement of the main research work. Familiarization visit communities selected for this study was performed, and the significance of this study was explained to the understanding of village heads of the targeted communities. Volunteer research assistant from each community was recruited to assist in sample collection.

Formal-Ether Concentration Technique

To a 15ml centrifuge tube, 7mls of 10% Formal-Ether was transferred and a portion of stool samples (1g) was added using an applicator stick. This was thoroughly emulsified and an additional 3ml of 10% of formol-ether was added. The emulsified stool was sieved and the filtrate collected in a centrifuge tube. To the filtrate, 4mls of diethylether was added, stopped with cork and mixed for 1 minute.

Polymerase Chain Reaction (PCR) Technique

Stool samples were washed with phosphate Buffer Saline (PBS), following which parasite DNA was extracted from a total of two hundred and thirty nine (239) samples found positive for Soil-transmitted Helminths (STHs), using the Power Soil DNA extraction kits.

Urine Sample, Collection and Analysis

One thousand four hundred and four (1,404) urine samples were collected using simple random sampling technique. A well labeled, dry and clean wide mouth plastic specimen bottles were used for urine sample collection. Few drops of early morning urine was obtained from subjects who consented to participate in this study. (Cheesbrough, 2005). Urine samples were carefully observed for the presence of haematuria and then preserved by adding 5 drops of 1% V/V bleach solution as recommended by Cheesbrough (2008) and Ladan, *et al.* (2011).

Data Analysis

Data were analyzed using Statistical Package for Social Sciences (SPSS), version 22. Percentages, charts and graphs were used to express the prevalence; ANOVA and

Chi-square, test and correlation/regression were also used to analyze the differences, association and relationship of the findings, with $p<0.05$ considered as significant.

RESULTS

Prevalence of Soil-transmitted Helminths infection and Schistosomiasis in the study Area

Results obtained (Table 1) revealed that, out of the two thousand eight hundred and eight (2,808) faecal and urine samples collected from one thousand four hundred and four (1,404) subjects enrolled in this study, overall prevalence of 565(40.2%) was recorded, with 239(17.0%) prevalence of soil-transmitted helminths and 326(23.2%) prevalence of schistosomiasis respectively. Out of the positive cases, 73(5.2%) were co-infected with both infections. Statistical analysis showed that soil-transmitted helminthiasis prevalence varied significantly ($P<0.05$) from schistosomiasis among subjects. Also, there was a linear correlation between the prevalence of the two infections ($r=0.734$). Eggs Count per Gram (epg) of faeces was analyzed by modified Mac Master Technique and Turkey-Kramer Multiple comparison test was used to compare differences between the STHs egg count at $p<0.05$. While, mean values followed by the same letter(s) in the same column showed that there is no significant ($p>0.05$). Conversely, intensity of *S. haematobium* was expressed as mean±Standard Deviation in 10mls of urine. Polymerase chain reaction analysis was also conducted for its specificity and sensitivity in detecting parasites and it reveals 331 Soil-transmitted Helminths in the stool samples, compared to 201 Soil-transmitted Helminths by Microscopy technique.

Prevalence of STHs and Schistosomes in the Study Area

Overall, 62(51.7%) infections with STHs and Schistosomiasis were recorded in Bellel, while Pakka, Gella, Dribishi, Maduguva, Bahule, Garta, Bororo, Yenagu and Kuda had 54(45.0%), 100(41.7%), 71(39.4%), 44(45.8%), 37(35.8%), 65(37.4%), 56(32.2%), 42(32.2%) and 35(34.3%) infections, respectively (Table 4.1). Based on these findings, more infections were recorded in Bellel and Bororo had the least infection. Similarly, out of

1404 subjects from the five (5) Local Government Areas enrolled in this study, more infections 113(47.1%) were recorded in Maiha followed by Mubi North 79(41.2%) and Mubi South 163(38.8%). Madagali had the least infections 76(37.3%) recorded (Table 4.1).

Table 4.1: Prevalence of Soil-transmitted helminthiasis and schistosomiasis according to communities and Local Government Area in the Study Area

Location		No. Examined	Number Infected	Percentage Infected
Cum	Bellel	120	61	50.8
	Pakka	120	54	45.0
	Gella	240	100	41.7
	Dribishi	80	71	39.4
	Madugova	96	44	45.8
	Bahule	96	37	38.5
	Garta	174	65	37.4
	Bororo	174	56	32.2
	Yenagu	102	42	41.2
	Kuda	102	35	34.3
LGAs	Maiha	240	115	47.9
	Mubi South	420	171	40.7
	Mubi North	192	91	47.5
	Michika	348	121	34.8
	Madagali	204	77	37.8
	Total	**1404**	**565**	**40.2**

Cum = Communities; LGA = Local Government Areas

Prevalence of Soil-transmitted Helminthiasis and Schistosomiasis based on Months

Table 4.2 shows the distribution of infection in relation to months. The total prevalence of Soil-transmitted helminthiasis and Schistosomiasis recorded across the months was 565(40.2%), where September was the highest 107(45.7%) and February was the lowest 85(36.3%). Of 239 positive cases recorded for soil-transmitted helminthes, 27(11.5%), 32(13.7%), 39(16.7%), 37(15.8%), 45(19.2%) and 59(25.2) were recorded in August, September and October, January, February and March respectively, while the prevalence of schistosomiasis recorded in relation to months showed 70(29.9%), 64(27.4%), 68(29.0%), 48(20.6%), 41(17.6%) and 35(15.0%) recorded in July, August, September, February, March and April respectively. Chi-square analysis has indicated that there was no statistically significant ($p>0.05$) difference between prevalence of infection by months.

Prevalence of Human Soil-transmitted Helminthiasis and Schistosomiasis in relation to Predisposing Factors

Table 4.3 presents prevalence rate of soil transmitted helminthiasis and schistosomiasis in relation to occupation, source of water, toilet facilities, season of the year, gender differences and school background. The prevalence of soil-transmitted helminthiasis and schistosomiasis in relation to occupation showed that out of the 1,404 participants sampled for the study, 70(27.1%) and 61(23.6%), 19(10.3%) and 30(16.4%), 68(20.3%) and 128(38.2%), 33(11.3%) and 14(4.8%), 27(20.0%) and 23(17.0%) 22(11.0%) and 70(35.0%) were recorded among farmers, civil servants, students, business men and women, house wives and fisher men respectively. There was significant ($P < 0.05$) statistical difference in the infection rate in relation to occupation.

The prevalence of soil-transmitted helminthiasis and schistosomiasis in relation to the participants' source of water was 92(25.4%), 196(37.6%) and 257(53.3%) across users of Boreholes, Wells and Rivers/Streams. Out of 362 subjects that fetch water from Borehole, 42(11.6%) and 50(13.8%) were positive for soil-transmitted helminthiasis and schistosomiasis. Those fetching from wells had 86(16.3%) and 112(21.3%) soil-transmitted helminthiasis and schistosomiasis respectively. However, participants that patronized Rivers/Streams had the highest infections for soil-transmitted helminthiasis and schistosomiasis with 111(21.5%) and 164(31.8%) respectively. There is association ($P < 0.05$) between infections and sources of drinking water. Out of 677(48.2%) participants defecating and urinating in nearby bush that were examined, 142(18.8%) and 175(24.1%) subjects were found to be positive with soil-transmitted helminthiasis and Schistosomiasis accordingly. while, 97(9.6%) and 151(22.3%) soil-transmitted helminthiasis and Schistosomiasis were observed among those using pit toilet (Table 4.4). There is no significant ($P > 0.05$) difference in the infection between those using pit toilets and nearby bush.

Total prevalence of STHs and Schistosome infections in relation to wet and dry seasons were 300(42.8%) and 265(37.8%) respectively. Higher rate of soil-transmitted helminthiasis 141(20.0%) were observed in dry season than in wet season 98(14.0%). High cases of schistosomiasis were observed in wet season 202(28.8%) while 124(17.7%) was recorded in dry season. There was significant ($p<0.05$) relationship between infections and season.

Soil-transmitted helminthiasis has been recorded with a total of 41.4% and 39.1% among males and females respectively. The prevalence of infections by school/institution attended revealed 32(9.6%), 74(18.8%), 83(26.1%) and 50(13.9%) for subjects that attended tertiary institution, Secondary schools, Primary School and none formal education respectively. while 12.9%, 19.3%, 38.7% and 23.4% were recorded for subjects that attended tertiary institution, Secondary schools, Primary School and none formal education respectively. Chi-square analysis showed no significant ($p>0.05$) difference. The results revealed that subjects within age bracket 5-14, years old had 98(28.5%) and 126(36.6%) for STHs and Schistosome infections respectively (Table 4.4). There was no significant difference ($P>0.05$) between infection and age groups.

Table 4.2: Distribution of Human Soil-transmitted Helminthiasis and Schistosomiasis by Months in the study Area

Location	Number Examined	STHs Infection (%)	Schistosomiasis (%)	**Total (%)**
August	234	27(11.5)	70 (29.9)	**97(41.5)**
Sptember	234	32(13.7)	64(27.4)	**96(41.0)**
October	234	39(16.7)	68(29.0)	**107(45.7)**
January	234	37(15.8)	48(20.6)	**85(36.3)**
February	234	45(19.2)	41(17.6)	**86(36.8)**
March	234	59(25.2)	35(15.0)	**94(40.2)**
Total	**1404**	**239(17.0)**	**326(23.2)**	**565(40.2)**

STH = Soil-transmitted helminthes

Table 4.3: Distribution of Human STHs Infection and Schistosomiasis based on predisposing factors in the study Area

S/N	Predisposing factors	No. Examined (%)	No. Positive (%)	Infection With STH (%)	p. value	Infection with Schistosomiasis (%)	P. value
Occup							
	Farming	253(18.4)	131(50.7)	70(27.1)		61(23.6)	
	C/Servant	184(13.1)	49(26.7)	19(10.3)		30(16.4)	
	Student	335(23.9)	196(58.5)	68(20.3)		128(38.2)	
	Business	292(20.8)	47(16.1)	33(11.3)	0.04*	14(4.8)	0.01*
	H/wife	140(9.6)	50(37.0)	27(20.0)		23(17.0)	
	Fishing	200(14.2)	92(46.0)	22(11.0)		70(35.0)	
Source water							
	Borehole	362(25.8)	92(25.4)	42(11.6)		50(13.8)	
	Well	526(37.5)	198(37.6)	86(16.3)		112(21.3)	
	River/Stream	516(36.8)	275(53.3)	111(21.5)	0.56	164(31.8)	0.04*
Toilet system							
	Pit	677(48.2)	248(31.9)	97(9.6)		151(22.3)	
	Nearby Bush	727(51.8)	317(42.9)	142(18.8)	0.04*	175(24.1)	0.01*
Season							
	Wet	702(50.0)	300(42.8)	98(14.0)		202(28.8)	
	Dry	702(50.0)	265(37.8)	141(20.1)	0.60	124(17.7)	0.04*
Gender							
	Male	725(51.6)	300(41.4)	115(15.9)		185(25.5)	
	Female	679(48.4)	265(39.1)	124(18.3)	0.84	141(20.8)	0.06
E. St							
	Tertiary	334(23.8)	75(22.5)	32(9.6)		43(12.9)	
	Secondary	393(28.0)	150(38.1)	74(18.8)		76(19.3)	
	Primary	318(22.6)	206(64.8)	83(26.1)		123(38.7)	
	None	359(25.6)	134(37.3)	50(13.9)	0.06	84(23.4)	0.09
Age							
	5-14	344(24.5)	224(65.1)	98(28.5)		126(36.6)	
	15-24	320(22.8)	166(51.9)	71(22.2)		95(29.7)	
	25-34	268(19.9)	73(27.2)	30(11.2)		43(16.0)	
	35-44	158(11.3)	30(19.0)	11(7.0)		19(12.0)	
	45-54	119(8.5)	35(17.5)	17(8.5)		18(9.0)	
	55& above	195(13.8)	37(32.1)	12(10.4)	0.00*	25(21.7)	0.02*
	Total	**1404(100)**	**565(40.2)**	**239(17.0)**		**326(23.2)**	

Occup = Occupation; E. St = Educational Status

Distribution of co-infection of Soil-transmitted Helminthiasis and Schistosomiasis by LGAs and Months

Co-infection in relation to Local Government Areas revealed that Mubi South Local Government Area was higher than Maiha, Mubi North, Michika and Madagali LGAs where the least co-infection was observed in Lamurde Local Government Area with 7.8%, 2.1%, 4.2%, 7.5% and 1.0% respectively (Table 4.9.1). The table also shows persistence decrease of co-infection in relation to months from August 26(11.1%) being the highest to October, and from January 10(4.3%) to February 6(2.6%) being the lowest. There was no co-infection recorded in the month of March.

Table 4.4: Distribution of Co-infection between STHs infection and Schistosomiasis by LGAs and Months

Location		Number Examined	No. Infected	Co-infection Percentage Infected
LGAs	Maiha	240	5	2.1
	Mubi South	420	33	7.8
	Mubi North	192	7	4.2
	Michika	348	26	7.5
	Madagali	204	2	1.0
Mont	August	234	26	11.1
	September	234	19	8.1
	October	234	12	5.1
	January	234	10	4.3
	February	234	6	2.6
	March	234	0	0.0
	Total	**1404**	**73**	**5.2**

STHs = Soil-transmitted Helminths; LGAS = Local Government Areas; Mont = Months

Prevalence of Co-infection between Soil-transmitted helminthiasis and Schistosomiasis by Gender and Occupation

The prevalence of co-infection with respect to gender as appeared on table 4.9.3 showed that Males have high percentage of 6.8% while 3.4% were observed among Females with no statistical significant difference (p>0.05). Table 4.5 shows the frequency of co-infection between soil-transmitted helminthiasis and schistosomiasis in relation to occupation. Out of 73(5.2%) co-infection cases, fisher men and women had 16(8.0%), while Civil Servants had 2(1.0%) and there was no significant (P> 0.05) difference.

Table 4.5: Prevalence of Co-infection between STHs infection and Schistosomiasis According to Gender and Occupation

		Co-infection	
Gender	**Number Examined**	**No. Infected**	**Percentage Infected (%)**
Male	752	51	6.8
Female	652	22	3.4
C/Servant	184	2	1.0
Student	335	26	7.8
Business	292	4	1.4
H/Wife	135	5	3.8
Fishing	200	16	8.0
Total	**1404**	**73**	**5.2**

STHs = Soil-transmitted Helminths

Confirmation of positive Samples with Polymerase Chain reaction (PCR)

Each primer combination had 99.9% specificity, using genomic DNA of STHs; it was shown that the assays specifically amplified the appropriate target genomic DNA but there was no amplification of DNA from the other parasites. Two primers were used for each parasite which were forward and reversed primers with a target region each as shown (Table 4.6).

Table 4.7 shown a total of 201 parasites were observed using microscopy and 331 using PCR out of 239 samples with statistical differences ($P<0.05$) between Microscopy and PCR techniques. However, 77 and 136%, 81 and 117, 43% and 78 *A. lumbricoides*, *A. duodenali*, *N. americanus* and *T. trichiura were* recorded respectively, with significant statistical difference among the parasites and the techniques.

Proportion of stool positive for A. lumbricoides, Hookworm and T. trichiura by Microscopy and PCR

The two techniques used for observation of STHs in stool samples signified different specificity as it was noted on figure 4.1 and 4.2 with *A. lumbricoides* having the highest proportion in microscopy and PCR (21.4% and 37.7%) and least among *T. trichiura* with

11.9% and 21.5% in the two techniques. However, it has not indicated any statistical difference between infections and the techniques (p>0.05).

Venn diagram of STHs based on Microscopy

Figure 4.1 revealed the occurrence of three different STHs parasites with different co-infections following varieties of proportions in this order of 81, 77 and 43 for Hookworm, *A. lumbricoides* and *T. trichiura* with no significant difference (p>0.05). Moreover, co-infections were also recorded with proportion of 10, 5 and 4 for *A. lumbricoides* and Hookworm, *A. lumbricoides* with *T. trichiura,* Hookworm and *T. trichiura,* and it revealed no statistical (P>0.05) difference. Meanwhile, triple co-infection has not been recorded during the study with microscopy.

Figure 4.2 showed the proportion of four different STHs parasites species by PCR technique with highest proportion in *A. lumbricoides* (136) and relatively low proportions across *T. trichiura* (72), *A. duodenale* (65), *N. americanus* (52) and highest co-infection were recorded among *A. duodenale* and *A. lumbricoides* (23) followed by *A. lumbricoides* and *N. Americanus* (12) and the same were recorded between *A. duodenale* and *T. trichiura* with significance difference (p<0.05). Triple infections were also recorded among *A. lumbricoides, T. trichiura* and Hookworm.

Table 4.6: Sequence Information of some STHs Parasites using Polymerase Chain Reaction (PCR)

S/N	Parasite	Oligonucleotide Sequence 5'-3'	Target region
1.	Forward Primer*A. lumbricoides*	F: 5'GGAGGTTTTTGGGTCTTTGG3'	ITS-I
	Reverse primer *A. lumbricoides*	R: 3'CCAAACAAGGTAGCCAACCA5'	
2.	Forward Primer *A. duodenale*	F: 5'ATGCTTGGCAAGAGTCGTTT3'	DNA-like protein
	Reverse primer *A. duodenale*	R: 3'TGTTGGCGTCCACACATATT5'	
3.	Forward Primer*N. americanus*	F: 5'CTGTTTGTCGAACGGTA3'	ITS-2
	Reverse primer *N. americana*	R: 3'ATAACAGCGTGCACATGTTGC5'	
4.	Forward Primer *T. trichiura*	F: 5' CTGCGAGGATTGACAGATCA 3'	rRNA
	Reverse primer *T. trichiura*	R: 3' GTACAAAGGGCAGGGACGTA 5'	

ITS = Intestinal Transcript Spacer
rRNA = ribosomal RNA

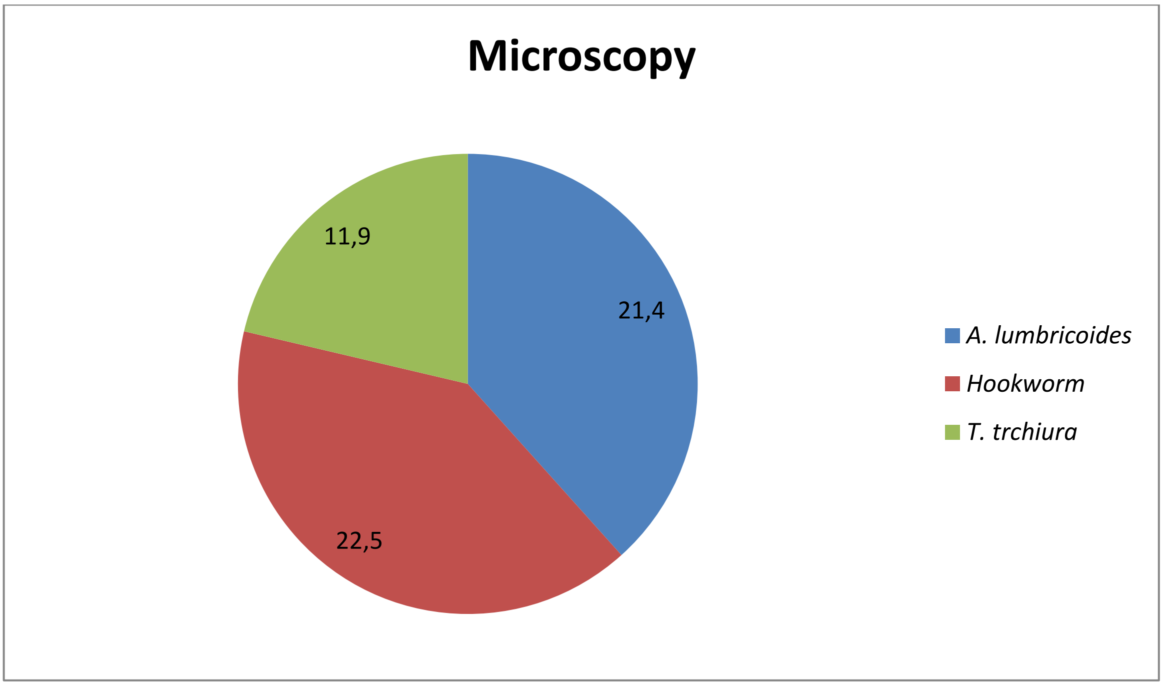
Table 4.7: Comparison of Microscopy and PCR in Examination of Some species of

S/N	Parasite	Microscopy	PCR	DNA Concentration (fg/µ) in positive Stool sample by microscopy. Median (range)
1.	*A. lumbricoides*	77	136	3.01(0.1-0.01)*
2.	*A. duodenale*	81	65	0.22(0.3-0.10)*
3.	*N. americanus*		52	0.05(0.0-0.21)*
4	*T. trichiura*	43	78	21.12(0.11.0.01)*
	Total	**201**	**331**	**24.80(0.51-0.32)**

STHs

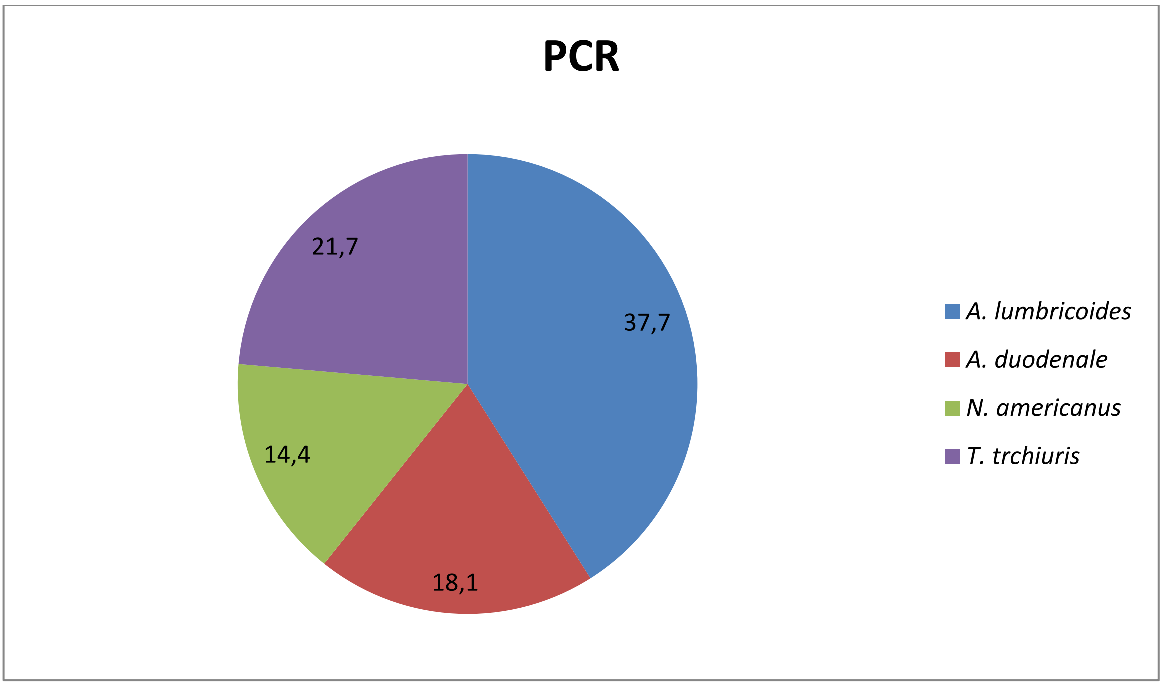
N= 239

*significant difference (p<0.05)



N= 239

Figure 4.1: Proportion of stool positive for *A. lumbricoides*, Hookworm and *T. trichiura* by microscopy



N= 239

Figure 4.2: Proportion of *A. lumbricoides*, *A. duodenale, N. americanus* and *T. trichiura* by PCR

DISCUSSION

Prevalence of Soil-Transmitted Helminthiasis and Schistosomiasis by Location

This study of soil-transmitted helminthiasis and schistosomiasis was conducted from August to October, 2024 and from January to March, 2025. And the findings revealed low prevalence of soil-transmitted helminthes and schistosomiasis in the study area. Also the results showed a concomitant infection rate of 5.2% between soil-transmitted helminthes infection and schistosomiasis. Statistically, analysis of variance (ANOVA) showed that soil-transmitted helminthes prevalence varied significantly from schistosomiasis (ANOVA = 47.20, $p < 0.05$) with slight correlation between the distribution of the two infections (r = 0.7.34). More details of the findings were subsequently discussed with reference to locations, source of water and toilet system and influence of demography on the distribution of the infections. The low prevalence rate recorded for soil-transmitted helminthiasis in this study disagreed with the findings of Naphtali, *at al.* (2017) and Isyaku, *et al.* (2013) who conducted their research in Adamawa and Kebbi State Nigeria respectively. The differences could be as results of seasonal variation or hygiene condition of the subjects and their environs, and also the technique of sample analysis employed by the previous researchers. Linking the rate of STHs infection with location, Bororo community was recorded with 23.6% being the highest, while, 12.5% was recorded in Pakka community being the lowest. High prevalence recorded in Bororo of this study agreed with the work of Omah, *et al.* (2014) research conducted in Umuibu community of Ukwuani Local Government Area, Delta State, Southern Nigeria, and disagreed with the low results recorded in Pakka community. However, this was in contrast with the findings of Eke, *et al.* (2015) who observed relatively high infection in their study in Kura Local Government Area of Nasarawa State, Nigeria. These differences could be as a result of proper usage of anti-helminthes drugs among the populations where this research was conducted and the mass campaign on helminthiasis and health education embarked on by Primary Health care Development Agency Authority (PHCDAA) across the state might have been the reason behind low infection rate in this present study.

Discussing the rate of schistosomiasis with location in the study area, Bellel community was recorded with the highest infection, this implies that schistosomiasis is endemic in Pakka community, and it could be due to ignorance and lack of good public hygiene among the community, while, Kuda community was recorded with lowest infection. This finding is in contrast with Shinkafi, *et al.* (2013) who observed high infection in Sabongari, and the differences could be attributed to geographical variation of the two study areas.

Soil-transmitted Helminthiasis and Schistosomiasis in Relation to Age, Gender and Occupation

The age bracket 5-14 years old 28.5% were the most affected with STH and schistosomiasis, while subjects within age of 35-44 years had the least infections, and it is in line with the report of (Ogomaka *et al.*, 2012). The distribution of schistosomiasis by age showed highest prevalence of 36.6% infection among age group 5-14 years old, while age group 45-54 years old had low schistosome infection. This report has quite agreed with (Ivoke *et al.*, 2014). The differences between the age groups could be proved by their frequent visit to streams and river especially after school hours both in rainy and dry season.

The moderate prevalence of soil-transmitted helminthiasis seen among women than men could be due to their low immunity, social and sanitary habits since they spend more time taking care of infants and children which might have predisposed them to intestinal parasites. This result differs from the previous records by Luka, *et al.* (2000), who reported high infection in male than female in Lare Local Government Area of Kaduna State, Nigeria. This occurrence could be attributed to the exposure of males rather than females in the study area.

Prevalence of 25.5% and 20.8% infection recorded among males and females in this study is in line with the report by (Shinkafi *et al.*, 2013) who recorded higher infections among males (3.6%) than females (2.7%). The differences may likely be as a result of male career which is associated to outdoor activities in the study area. Infection with soil-transmitted helminthes revealed, Civil servant and farmer had 10.3% as highest and lowest infection prevalence in the study area which is in line with previous research conducted by (Momoh *et al.*, 2013) who observed low infection among Civil servant than any other occupation in Tertiary Hospitals in Nigeria. Meanwhile, Infection with *S. haematobium* species has shown in this research revealed that, Fishermen had (35.0%) which was not surprising as it agreed with records of (Edungbola *et al.*, 2019) and (Okanla, 2019) who have observed clear relationship between water utilization in occupation and Schistosomiasis. More schistosomiasis by occupation was observed among students, (34.2%) and was supported by Chidozie and Daniya, (2008) and contradict the report of Jinabhi, *et al.* (2012) who demonstrated high prevalence of schistosomiasis in school children. this was also in line with Odaibo, *et al.* (2014) and Okoli, (2014) who stated that, prevalence of schistosomiasis could be from 20-40% among school aged children.

Co-infection between the Parasites

This findings has revealed 5.2% as an overall co-infection rate out of 239(17.0%) STH and 326(23.2%) Schistosomiasis during the study and it is in line with with the report by (Mathewmwn, 2017). The variation in prevalence of co-infection by location may be as result of cultural differences and beliefs from one locality to another. Mubi South and Michika had the highest co-infection with 8.8% and 8.3% respectively, while the lowest was observed in Madagali LGA (1.0%). This difference could be attributed to the large samples collected in Girei and Michika LGAs than any other LGAs. With respect to month, August had 11.1% co-infection and February had 2.6% as the highest and lowest while, no infection were recorded in March and there was significant statistical difference ($p<0.05$) between months and co-infection. The prevalence of co-infection by season revealed 7.0% and 3.4% in wet and dry seasons; this is in line with the work of (Naphtali *et al.*, 2017). Age related co-infection uncovered high infection among age bracket 5-14 years old (8.0%)

while age bracket 45-54 had the least (1.0%), Age bracket, and there was no significant statistical difference (p>0.05). Further analysis of co-infection showed a higher distribution (6.8%) among males than females (3.2%), with no statistical significant difference (p>0.05). This is line with the report by (Okoli and Iwuala, 2014), in Imo State, Nigeria.

Fishermen/women had 8.0%, farmers and students had 7.8% each where least was observed among business people (1.4%) with statistical significant (P<0.05) different The frequency of co-infection in relation to water source and toilet system, were 9.1% and 6.9% among those that drank from river/Stream and those using nearby for convenience being the highest accordingly.

Positive Samples Analyzed with Polymerase Chain reaction (PCR)

Using genomic DNA of STHs it was shown that the assays specifically amplified the appropriate target genomic DNA but there was no amplification of DNA from the other parasites. Two primers were used for each parasite which was forward and reversed primers with a target region each, a total of 201 STHs observed using microscopy varied from the 331 using PCR out of 239 samples. And there was a statistical significant differences (P<0.05) between Microscopy and PCR. This finding is in consonance with the work conducted in Ecuador by Rojelio, *et al.* (2013) who reported that, PCR had higher sensitivity and specificity rates for all parasites compared to the conventional technique. This is also in line with (Stacey *et al.*, 2016).

The two techniques used for observation of STHs in stool samples signified different specificity with *A. lumbricoides* having the highest proportion with microscopic technique and PCR. However, this has not indicate any statistical difference between infections and the techniques (p>0.05).

Co-infection of STHs Based on Microscopy and PCR

Soil-transmitted Helminthes parasite with different co-infections following varieties of proportions in this order, 81, 77 and 43 for Hookworm, *A. lumbricoides* and *T. trichiura* is consistent with the similar research carried out in Cambodia by (Stacey *et al.*, 2016) who recorded same pattern observed with microscopy and there was no significant difference (p>0.05). Moreover, co-infections were also recorded with proportion of 10, 5 and 4 for *A. lumbricoides* and Hookworm, *A. lumbricoides* and *T. trichiura* and Hookworm*,* Hookworm and *T. trichiura,* this has shown no difference statistically (P>0.05). Meanwhile, triple co-infection has not been recorded during the study.

Soil-transmitted helminths parasite species with highest proportion is *A. lumbricoides* (136) and relatively low proportions across *T. trichiura* (72), *A. duodenale* (65), *N. americanus* (52) and highest co-infection were recorded among *A. duodenale* and *A. lumbricoides* (23) followed by *A. lumbricoides* and *N. americanus* (12) and lowest between *A. duodenale* and *T. Trichiura* with significance difference ($p<0.05$). Triple infections were also recorded among *A. lumbricoides, T. trichiura and* Hookworms. However, this record has disagreed with that of (Salwa *et al.*, 2017)

Summary of the Findings

The study has clearly demonstrated the occurrence of soil-transmitted helminthiasis and schistosomiasis at the same time, revealed the distribution of co-infection among residents of Adamawa Northern Senatorial District, from 2024-2025.

Although, was paucity of published information on soil-transmitted helminthiasis and schistosomiasis that has been conducted in the zone. This study was the first of its kind that has documented such findings which covered rural deprived communities in the study area. Therefore, the findings may serve as base-line information for further epidemiological studies on soil-transmitted helminthiasis and schistosomiasis in the state. The records can also serve as a leading way for control of such infections. In this study, five LGAs across ten (10) communities and 1,404 participants were sampled at random for wider coverage. Structured questionnaires and in-depth interview were used for the collection of demographic data from the respondents, where Conventional and PCR were adopted for stool and urine samples. While, Chi-square, ANOVA, Correlation, Percentage and Man-whetney were adopted for the data analysis using SPSS version 22.

CONCLUSION

This study shows soil-transmitted helminthes and schistosomiasis as relatively distributed in the study area, with high prevalence and intensity among school children (5-14 years). These infections decreased with increase in age with males being mostly infected with STHs than the females' counterpart. Meanwhile poor environmental hygiene, poor personal hygiene as well as inadequate or no supply of potable water are considered as the predisposition factors of the infections in the study areas. It was noted that, egg count per gram of faeces and intensity of schistosomiasis per 10mls of urine are below the range of high intensity. Distributions of co-infections were also observed between STHs parasites and schistosome parasites. Hence it was known that, the infections have tremendous effects on the health and wellbeing of individuals. With reference to malacological study, this study was the first Medical malacological survey so far conducted along River Benue Adamawa State, as there is no any published article recorded so far. This study has established the presence of three snail intermediate host for schistosomiasis and fascioliasis by extension in the Study area. However, snail infection rate, Community locations, season, sanitary behaviour and proximity to natural body of water play great role in transmission and distributions of STHs and Schistosomiasis in the study Area.

The risk of future complication may probably be high therefore, in view of this, large campaign on soil-transmitted helminthiasis and schistosomiasis is advocated across the study areas and treatment should be regardless of location, age, gender, occupation and educational status. Moreover, the fresh water snails and the schistosomes responsible for schistosomiasis are mostly from the communities as shown by this finding.

Having *A. lumbricoides* to be prevalence among the 239 stool samples examined with PCR technique has generally shown its effectiveness over microscopy, although it is not feasible in resource poor settings and peripheral laboratories. With the outcome of the PCR results, that shows high STHs parasite in the study area, has given indications that, the populace are at high risk of developing disease complication. The study has also showed that, Schistosomiasis is higher than STHs infection, while, urinary schistosomiasis predominates intestinal Schistosomiasias may be due to the abundance of the intermediate host.

Recommendations

Our recommendations is as follows

Integrated control measure such as health education, proper sewage treatment and chemotherapy should be encouraged. With regard to the aforementioned, there is need for Local Government Authority, State Government and Federal Government as well as Non-governmental to strengthen their effort toward integrated control measure especial in the study areas. Basic amenities like pipe-borne water, good toilet systems, health centers and clinics should be provided to the communities for reduction further infections.

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