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Prevalence and molecular characterization of human urogenital schistosomiasis in selected communities in Keffi local government area, Nasarawa State, Nigeria

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Abstract

Urogenital schistosomiasis is a major public health concerns in Sub-Saharan Africa. Therefore, it is important to describe the burden of the disease in this research work using innovative diagnostic tools. This study aimed to assess the prevalence and molecular characterization of schistosomiasis in some selected communities in Keffi. A cross-sectional survey was carried out across all ages in May - October, 2024. A total of 320 participants' urine samples were enrolled in this study. Out of which, 14(4.4%) (95% CI: = 2.13 - 6.62) were positive and 306 (95.6%) were negative to Schistosomiasis. Urine samples of the participants were examined using Combi 10 reagents strips, sedimentation technique and Polymerase Chain Reaction (PCR). Male participants had a higher prevalence of 82.8% (265/320) (95% CI: 78.7% – 86.9%), compared to female participants - 17.2% (55/320) (95% CI: 13.1% – 21.3%). The age group of <5–14 years had the highest overall prevalence of 47.5% (152/320) (95% CI: 42.0% – 53.0%). Farmers have the highest occupational prevalence of 34.1% (109/320) (95% CI=28.9-39.3) followed by pupils with a prevalence of 30.6% (98/320) (95% CI=25.6-35.7). Educationally, Uneducated and Non-formal education have the highest prevalence of 35.3% (113/320) (95% CI= 30.1-40.5) and 28.1% (90/320) (95% CI= 23.2-33.1) respectively. Angwan Jaba has the highest schistosomiasis prevalence of 71.4% (10/14) (95% CI= 14.19-40.19). Participants whose source of water was from the stream and those who bath in stream have higher risk of 71.4% (10/14) (95% CI: 2.75–10.95) and 57.1% (8/14) (95% CI= 1.14-5.98) respectively. All the samples that were negative by microscopy were also negative by PCR. Conclusively, Schistosomiasis is prevalent and those who uses contaminated stream water are at higher risk of the disease therefore control measures should be employed to avoid the spread of the disease in the study population.

Keywords: Schistosomiasis; Urogenital; Microscopy; Molecular; Nasarawa

1. Introduction

Schistosomiasis is a neglected tropical, water borne disease caused by a parasitic fluke (trematodes) of the genus *Schistosoma.* It is a pervasive global public health issue with an estimated 101.3 million people at risk of infection and 29 million of the people being infected [1]. There are five species causing Schistosomiasis in humans namely: *Schistosoma haematobium, Schistosoma mansoni*, *Schistosoma mekongi*, *Schistosoma intercalatum* and *Schistosoma japonicum* but *S. haematobium* and *S. mansoni* are the common species found in Nigeria, while *S. haematobium* and *S. mansoni* are responsible for urinary and intestinal Schistosomiasis respectively [2]. The parasite was first discovered by Theodor Bilharz, a Garman Physician in 1851 in Cairo Egypt in the blood of mesenteric vein of a young man on autopsy and he was the first to describe urinary Schistosomiasis and named it after his own name, Bilharzia [3]. It is transmitted when

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humans uses water bodies such as stream, lakes, canals or ponds which has been contaminated with stool or urine from infected persons [2].

Schistosomiasis affects over 250 million people each year presenting with intestinal and urogenital diseases caused by *S. mansoni* and *S. haematobium* [4] with sub-Saharan African Countries having the highest *Schistosoma* cases of about 90% of the global cases [5]. Nigeria is a Country mostly affected by schistosomiasis worldwide, school age children are mostly affected and about 20 million people need to be treated every year [2]. Praziquantel (PZQ) is the drug of choice for the treatment of schistosomiasis because of its efficacy against all species of *Schistosoma,* and it is available, safe, cost effectiveness and requires minimal training of non-medical personnel [2].

Urogenital Schistosomiasis if not treated could lead to: Blood in urine (*hematuria*), Bladder inflammation and fibrosis, Urinary tract obstruction and kidney damage, Increased risk of bladder cancer (squamous cell carcinoma) and Infertility and sexual dysfunction (in both men and women). The study is aimed at determining the prevalence and molecular detection of *Schistosoma haematobium* in urine of subjects in selected communities in Keffi local government area of Nasarawa state, Nigeria

2. Materials and methods

2.1. Materials

2.1.1. Reagents and Chemicals

Reagents and chemicals that were used in this study include, Combi 10 urinalysis test strip, Proteinase K, Absolute ethanol, Elution buffer, Lysis solution, Wash buffer1, Wash buffer 2, 0.01M Phosphate buffer Saline, EDTA, Q5* Hot Start High-Fidelity 2X Master mix, Nuclease free water, Agarose 1.5%, Incorporation buffer, Syber Safe DNA stain (Dye), Qubit Fluorometer, Qubit ™ dsDNA Hs Buffer, Qubit ™ds DNA Hs Standard 1and Qubit ™ds DNA Hs Standard II.

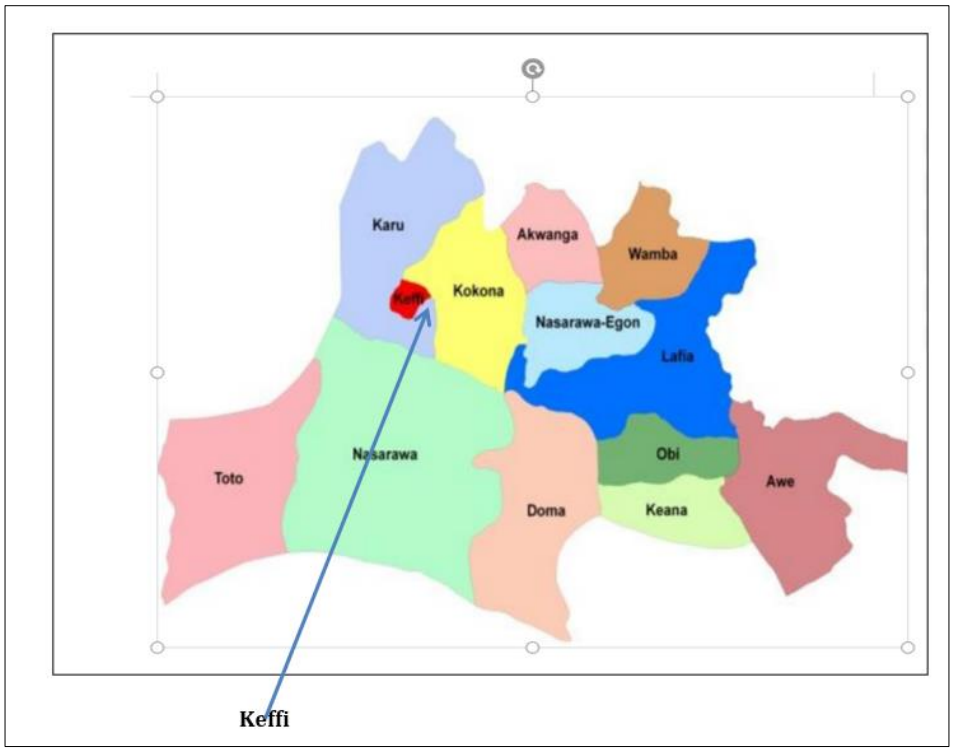
2.1.2. Equipment, Glassware and tools

The equipment, glasswares and tools that were used for this study includes Bright field microscope, Centrifuge, falcon tubes with stopper, weighing balance, refrigerator, glass slide, cover slip, cotton wool, Eppendorf tubes, Gene JET Genomic DNA purification column, collection tubes, vibrating incubator, Vortex, Bio-safety cabinet, others are test tube rack, micro pipette, pipette tips and Micro-Amp optical 8-tube strip (0.2ml), Electrophoresis machine, PCR Instrument.

2.2. Methods

2.2.1. Study Area

This study was carried out in 8 selected communities in Keffi local government area of Nasarawa State, Nigeria namely: Gidan Zakara, Sabon Gida, Jigwada, Yar kadai, Angwan Jaba, Kawo, Anguwan Lambu and Kaibo Mada. These communities were selected because of their proximity to the stream, where the local people go to swim, bath and do their domestic chores, which exposes them to infested fresh water which harbors snails, the intermediate host of the parasite [6]. Keffi is approximately 68km from Abuja, the Federal Capital Territory and 128km from Lafia, the capital of Nasarawa state. It is located between Latitude 8°5N of the equator and Longitude 7°8E and situated on an altitude of 850m above sea level with the total population of 142, 900 people [7].



(Source: catalog.ihsn.org/index.php/catalog/13340/download/48521)

Figure 1 Map of Nasarawa State showing Keffi LGA, the study site

2.2.2. Sample Size

The sample size was determined by the prevalence of 16.3 = 0.163 with a confidence interval of 95% using the formula previously described by [6] as shown below:

$$n = \frac{Z^2 Pq}{d^2}$$

Where n = Sample Size

Z = Standard normal distribution at 95 confidence Limit = 1.96

P = Prevalence rate 16.3 = 0.163

q = 1- p

d = allowable error (0.05)

This implies:

$$n = \frac{(1.96^2)\ x\ 0.163\ x\ 1 - 0.163}{0.05^2} = \frac{3.8416\ x\ 0.163\ x\ 1 - 0.163}{0.0025}$$

$$\frac{3.8416\ x\ 0.163\ x\ 0.837}{0.0025} = \frac{0.5241}{0.0025}\ \text{n} = 209$$

10% = 209 = 229.9. Approximately = 230.

Actual sample size: = 230, but to increase the chances of getting Schistosoma specie, the sample size was increased to 320 samples.

2.2.3. Sample Collection

A total of 320 urine samples were collected from subjects in these selected communities in Keffi, Nasarawa State, Nigeria into sterile leak proof universal containers. The samples were labeled and stored at 4^{o}C until ready for analysis. Demographic information were obtained using well-structured questionnaire at the point of sample collection.

2.2.4. Subject Selection (Eligibility criteria)

Inclusion Criteria

Subjects residing in these selected communities in Keffi Nasarawa State and were willing to participate were included in this research work.

Exclusion Criteria

Subjects residing in these selected communities in Keffi but were not willing to participate and those residing outside keffi communities were excluded in this research work.

2.2.5. Ethical Clearance

The ethical clearance for this research work was obtained from Keffi Local Government Secretariat, Keffi Nasarawa state.

2.2.6. Laboratory investigations

All the urine samples were examined macroscopically for color, appearance, presence or absence of blood, while the urine was examined microscopically for presence or absence of ova of *S. haematobium* using standard protocols as earlier described by [6].

DNA Extraction

The extraction was carried out using DNA extraction kit (Qiagen, USA), following manufacturer's instructions. Briefly, all samples and reagents were brought to room temperature. To the 200µL parasite suspension in a 1.5 ml nuclease free micro tube, 400µl of Buffer AVL was added , mixed by vortex for 15 Seconds, Incubated overnight at room temperature. Thereafter, 300uL of absolute ethanol was added, incubated at -20^{0}C for 1hrs. Carefully, the solution was added to the QIAamp Mini column in a 2ml collection tube. The cap was closed and centrifuge at 8000 rpm for 1 min. The QIAamp Mini column was transferred to a clean 2ml collection tube, and the tube containing the flow-through was discarded. Subsequently, 500µl Buffer AW1 was added to the spin column and centrifuge at 8000rpm for 1min, and discarded the flow-through. Furthermore, 500µl Buffer AW2 was added, centrifuged at full speed (13,000 rpm) for 3 min and discarded the flow-through. The tubes were spun dried by centrifuging again for 3 minutes without adding any reagent. The QIA-amp Mini column was placed in a clean nuclease free 1.5 ml micro-centrifuge tube and the old collection tube containing the filtrate was discarded. Carefully, 60 µl Buffer AE equilibrated to room temperature was added directly to the silica membrane of the spin column and incubated at room temperature for 5 min and centrifuged at 8000 rpm for 1 minute. The spin column was discarded and the micro tube containing the DNA was caped and stored at -20^{0} C until required.

DNA quantification.

The extracted DNA was quantified to determine the amount of DNA in the urine samples as follows: Micro-Amp Optical 8-tube strip (0.2ml), were labeled and arranged on a rack, Qubit (Life Technologies Corporation, Eugene, Oregon 97402) reagent was prepared according to manufacturer's procedure, 200µL of the prepared Qubit reagent and standards were dispensed into each of the MicroAmp Optical 8-tube strip. 20µl of the purified urine samples as described above, were dispensed into each of the Micro Amp Optical 8-tube strip, and allowed to incubate at room temperature for 2minutes. The tubes were placed individually in a Qubit 4 Fluorometer and the amount of DNA present in the sample was displayed on the screen.

Primer Synthesis for Schistosoma haematobium Detection

The primer sequences targeting the 267 bp variable region of the Cytochrome C Oxidase sub-unit 1 (Cox1) mitochondrial gene of *Schistosoma haematobium* were synthesized by INQABA Biotech, a leading DNA synthesis company. These primers were designed using the PrimerQuest tool from Integrated DNA Technologies (IDT) to ensure specificity and efficiency in detecting *S. haematobium*. The forward primer (Sh-Forward: 5′-GGATTGATTTGTGCTATGGC-3′) and reverse primer (Sh-Reverse: 5′-CACCGCCWAYCGTAAATAAA-3′) were based on

sequences retrieved from GenBank, specifically accession numbers ON237715, ON237716, ON237717, and ON237718. These sequences were carefully analyzed to avoid regions with high self-complementarity, hairpin structures, or primer dimers, while maintaining optimal melting temperatures (Tm) and GC content for robust PCR amplification.

The primer synthesis request was submitted through INQABA Biotech's online platform, specifying details such as primer names, sequences, synthesis scale (25 nmol), and purification method (desalted). Upon synthesis, the primers were shipped in lyophilized form along with a detailed datasheet containing quality assurance data, including purity percentage and synthesis success. After delivery, the primers were reconstituted in nuclease-free water to prepare a 100 µM stock solution and stored at -20°C for long-term use. Validation was performed using a standard PCR protocol to confirm specificity and amplification efficiency, utilizing *S. haematobium* DNA as a positive control.

PCR Amplification of Dra1 gene

Polymerase Chain Reaction targeting Dra1 gene was performed using standard protocol. The total 25 µl amplification reaction mixtures contained: Master mix 12.5µL (Qiagen, USA), 2.5µL of coral load, 1 µL of 10mM each of Sh-F and SH-R (Table 1), 3 µL of nuclease free water and 5 µL of DNA template. The tubes were carefully mixed and transferred to applied bio-system 9700 programmed with the following cycling conditions: Initial denaturation at (94 °C for 5 min) followed by 40 cycles of denaturation at 94 °C for 30 seconds. Annealing specific to 16sRDNA gene at 60 °C for 1 min and the extension at 72 °C for 1 min 30 seconds, followed by final extension at 72 °C for 10 min. The PCR products thus obtained were kept at 4°C until required.

Table 1 Primer sequences and cycling conditions used to amplify Dra1 gene

Primer Name	Primer Sequences (5' - 3')	Melting temperature	Amplicon size
Sh-Forward	GGATTGATTTGTGCTATGGC	55.2	267-bp
Sh-Reverse	CACCGCCWAYCGTAAATAAA	57.4	
	Sh = *Schistosoma haematobium*	Bp = Base pairs	

2.2.6.5 Agarose Gel Electrophoresis

In the analysis of the amplified products, the submarine Agarose gel electrophoresis was performed. Agarose gel (1.5%) were prepared by putting 0.75 gm Agarose in 50 ml 1XTris- Acetate EDTA (TAE) buffer and subjected to heat until the Agarose was completely dissolved and appeared as a clear transparent solution. The Agarose solution was allowed to cool to 50°C and then 10µL of ethidium bromide (0.5µg/ml) dye was added to it. Thereafter, the gel was poured into the gel casting tray held within the gel casting gates and the comb was placed into the slots on the tray in such a manner that a gap of 0.5 mm was left between the tips of comb teeth and the floor of casting tray and the wells were completely sealed by the Agarose. The gel was allowed to solidify 30 min and then the comb was gently removed, and the gel slab along with the running tray was submerged carefully into the electrophoresis tank containing 1X TAE buffer.

A total volume of 8 µl amplicon was transferred on a clean Para film and mixed with 2 µl of 6X gel loading dye (Biolabs, UK) and loaded carefully into the wells of Agarose gel. To determine the size of the amplified PCR product, 100-bp DNA ladder (Biolabs, UK) were loaded in the first well. Electrophoresis was performed at 70 V for 1 hour and the mobility were monitored by the migration of the dye in the gel. After appropriate migration, the Agarose gel was visualized under UV trans-illuminator in a Bio-Rad gel documentation device and the results documented.

Statistical Analysis

Data obtained was used to determine the prevalence of Schistosomiasis based on socio-demographic characteristics of study participants. Results were analyzed using MedCalc Software Ltd. Diagnostic test evaluation calculator version 22.009 [8]

3. Results

3.1. Prevalence of Schistosomiasis in the Study Population

A total of 320 participants (40 per study site) were recruited in eight (8) communities in Keffi local government area of Nasarawa state with a total of fourteen (14) infected cases of Schistosomiasis giving a prevalence rate of 4.4% (14/320) ((95% CI: = 2.13 - 6.62). Out of the total participants, prevalence rates based on study sites includes: Gidan Zakara =

7.14% (1/14), (Sabon Gida = 7.14% (1/14), (Jigwada = 0.0% (0/14), (Yar' Kadai = 0.0% (0/14), (Angwan Jaba = 71.4% (10/14), (Kawo = 7.14% (1/14), (Angwan Lambu = 0.0% (0/14) and Kaibo Mada = 7.14% (1/14) (95% CI: 0.05–1.331) respectively. Community wise, Angwan Jaba had the highest Schistosomiasis prevalence rate of 71.4% (10/14). This result is presented in Table 2.

Table 2 Prevalence and distribution of *S. haematobium* infection in relation to Selected Communities in Keffi Local Government Area, Nasarawa State, Nigeria.

Selected community	No examined (N = 320)	Prevalence n(%)	95% confidence interval
Gidan Zakara	40	1(7.14)	(0.44% - 12.88%)
Sabon Gida	40	1(7.14)	(0.44% - 12.88%)
Jigwada	40	0(0.00)	(0.00% - 8.76%)
Yar Kadai	40	0(0.00)	(0.00% - 8.76%)
Angwan Jaba	40	10(71.4)	(14.19% - 40.19%)
Kawo	40	1(7.14)	(0.44% - 12.88%)
Angwan Lambu	40	0(0.00)	(0.00% - 8.76%)
Kaibo Mada	40	1(7.14)	(0.44% - 12.88%)
Total	320	14(4.4)	2.13% - 6.62%

3.2. Soscio-demographic variables of the Study Participants.

Of the 320 participants from selected study sites, 82.8% (265/320) and (95% CI: 78.7% – 86.9%) were males, while 17.2% (55/320), and (95% CI: 13.1% – 21.3%) were females. Majority of the participants - 47.0% (152/320), and (95% CI: 42.0% – 53.0%) belonged to the age group <5-14 years. The age group of 75 years and above had the least number of participants compared to the first age group. Based on occupation, highest prevalence rates of 34.1% (95% CI: 28.9% – 39.3%) was observed in farmers while the least prevalence of 5.6% (95% CI: 3.1% – 8.1%) was seen in housewives. On educational level, Uneducated had the highest prevalence of 35.3% 95% CI= 30.1% – 40.5%) while those in Nursery school and primary schools had the lowest prevalence rate of 11.9% (95% CI= 8.3% – 15.4%) each. No Schistosoma was detected in participants that had tertiary and post tertiary education as shown in (Table 3) below.

Table 3 Prevalence and distribution of *S. haematobium* infection in relation to Socio-Demographic variables/characteristics of study participants

Socio-demographic variables	Category	Frequency (n= 320)	95% confidence interval
Age (yrs)	<5-14	152 (47.5%)	42.0% – 53.0%
	15-24	77 (24.1%)	19.4% – 28.7%
	25-34	31 (9.7%)	6.4% – 12.9%
	35-44	26 (8.1%)	5.1% – 11.1%
	45-54	11 (3.4%)	1.4% – 5.4%
	55-64	9 (2.8%)	1.0% – 4.6%
	65-74	8 (2.5%)	0.8% – 4.2%
	75-84	6 (1.9%)	0.4% – 3.4%
Occupation	Farmer	109 (34.1%)	28.9% – 39.3%
	Fisher Man	95 (29.7%)	24.7% – 34.7%
	House Wife	18 (5.6%)	3.1% – 8.1%
	Pupil	98 (30.6%)	25.6% – 35.7%
Educational Level	Uneducated	113 (35.3%)	30.1% – 40.5%
	Non Formal	90 (28.1%)	23.2% – 33.1%

	Nursery	38 (11.9%)	8.3% – 15.4%
	Primary	37 (11.6%)	8.1% – 15.1%
	Secondary	42 (13.1%)	9.4% – 16.8%
	Tertiary	--	-
	Post Tertiary	--	-

N = no of respondents; % = Percentage

3.3. Distribution of Potential Risk Factors

The study revealed that a total of 146 (45.6%) with prevalence rate of 71.4% (8/14) (95% CI: 2.75% - 10.95%) of participants' source of water was from the stream, 293 (91.6%) with prevalence rate of 92.9% (13/14) (95% CI= 2.08% - 6.79%) have haematuria, 225 (70.3%) prevalence rate of 57.1% (8/14) (95% CI= 1.14% - 5.98%) have been bathing in the stream, 199 (62.2%) prevalence rate of 50.0% (7/14) with (95% CI= 0.96% - 6.08%) wash in the stream, 293 (91.6%) prevalence rate of 92.9% (13/14) with (95% CI= 2.08% - 6.79%) use pit latrine as detailed in Table 4.

Table 4 Distribution of Potential Risk Factors among respondents in Selected Communities in Keffi Local Government Area, Nasarawa State, Nigeria

Potential risk factors	Category	No Examined (N= 320)	No positive (n= 14)	Proportion (%)	95% confidence Interval (CI)	P -value
Source of water	Tap Borhole Stream Well	0 (0%) 37 (11.6%) 146 (45.6%) 137 (42.8%)	0 2 10 2	0.0% 14.3% 71.4% 14.3%	(0.00% - 0.00%) (-1.88% - 12.69%) (2.75% - 10.95%) (-0.55% - 3.47%)	0.099
Have You Ever Urinated Blood	Yes No	293 (91.6%) 24 (7.5%)	13 1	92.9% 7.14%	(2.08% - 6.79%) (-3.83% - 12.16%)	1.000
Do you bath in water: Stream or River etc	Yes No Sometimes	225 (70.3%) 55 (17.2%) 40 (12.5%)	8 3 3	57.1% 21.4% 21.4%	(1.14% - 5.98%) (-0.55%, - 11.46%) (-0.66% - 15.66%)	0.521
Do you wash in Water: Stream or River etc	Yes No Sometimes	199 (62.2%) 50 (15.6%) 71 (22.2%)	7 3 4	50.0% 21.4% 28.6%	(0.96% - 6.08%) (-0.58% - 12.58%) (0.27% - 10.99%)	0.653
What type of toilet do you use	Water system Pit latrine Bucket latrin	0 (0%) 293 (91.6%) 12 (3.8%)	0 13 1	0.0 % 92.9% 7.42 %	(0.0 - 0.0) (2.08% - 6.79%) (-7.30% - 23.97%)	0.448
Urinalysis	Positive Negative	14 (4.4%) 306 (95.6)	14 0	100% 0.0%	(100% - 100%) (0.0 - 0.0)	
Macroscopy	Cloudy/bloody Clear /amber	14 (4.4%) 306 (95.6)	14 0	100 % 0.0%	(100% - 100%) (0.0 - 0.0)	
Microscoy	Positive Negative	14 (4.4%) 306 (95.6)	14 0	100% 0.0 %	(100% - 100%) (0.0, 0.0)	

3.4. Molecular Characterization of Dral -1 gene in *S. haematobium* strain

Inter simple sequence repeats of PCR test performed for the 320 collected urine samples; the agarose gel image displays the successful amplification of a 267 base pair (bp) fragment corresponding to *Schistosoma haematobium*. The amplified band in the sample wells aligns precisely with the expected size, confirming the presence of the target DNA. A 100 bp molecular ladder (Trans gene) was included to provide size references, with distinct bands at known intervals to confirm the accuracy of the fragment size estimation. In contrast, the negative control (NC) shows no visible bands,

indicating the absence of contamination or non-specific amplification, thereby validating the reliability of the PCR reaction. This result demonstrates sensitivity, specificity, efficiency and accuracy of the assay. Thus, 14 urine samples out of the total study population were confirmed positive for the targeted DNA for *Schistosoma haematobium* as shown below in Figures: 2, 3, 4 and figure 5 respectively.

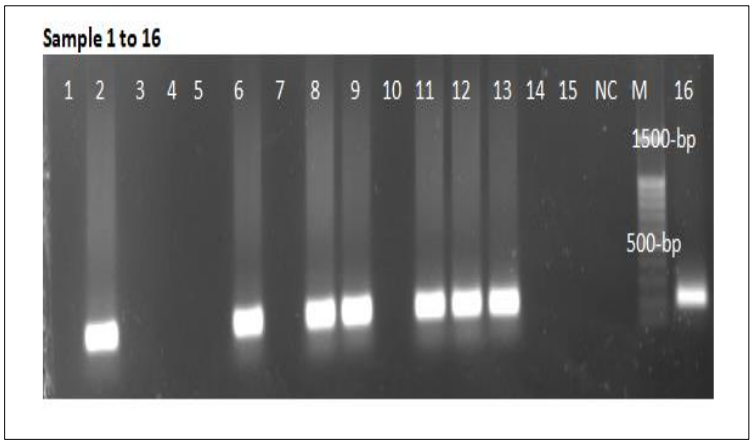


Figure 2 Electrophoresis films of samples 1 - 16. Where M indicates 100bp DNA ladder, NC = Negative control, samples 2, 6, 8, 9, 11, 12, 13, and sample 16 are positive samples showing bands of 267bp while the rest without bands are negative samples

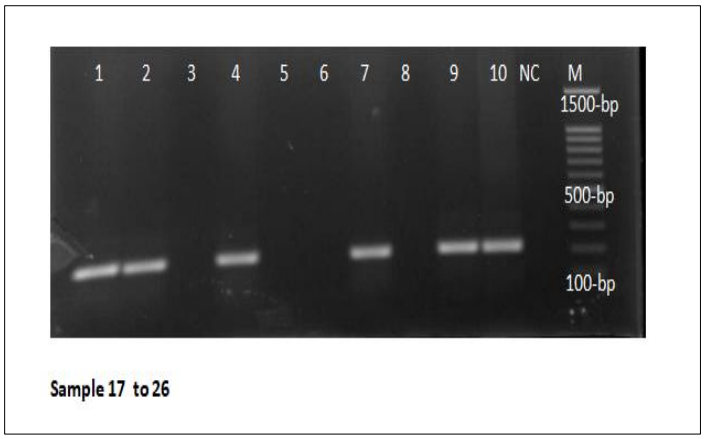


Figure 3 Electrophoresis films of samples 17 - 26 which were mistakenly labeled 1 - 10. Where M indicates 100bp DNA ladder, NC = Negative control. No samples was positive for *S. heamatobium*

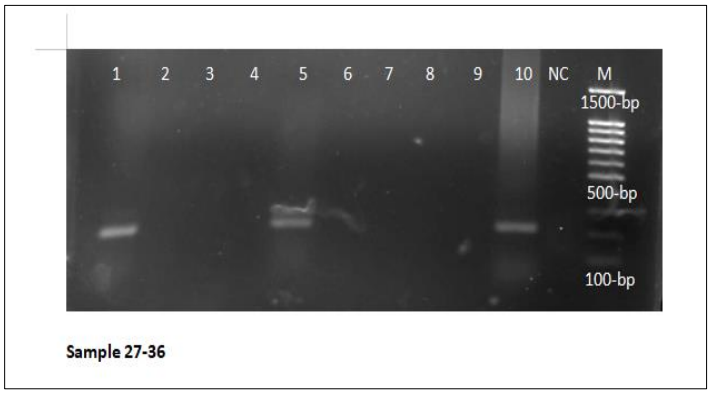


Figure 4 Electrophoresis films of samples 27 - 36 which were mistakenly labeled 1 - 10. Where M indicates 100bp DNA ladder, NC = Negative control. No samples was positive for *S. heamatobium.*

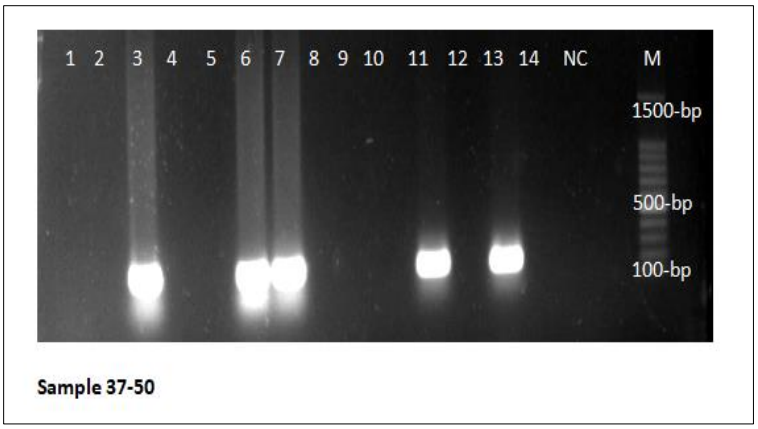


Figure 5 Electrophoresis films of samples 37 - 50 which were mistakenly labeled 1 - 14. Where M indicates 100bp DNA ladder, NC = Negative control. Samples 3, 6, 7, 11 and 13 are positive samples showing bands of 267bp of the *S. heamatobium.*

4. Discussion

A total of 320 participants were recruited in eight (8) selected communities (40 in each community) in Keffi Local government area to determine the prevalence and molecular characterization of urogenital Schistosomiasis in the study area. Out of the number, 265 (83%) (95% CI = 78.7% – 86.9%) participants were males and 55 (17%) (95% CI = 13.1% – 21.3%) were females (Table 3). Results showed 4.4% (95% CI = 2.13% - 6.62%) prevalence by both microscopy and PCR. This prevalence of 4.4% is consistent with a research conducted in Nigeria by [6]. The results is however lower than results by other researchers [4, 9] who reported 40% and 58.1% respectively. The observed reduction in prevalence in this study may be attributed to ongoing public health measures, such as increased access to praziquantel through mass drug administration (MDA), improved health education, and enhanced awareness of waterborne diseases.

The Socio-Demographic variables of the 320 participants across Gidan Zakara, Sabon Gari, Jigwada, Yar' Kadai, Angwan Jaba, Kawo, Angwan Lambu and Kaibo Mada shows that 82.8% (95% CI: 78.7% – 86.9%) are males, while 17.2% (95% CI: 13.1% – 21.3%) are females. Prevalence was higher in Angwan Jaba (71.4%) (95% CI = 14.19% - 40.19%). The majority of the participants: 47.0% (95% CI: 42.0% – 53.0%) belonged to the age group <5-14 years. The age group of 15 years and above had the least number of participants compared to the first age group (Table 3).

Prevalence of Schistosomiasis based on Microscopic examination across all communities was: (Gidan Zakara: 7.14% (1/14), (Sabon Gida: 7.14% (1/14), (Jigwada: 0.0% (0/14), (Yar' Kadai: 0.0% (0/14), (Angwan Jaba: 71.4% (10/14), (Kawo: 7.14% (1/14), (Angwan Lambu: 0.0% (0/14) and (Kaibo Mada: 7.14% (1/14) with (95% CI: 0.05–1.331) respectively. The significantly high prevalence in Angwan Jaba (71.4%) mirrors findings from [10], who identified hotspots of infection near freshwater bodies. Communities that rely on untreated water sources, such as streams or ponds, tend to have higher rates of infection due to the presence of snail intermediate hosts (*Bulinus spp*).

Male participants had a higher prevalence at 71.4% (10/14) (95% CI = 78.7% – 86.9%), compared to female participants—28.6% (4/14) (95% CI: 13.1% – 21.3%) while Farmers have the highest prevalence rates 34.1% (95% CI: 28.9% – 39.3%) followed by Pupils 30.6% (95% CI: 25.6% – 35.7%) and then Fishermen 29.7% (95% CI: 24.7% – 34.7%) while the least prevalence was among Housewives (5.6%) (95% CI: 3.1% – 8.1%). This higher occurrence is attributed to these category of participants' frequent engagement in activities such as fishing, farming, or bathing in freshwater bodies. Similarly, cultural norms and occupational practices make men more exposed to waterborne diseases than women in sub-Saharan Africa [11]. The age group of <5–14 years had the highest overall prevalence at 57.1% (8/14) (95% CL: 42.0% – 53.0%). This is to be expected as school-age children (SAC), who are usually under 14 years of age, have been shown to be the most vulnerable group for schistosomiasis infection as they are more likely to engage in activities that may expose them to contaminated freshwater, like playing in infested water, swimming, washing [11, 12, 13, 14].

Considering the distribution of potential risk factors, the study found out that a total of 146 (45.6%) of participants' source of water was from the stream with prevalence rate of 71.4% (95% CI: 2.75% - 10.95%). There is however no statistical significance association between using water from the stream as a risk factor and Schistosomiasis prevalence (P = 0.099). On the other hand, 37 respondents (11.6%) with 14.6% prevalence (95% CI = -1.88% - 12.69%) uses

borehole as their source of water. The high prevalence of those exposing themselves by washing, bathing and swimming in fresh/open water bodies like stream, is a confirmation of the fact that streams harbour snails that serve as intermediate hosts for the transmission of Schistosomiasis. There is however no statistical significant associatio between these risk factors and Schistosomiasis prevalence (P > 0.05). Similarly, careless people tend to urinate in the water bodies like streams thereby increasing the chances of infesting the water with Schistosoma eggs. This results agrees with the submission of [6] posited that the endemicity of this Neglected Tropical Disease (NTD) in Keffi Nasarawa State is associated with extreme poverty, inadequate or lack of social amenities such as portable water for drinking and other domestic activities. The presence of haematuria which is a clinical sign of Schistosomiasis was also assessed using urinalysis strip. Results indicated that 293 participants agreed to have ever urinated blood having a 92.9% (13/14) prevalence (95% CI: 2.08% - 6.79%). Haematuria is a non specific schistosoma diagnosis symptom that is only used as a surrogate for schistosomiasis haematobia therefore the high prevalence of haematuria in the study population is suggestive of schistosomiasis, a position that is consistent with other researchers [5, 12, 13, 14,].

Results from the PCR amplification detected a prevalence of 4.4% (14/320) similar with that of microscopy. This result is in contrast with other researchers who reported a higher sensitivity of PCR over microscopy. The outcome of this result could be as a result of the microscopist taking extra time to examine the urine deposits thoroughly thereby detecting the parasite eggs in all the positive urine samples.

5. Conclusion

The findings of the current study indicate that *S. haematobium* infection is still endemic in the selected communities and is associated with several risk factors related to water contact activities. Although, PCR method is reported to have a higher sensitivity for schistosomiasis diagnosis by other researchers, the PCR and microscopy detected all the parasites detected by the PCR thus making microscopy as the gold standard because it has the ability to detect active infection, it is a cheaper and readily available method needing less technical knowledge. In order to eradicate and or at least reduce the spread of the parasite, it is therefore imperative to educate people on the treatment, prevention and control of the parasitic disease, especially in communities where high prevalence has been reported.

Recommendations

- **Protective Measures:** Encouraging the use of protective clothing and equipment during activities that involve contact with freshwater can help minimize exposure.
- **Health Education:** Implementing targeted awareness campaigns to inform at-risk populations about transmission routes and prevention strategies is crucial.
- **Environmental Management:** Controlling snail populations through environmental modifications and introducing safe water practices can reduce the risk of transmission.

Compliance with ethical standards

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Author's Contributions

The study was designed by Eno-Obong Emmanuel Asuquo who also conducted the experiments. Daniel Ohilebo Ugbomoiko and Theophilus Ogie Erameh supervised the study. Rosemary Edward handled the statistical analysis while Isaac Nyiayem Igbawua prepared the manuscript. All authors proof-read and approved the article.

Disclosure of conflict of interest

The authors declared no conflict of interest.

Statement of ethical approval

The ethical clearance for this research work was obtained from Keffi Local Government Secretariat, Keffi Nasarawa state.

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