TITLE PAGE

BACTERIOLOGICAL QUALITY OF WATER

SUPPLIES AND THE PREVALENCE OF

SALMONELLA AND PARASITIC INFECTIONS

IN SOME RURAL COMMUNITIES OF

KADUNA STATE

This thesis was submitted to the Postgraduate School

in partial fulfillment of the requirements for the award

of a Doctor of Philosophy (Ph.D) degree in

Public Health Microbiology

by

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DECLARATION

I hereby declare that the work presented in this thesis was carried out by me under the careful supervision of Doctors M. Galadima, I.J.Ogbadu and C. Okuofu in the Laboratory of the Department of Microbiology, Ahmadu Bello University, Zaria.

No part of this work has been submitted for any degree or qualification before. The works of other workers were referred to during this work are duly acknowledged.

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CERTIFICATION

This Thesis entitled "Bacteriological quality of water supplies and the prevalence of Salmonella and parasitic infections in some rural communities of Kaduna State" meets the regulation governing the degree of Doctor of Philosophy (Ph.D), Ahmadu Bello University, Zaria and is approved for its contribution to scientific knowledge and literary presentation.

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ABSTRACT

A total of 1.080 stool samples were collected and examined over a 12-month period for the prevalence of Salmonella spp. Only one stool specimen (0.92%) was positive in the dry season while 43(7.%%) were positive in the wet season. Of the 115 isolates confirmed biochemically, 40(34.7%) showed agglutination with the IS monoNalent antisera used while 00 did not react with them. They might however contain other antigens which would not agglutinate the antisera in the kit used. Of the 40 serotypes, 14 were identified as Salmonella typhi while the 26 were identified as Salmonella enteriticl.js with different varieties. Out of the 14 S. typhi isolates, 9 were isolated from water while 5 were from stool specimens.

With respect to water quality.peak levels of faecal coliforms in rural wells were observed in the month of May and gradually fell from then to October. They were also isolated from surface water sources in the study area. Counts of 1.0 x 10^1 - 8.0 x 10^2 faecal coli forms per 100ml of water were found.

Parasitological examination of a total of 1,080 stool specimens for the prevalence of parasitic intestinal helminths and protozoa showed that 621 (57.5%) were infected. A breakdown of this figure

showed that 226 (20.92%) harboured Ascaris lumbricoides, 143 (13.24%) had hookworm. 92(8.51%) had Entamoeba histolytica and 43 (3.98%) had Giardia lamblia. Others included the following number of cases: 31 (2.8%) of Schistosoma mansoni: 14(1.29%) of Schistosoma bovis, 16 (1.48%) of Entamoeba coli. and 1 case (0.92%) of the following: Enterobius spp, Trichuris spp. Taenia and Strongvloides stercoralis. The prevalence rates were independent of the location but dependent on season at P = 0.05. Polyparasitism was observed amongst those infected with A. lumbricoides and hookworm pairwise combination being the commonest. The importance of provision of potable and safe water as well as health education to members of the community are stressed.

CHAPTER ONE

INTRODUCTION

Most of the people in Nigeria are rural dwellers whose main sources of water for domestic and other purposes (such as cooking, bathing and general washing), are surface waters. The sources include streams, rivers, brooks, ponds and lakes which are often of questionable quality. These water sources are more vulnerable to pollution than ground water (bore holes and wells). The quality of the water can vary depending on seasonal factors and man's activities in the catchment serving the source (UNU, 1983; Uma and Igboka, 1988; Jayakaran and Gilpin 1989). The primary requirement of a water supply is that it should be sufficient and safe. The status of rural water supplies in any particular country usually reflects its state of development (WHO, 1983). In many rural areas of Nigeria, the waste water discharges come in contact with the surface waters and ground water which are used directly without treatment.

According to Hutchinson and Ridgeway (1975), the water cycle is an obvious mode of transmission of enteric diseases. Outbreaks of typhoid, dysentery or cholera epidemics are caused by bacteriologically polluted water. In addition, water of poor physico-chemical quality may have adverse health effects, causing avoidable economic and human losses. From a public health point of view, the essential requirements of a community water supply are safety, adequacy, convenience and

continuity. If water is insufficient, people tend to use any source of water whether it is safe or not (WHO, 1969). The World Health Organisation (1976) reported that about 1.5 billion people world wide drink filthy water. This number is thought to be increasing by about 20 million people each year. Up to 25,000 people die each day in the world, from water-related infections and the figures are increasing.

Natural water bodies such as rivers, streams, lakes and ground water may contain bacteria and a wide variety of other pathogenic micro-organisms. These organisms get into the aquatic environment through sewage discharges and their presence in water is potentially hazardous to health. The incidence of water-borne epidemic diseases in the rural areas is of considerable concern. Some of the illnesses in rural areas may be traced to the use of sewage polluted water. Hutly et al. (1990) observed that in Imo State of Nigeria, diarrhoea accounted for up to 75% of all illnesses in young children and about 20% in adults. The risk factors responsible for this included low socio-economic status, uncleaned domestic environments, use of untreated waste and lack of soap.

Earlier work by Okoro (1986) showed that the surface water sources in four villages in Imo State of Nigeria were heavily polluted with faecal coliforms and faecal streptococci. Sandiford et al. (1989) observed that hand-dug unprotected wells had significantly higher levels of faecal contamination than protected riverside wells and springs during the dry

season. Okuofu et al. (1990) also showed that wells in Samaru. Zaria were heavily polluted using faecal coliforms and faecal streptococci. They observed that none of the wells reached the World Health Organistion standard. Outbreaks of gastroenteritis may be due to polluted water samples without faecal coliforms. This has been observed by Schubert and Scheiber. (1979). The increase in the number of cases with typhoid fever and gastroenteritis in our hospitals could be linked to the diverse kinds of serotypes of Salmonella that abound in the environment. There is a danger that a new serotype can suddenly become endemic in an area and cause serious problems. The spread of Salmonella serotypes from different sources in the environment is important. In view of this and the fact that plasmid acquisition or mutation can confer resistance to treatment, the examination of water and stool for the diverse kinds of Salmonella serotypes in our environment is imperative. This is vital to the success of any public health programme.

Bearing in mind the public health implications of these to the rural communities in particular, this study has the following objectives.

1. To assess the bacteriological quality of rural water sources in Kaduna State using faecal coliforms as indicators.

2. To determine the influence of water supply and sanitation on the incidence of diarrhoeal diseases in the rural areas studied by comparing

the documented cases in the local primary health care centres with the occurrence of the organisms in their water supplies.

3. To attempt to isolate Salmonella spp from the faeces of primary school pupils and from water and to serotype the isolates for possible linkage of the source of the organism with water or faeces.

4. To assess the prevalence of intestinal helminths and protozoans as in primary school pupils in the communities under study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Bacteriological quality of water - an overview

2.1.1 Bacteriological quality of well water

Several studies showed that the quality of water depended greatly on the type of water source from which it was drawn, the weather prior to the time of sampling and whether it was taken directly from the source or from a storage vessel in the home (Dreij et al., 1978; Barell and Rowland, 1979, Schneider et al., 1978; Shiffman et al., 1978; Torun, 1982).

Protected wells were found to be less contaminated than unprotected wells during the dry season (Tomkins et al., 1978 ; Wright 1982). The bacteriological quality of rural water supplies in Nicaragua was studied by Sandiford et al., (1989). They noted that hand-dug unprotected wells had significantly higher levels of faecal contamination than protected riverside wells and springs during the dry season. The explanation offered by the authors was that most privately owned wells were situated about 10m from the latrines. The unprotected wells also contain a much greater volume of water than protected riverside wells which are emptied once or twice a year by their owners.

Ogan (1989) noted that unprotected wells were contaminated during the rainy season by "washback" and spilled water draining from the platforms. Also cross contamination through the use of buckets and ropes previously placed on the bare ground may occur. This correlates with earlier studies by Kourany and Telford (1981) who found that many unprotected wells were vegetated with algae, mosses and the fern Nephrolepsis biserata on the walls. Crevices in the wells also provide

hiding places for toads and frogs which may be faecally contaminated in search of flies on soil surface. Organic residue from anthropogenic sources, probably contaminated with faecal matter and from wall vegetation may provide additional sources of faecal coliforms in unprotected wells.

Tobin (1989) observed that Yersinia enterocolitica and Campylobacter jejuni were known to persist in natural waters and might proliferate in well water and cause disease even in the absence of faecal coliforms.Okuofu et al., (1990) examined the bacteriological and physico chemical characteristics of six wells in Ahmadu Bello University ,Samaru, Zaria. They noted that the wells had higher faecal coliforms and streptococci. They found that the unprotected wells had dead lizards and other rubbish floating in the water. They also observed that individual householders use contaminated buckets and ropes to fetch water. The wells were also observed to be in close proximity to busy footpaths and road. As such dust and other extraneous materials could gain easy access to the unprotected water.

2.1.2 **Bacteriological quality of piped borne water**

Schubert and Scheiber (1979) reported that Salmonella could frequently be isolated from piped drinking water in Togo, even in the absence of E. coli and coliforms. This was attributed to faulty well-heads and broken reservoir covers allowing access to rainbow lizards (Agama agama). These were often found to excrete Salmonella and sometimes few or no E coli and other coliforms. Peters and Odeyemi (1990) observed that the faecal coliforms estimated from the piped water distribution system from Mokuro dam in Ile-Ife, Nigeria were higher in the dry season than in the

rainy season. Faecal streptococci were also found but exhibited no definite seasonal pattern. Ejeikwu and Anebi (1991) isolated specific coliforms from the pipe-borne water supplying Jos metropolis. These coliforms were characterised as Citrobacter sp; E. aerogenes., E. coli and Klebsiella aerogenes. Bacteria may gain access to the water in the distribution system from booster pumps, packing materials in joining mains and damaged pipe lines.

2.1.3 **Bacteriological quality of surface water**

Cherry et al. (1972) observed that Salmonella could be found in polluted surface water using a polyvalent fluorescent antibody reagent. They observed that Salmonella dublin was the major serotype isolated. Okoro (1986) assessed the traditional water sources (rivers and streams) from four villages in Ohoazara Local Government Area of Imo State, Nigeria. He noted that the levels of faecal pollution were higher during the rainy season than in the dry season.

Peters and Odeyemi (1990) observed that the Mokuro dam (in Ile-Ife, Nigeria) had higher aerobic heterotrophic bacteria population (6.4 x 10^6 ml) during the dry season than in the rainy season (7 x 10^2/ml). The raw water could be contaminated through the run-off from bushes and farms surrounding the dam and the stream.

2.2 Possible indicators for assessing water quality

2.2.1 Organisms indicative of faecal pollution

The use of normal intestinal organisms as indicators of faecal pollution rather than the pathogens is a universally accepted principle for monitoring and assessing the microbial safety of water supplies (WHO, 1971). Indicator organisms should be abundant in faeces but absent in other sources, they should be easily isolated, identified and counted and they should not easily multiply in water. They should survive longer than pathogens in water and should be more resistant to disinfectants (Geldreich, 1981; WHO, 1984). These criteria can hardly be met by a single organism. However, coliforms especially E. coli has fulfilled almost all.

Bacteria used as indicators of faecal pollution include the coliform group of organisms, faecal coliforms, faecal streptococci and sulfite-reducing clostridia especially Clostridium perfringens. Anaerobic bacteria such as bifidobacteria and Bacteroides are more abundant than coliforms in faeces but routine methods for their detection and enumeration are not yet available (WHO, 1984).

2.2.1 a COLIFORM ORGANISMS

Coliforms have long been recognised as suitable microbial indicators of drinking water quality because they are easy to detect and enumerate in water. They are able to ferment lactose in culture at 35°c and 37°c. They

include E.coli, Citrobacter, Enterobacter and Klebsiella spp. (APHA, 1985). The presence of coliforms in water may be due to inadequate treatment or post treatment contamination (WHO, 1971).

Total coliforms have long been recognised as suitable microbiological indicators of water quality. The presence of any coliform bacteria should not be tolerated, and if found, suggests either inadequate treatment or post-chlorination contamination in the system (Kittrel and Furfari, 1962). The practical value of the total coliform measurement and its sanitary significance have been shown over the years (Berg, 1978). Geldreich et al. (1962) however showed that coliform bacteria could multiply in stream water. Many environmental factors influence the reactions of coliform bacteria in streams to produce the typical pattern of initial increase followed by a systematic decrease. Changes in nutrient level as well as the production of toxic materials are the most important factors (Kittrell and Furfari, 1962)

2.2.1.b **FAECAL COLIFORMS**

Faecal coliforms are coliform organisms that are able to ferment lactose at 44 - 44.5°c. They include Escherichia and to a lesser extent, strains of Citrobacter, and Klebsiella. Only E. coli specifically is of faecal origin, being present in faeces of man and other warm-blooded animals in large numbers (WHO, 1984). Faecal coliforms represent over 96% of the coliforms derived from human faeces (Geldreich et al., 1962). It also

represents 93% to 98% of those discharged in faecal excrement from other warm-blooded animals including livestock, poultry, cats, dogs and rodents (Geldreich, 1975). Faecal coliform concentrations range from 10^6 - 10^9 per gram in man, 10^6 - 10^7 per gram in cats and dogs, 10^4 - 10^5 in farm animals; and 10^4 - 10^7 in rabbits, chipmunks and mice (Geldreich, 1976). These variations reflect not only differences in faecal moisture content but also diet. Probably diet differences also influence the variety of strains found in the faecal coliform populations from different animal groups (Berg, 1978). For example, the ++ -- IMVIC strains, as well as other faecal coliform IMVIC types, are commonly found in the faeces of man and chicken.

In polluted waters, faecal coliform measurements relate more precisely to faecal contamination and are significantly less susceptible to bias caused by the re-growth characteristic of non faecal coliforms in receiving waters (Deaner and Kerri, 1969). Essential factors that stimulate bacterial re-growth in polluted waters are nitrogen, carbon and a warm water temperature. The re-growth phenomenon for faecal coliforms requires excessive nutrient discharges generally associated with poor treatment practices used on some food processing and paper mill wastes. When nutrients are available in polluted waters in concentrations sufficient to support faecal coliform persistence or re-growth, Salmonella and possibly

other bacterial pathogens that may be present, may also persist for extended periods. (Berg, 1978).

Faecal coliforms, Salmonella and enteroviruses have been found in sediments and studies of faecal coliform densities in these sediments compared to the overlying waters indicate a 100 to 1000 fold increase which may be expected in the bottom interface (Hendricks, 1981).

2.2.1.c FAECAL STREPTOCOCCI

The normal habitat of faecal streptococci is the intestine of man and other warm-blooded animals. They can therefore be used as indicators of faecal pollution. The following selective chemicals may be used to recover faecal streptococci: potassium tellurite, thallous acetate and sodium chloride. They can be enumerated by the most probable number method, membrane filtration method or by selective enrichment. (Saleh, 1980 ; APHA, 1985). Faecal streptococci are not recommended for assessing drinking water quality because of their persistence in water with moderate salt concentrations (Geldreich, 1976). When used as supplementary bacterial indicators with faecal coliforms they may be useful in locating the origin of faecal pollution in heavily contaminated sources of raw water. Human faeces contain at least 4 times as many faecal coliforms as faecal streptococci and this may vary in relation to the animal species and geographical locations (Teachem , 1975). Recent work in Leeds, England has led to the development of a bacteriological method to distinguish

between human and animal faecal pollution of water (Oragui, 1981 , 1982).

2.2.1.d **COLIPHAGES AS INDICATORS OF FAECAL POLLUTION**

A rapid coliphage analysis technique (ARCAT) for enumerating coliphages in natural waters has been evaluated by quality laboratories in the United States and a highly significant correlation has been established (Wenstel et al., 1982). The method detects about six coliphages per 100ml within 6hours.

The coliphage levels can be related to coliforms to give a quick indication of the number of coliform bacteria in potentially contaminated waters (Wenstel et al; 1982). Viruses have considerable ability to survive in the aquatic environment and may remain viable for days or months (WHO, 1984). Explosive outbreaks of viral hepatitis and gastroenteritis resulting from sewage contamination of water supplies which were not faecally contaminated at a detectable level, shows that a more sensitive indicator like the coliphage is needed to detect low levels of virus contamination of water. (Craun and Mc Cabe, 1973).

2.2.1.e **SULPHITE REDUCING CLOSTRIDIA**

Sulphite - reducing clostridia are anaerobic organisms, of which Clostridium perfringens is the most characteristic. The latter is present in faeces though in much smaller numbers than E. coli (WHO, 1984). It is

not used as a faecal indicator in the United States and only used peripherally in Europe. It is used more in England than any other country. There are no easy methods for the quantification of this obligate anaerobe. The spores can survive in water longer than organisms of the coliform group. The ability to produce spores is the major factor limiting the usefulness of Clostridium perfringens as indicator of water quality and pollution. The occurrence of high densities of sulphite - reducing bacteria in waste water and polluted waters suggests that they are of faecal origin (Geldreich, 1980). It has also been shown to persist more in water than *faecal coliforms and faecal streptococci (Bisson and Cabelli , 1980).*

2.2.1.f BIFIDOBACTERIA

The desire for an indicator system which unequivocally indicates the presence of faecal material and the existence of a potential health hazard has stimulated research along two lines - bacteriological and biochemical. One of the more promising and least studied bacteriological indicators are the bifidobacteria. These organisms , which constitute a major component of the guts of human and other warm-blooded animal species, are still relatively unknown. The obscurity is probably due to their requirement for anaerobic conditions, yet it is this same requirement that makes them ideal as indicators of faecal pollution. They cannot multiply in natural waters and under laboratory conditions have been shown to have survival characteristics similar to E.coli (Evison and James, 1973).

Mossel (1958) was one of the first researchers to recognise the potential of bifidobacteria as indicators of faecal pollution. Later studies by Evison and James (1978) supported the belief that the bifidobacterium test was faecal specific and that the test was sensitive. Levin (1977) noted that these organisms may provide a specific assay by which lower animal and human faecal pollution may be separated. This potential differentiation may be accomplished by the electrophoretic mobility of the enzyme, fructose - 6 - phosphate phosphoketolase which appears to be different in organisms isolated from birds, cattle and humans (Evison and Morgan, 1974). On the other hand, Okuofu and Dada (personal communication) observed that at high light intensities and temperatures, bifidobacteria survive less in river water than E. coli and faecal streptococci. When exposed to 12.58mv of light for 120 minutes, E. coli, faecal streptococci and bifidobacteria were progressively killed in river water samples.

2.2.1.g **PSEUDOMONAS AERUGINOSA**

This organism often occurs in the faeces of man but in much lower numbers than coliform organisms. It is an opportunistic pathogen of the very young and those already debilitated by disease, being frequently isolated from persons with urinary tract infections and skin burns (Hoadley, 1977; Cross, 1979). The organism occurs in raw water usually in the presence of coliform organisms (Nemedi and Langi, 1971). The organism can proliferate in water by utilising low levels of nutrients

present in the water or on plumbing materials in contact (Mc Peters et al., 1974).

Many well water samples which passed the coliform requirements have been shown to have over 1,000 Pseudomonas organisms per ml. They have been shown to attach to biofilms in a flow through excretion of polysacharides forming long particles (Tobin, 1989).

2.2.1.h **HETEROTROPHIC PLATE COUNT.**

This is used to assess the general bacterial content of water. It is however of little value in detecting the presence of faecal pollution but a sudden increase in the colony count from a groundwater source suggests an early sign of pollution of the aquifer (Mueller, 1977). The control of the aesthetic quality of potable water has been attributed to the control of heterotrophic plate count bacteria in distribution pipelines (Victoreen, 1974). A characteristic of many heterotrophic bacteria found in drinking water is the ability to form brightly coloured non-photosynthetic pigments (Herman, 1976). The use of heterotrophic plate counts and Pseudomonas aeruginosa has been advocated to assess the hygienic quality of drinking water (Geldreich, 1981).

2.2.2 **Miscellaneous indicators of water quality**

2.2.2.a **Coliform equivalent**

The detection of coliform equivalent has been advocated as a better measure of coliform densities in water (Nix and Holmes, 1989). The

coliform equivalent test measures coliform densities by correlation of enzyme activity with defined cell numbers in pure culture plate counts (Nix and Bratton, 1986). During incubation, enzyme activity is measured through a colour change brought on by the quantitative measure of coliform bacteria involving a test protocol which is simple and adaptable for use in the field. It also detects chlorine - stressed coliforms which cannot be detected by the MPN or MF technique.

Leclerc et al. (1977) proposed a method based on the production of glutamic acid decarboxylase and the use of a technico - Auto Analyser to automatically sample and analyse the water samples. In this ingenious process, the water samples are collected and filtered through ultra fine hollow fibres after which the concentrated solution of bacteria are enriched by culturing in lactose broth at 41°c for 4 hours. The carbon dioxide produced by the bacteria is stripped off, prior to the mixing of the culture fluid-bacteria mixture with a glutamate solution buffered at pH 3.9. Incubation continues at 41°c for 1^{1} 2 hours and the formed carbon dioxide is freed by the addition of sulphuric acid. A phenolphthalein indicator solution is used to absorb the gas. The colour change is measured colourimetrically and is related to the density of E. coli in the original water sample. The system is reportedly sensitive to enumerate one E. coli per 100ml of drinking water sample.

The Atlantic Research Corporation developed a rapid E. coli testing procedure for drinking water. This procedure is called the reverse phage titre rise reaction (Evison and James, 1978).Positive results are indicated by the formation of plaques within a bacterial lawn within 4 - 6 hours. The presence of plaques indicates that the water sample contained bacteriophage capable of infecting the E. coli host bacterium. The implicit assumption is that the presence of phage in water samples denotes the presence of bacteria capable of supporting the replication of phages (Evison and James, 1978). In the test, a 100ml sample of drinking water is mixed with a nutrient broth followed by the addition of an aliquot of host E. coli cells. The suspension is thoroughly agitated and a sample of this suspension is added to a 45°c agar after which more E. coli host cells are added. The top agar mixture is vortexed, then poured into a petri dish containing nutrient agar which is allowed to solidify. Plates are incubated at 35°c - 37°c for 4 - 6 hours and then examined for plaque formation (Evison and James, 1978).

Studies by Kenard and Valentine (1974) have shown that the ratio of phage to faecal bacteria is about 0.7:1 regardless of the level of contamination. The test is being improved to address sensitivity levels of one bacterium per 100 samples.

2.2.2.b **Immunological Methods**

The Enzyme - linked immunosorbent Assay (ELISA) with a Reader has been used by Obst. (1989) to detect an enzyme - Enterobacterial Common Antigen(ECA). This enzyme is released by enterobacteriaceae. It involves the pre-incubation of enterbacteriaceae in lactose broth (12-24 hours) followed by boiling for 15 minutes to release the enzyme. This method has been compared with conventional methods and has been found to yield faster results. Early work by Cherry et al. (1972) showed that a polyvalent fluorescent antibody reagent can be used to screen for Salmonella using enrichments of surface water samples. Other immunological methods used in detection of bacteria in water involve the use of antisera (polyvalent and monovalent). These bacteria include E. coli. Salmonella, Vibrio cholerae (APHA. 1985).

2.2.2.c **Faecal steroids**

The faecal sterol, coprostanol (5ß - cholestan 3ß - 0l) whose only well documented source is the faeces of humans and higher animals has been receiving attention as a potential indicator of faecal pollution (Murtaugh and Bauch. 1967; Smith and Gouron. 1969).

Coprostanol can be detected in the presence of other lipid - like compounds in water. Its level has been found to be highest in untreated sewage. Its concentration decreases as the sewage proceeds through the treatment processes. In the aquatic environment, coprostanol levels are

highest in the sewage outfall area. This decreases as one samples up or downstream from the outfall (Dukta and El-Shaarawi, 1975). Unlike biological indicators, faecal sterols do not appear to be affected by chemical disinfectants or toxic waste discharges. Thus for chlorinated effluents, coprostanol levels would appear to be ideal indicators of faecal contamination: and so of possible health hazards due to non-inactivated viruses. The presence of coprostanol in water would indicate the existence of faecal pollution in situations where the use of conventional bacterial indicators are impossible. It has also been suggested to be excellent indicator of well - water contamination under conditions where it is difficult to ascertain whether or not the isolated coliform - type organisms are of faecal origin or from landwash (Dukta et al, 1974).

There are problems militating against the use of coprostanol as an absolute indicator of faecal contamination. One of these is the laborious procedure required to process each sample. Under ideal conditions, only 10 - 12 samples per day can be processed. Another problem is the lack of knowledge of the relationship between pathogens, indicators and coprostanol in the aquatic environment (Dukta et al., 1974). It has also been observed by Dukta and El-Shaarawi (1975) that there is no consistent relationship between faecal sterols and traditional indicator bacteria. However, survey by Amund and Odubela, (1991) have shown that concentration of faecal steroids in water and sediments closely parallel

faecal coliform counts. They noted that the data on faecal steroid analyses have been found to be useful in detecting domestic waste in industrial outfalls that are low in micro organisms. They suggested that the information presently available indicated that it would be worthwhile extending the measurement of faecal steroids to water supply quality evaluation.

Faecal sterols have been found to be particle-bound and quickly absorb to surfaces. This poses a problem in sample replication since it is difficult to obtain a sample with homogeneously dispersed particles with each particle containing the same concentration of coprostanol (Evison and James, 1978). The observation that coprostanol and other faecal sterols are readily particle bound enhances their usefulness in monitoring sewage treatment plant efficiency. The better the treatment the sewage receives, the more particulate matter is removed. Hence the concentration of faecal sterols found in the effluent may be indicative of treatment efficiency. The finding of faecal sterols invaribly indicates particle-bound faecal material and pathogens associated with polluted water are generally considered to be associated with these particles (Evison and James, 1978).

2.2.2.d **Interrelationships between indicator organisms and pathogens in water**

Dunlop et al. (1952) reported ratios of one Salmonella per 255,000 total coliforms and 4,800 enterococci in irrigation waters. Geldreich (1970)

emphasised that the use of a given bacteriological parameter of water quality "must be ultimately related to the probable occurrence of water-borne pathogens". He demonstrated that Salmonella isolation occurred in less than 27.6% of fresh water samples when the faecal coliform concentration was less than 200 organisms/100ml. The frequency of isolation rose sharply when the range of faecal coliforms was 200 - 2,000 organisms 100ml while Van Donsel and Geldreich (1970) noted the relationships of Salmonella and faecal coliforms in bottom muds taken from fresh water, lakes and streams of varying size and quality. They recovered Salmonella from two - thirds of mud samples when the water above contained more than 200 faecal coliforms/100ml but only infrequently when the concentration was less than 200 faecal coliforms 100ml. They suggested that the level of 200 faecal coliforms 100ml might represent a significant limiting relationship between indicator and pathogen. The median of the ratios of Salmonella in mud to faecal coliforms in mud was 1 to 14,000. When the numbers of Salmonella in mud was compared to the numbers of faecal coliforms in the overlaying water, the median ratio was 1 to 150.

Smith and Twedt (1971) found an interrelationship of 11,580 coliforms, 300 faecal coliforms, 191 streptococci to two Salmonella per 100ml of sample river water. The distribution of faecal coliform bacteria in the Colarado river was reported as 48,000 faecal coliforms ml of the bottom

sediment. The log mean surface water faecal coliform density was 2.4 100ml (Geldrich, 1981). Bisson and Cabelli (1980) observed that Clostridium perfringens can be used as an indicator organism and its density related to that of E. coli. They observed that the E.coli / Clostridium perfringens density ratios decreased markedly with increasing distance from the sources of pollution. Berg (1978) found that the densities of sulfite reducing clostridia were less than 10/100ml in more than 40% of water samples from Lake Ontario bay. Since C. perfringens spores survive environmental stress better than E. coli, one would expect the ratio of one to the other at any sampling point to vary with the degree of disinfection at the source.

Wheater et al. (1979) found that the density of Pseudomonas aeruginosa is usually less than 3.0×10^1 100ml whereas counts above 5.0×10^5 100ml of P. aeruginosa were frequently obtained in hospital waste waters. Correspondingly, high counts of E. coli were found in hospital waste waters when compared to domestic waste waters. The ratio of E. coli to P. aeruginosa in hospital waste waters was less than 25 to 1.

2.3. Survival of Indicators and Pathogens

Following excretion, the concentration of all pathogens usually declines from the death or loss of pathogenicity. Viruses and protozoa will always decrease in numbers following excretion but bacteria may multiply if they find themselves in a suitable nutrient - rich environment (Feachem et al.,

1983) Multiplication of bacterial pathogens is generally rare and eggs of intestinal helminths will decrease in numbers following excretion. The rate of loss of pathogenicity of an organism depends on temperatures, dying more at higher than lower temperatures (See Appendix 1).

2.4.0 **Water borne protozoan diseases.**

2.4.1 **Giardiasis**

This is an infection of the small intestine but the bile duct and gall bladder may also be infected (Meyer and Radulescu.1979;Feachem et al., 1983). It has negative nutritional consequences, more likely to be severe in prolonged cases and in individuals with Protein - Energy Malnutrition, low gastric acidity and immuno deficiency. It is characterised by greasy, foul smelling stools without blood, flatulence, anorexia and abdominal cramps. Children are more prone to infection than adults. In a study by Tomkins (1981) in Northern Nigeria, the prevalence was found to be 1% in 0 - 3 month old babies; 51% in 2- 3 years old and 18% in adults. Studies in the Gambia showed that age - specific prevalence of Giardiasis were 1% in infant (under 1 year); 24% in children (3 - 4 years) and 6% in those over 40 years (Bray and Harris, 1977).

Ogunba (1977) found that Giardiasis was linked to the low standard of public sanitation in Ibadan. Data collected between May, 1967 and December, 1976 showed that Giardia infection in the population was about 1.65%. He noted that the regular seasonal distribution of higher

infection rates of Giardiasis corresponded with period of little or no rains (December to April) when the community depended more on well water probably contaminated with cysts.

Beavers have been shown to be reservoir hosts of this parasite (Jakubowski and Erickson , 1979). Craun (1979) noted that Giardiasis occurred primarily in mountainous area of U. S. A. where the community consumes untreated surface water contaminated by the faeces of beavers. Simple disinfection did not seem to protect the community against the disease and negative results for coliform tests do not provide assurance that the water is free of Giardia cysts. Giardiasis may occur when defective sewerage pipes are accidentally cross-connected with water distribution pipes. Infection leads to damage of the small intestine which causes malabsorption of carbohydrates, fats, vitamin B_{12} and fat-soluble vitamins (Leachem et al., 1983).

2.4.2 **Amoebic dysentery**

Amoebic dysentery is an infection of the large intestine caused by the protozoan Entamoeba histolytica. Many cases are symptomless or cause only mild abdominal discomfort. Death is rare except in the already malnourished. The infection is transmitted when contaminated water, food or vegetables are consumed (Listorti, 1990). A study of 26 villages in the Gambia by Barris and Harris (1977) showed that infection rates were 26% among male and 45% among females. A 30-month study

showed that prevalence rose to the peak at the start of the rains (May - June) and falling at the end of the dry season (April). The prevalence of E. histolytica in Venezuela was studied by Chacin - Bonilla et al (1992) who found that the overall amoebic infection rate was highest in female adults (39.7%). However, infection rate of E. histolytica was 8.7.% and that of Ent. coli was 24.8%. The latter is more common in stools of humans than the former. Survival experiments by Geldreich (1972) indicated that cysts of E. histolytica may persist in good quality water such as distilled water for at least 153 days at 12°c to 22°c.

2.4.3 **Balantidiasis**

Balantidiasis is an infection of the large intestine caused by a ciliate - Balantidium coli. It causes diarrhoea with blood stains. It is not very common but is perculiar to communities associated with pig- rearing (Feachem et al., 1983). Ogunba (1977) observed that the infection in Ibadan, Nigeria was 0.05% over a 10 year period.

2.5. **Diseases caused by parasitic worms**

2.5.1 **Ascariasis**

Ascariasis caused by Ascaris lumbricoides.is common among children in rural areas and in poor urban children. Ova are found in fine silts and clays than in sandy soils (Feachem et al. , 1983). Survival studies carried out on Ascaris ova in stream water samples indicated that survival varied with dissolved oxygen content. Larvae developed after 60 days of storage

of the ova in the stream water containing 7.0 to 9.0 mg/1 dissolved oxygen. In the absence of dissolved oxygen, no larvae developed (Geldreich, 1972). During the dry season, transmission may decrease because the eggs are desiccated in the dry soil. Prevalence of ascariasis may increase with the advent of the rains. It has been found that the transmission of ascariasis may be related to dietary practices. Soe et al (1969) noted a November - December peak in the transmission of ascariasis in South Korea and this has been attributed to increased intake of infested prickled vegetables. A study by Chacin - Bonilla et al (1992) showed that the incidence of ascariasis was higher in school children than in other age groups. Seasonality in transmission may also lead to a seasonal peak in pneumonitis associated with ascaris larval migration as has been reported in Saudi Arabia (Gelpi and Mustapha, 1967).

Transmission is commonest in areas of poverty and inadequate sanitation. Children from house holds with good sanitation could become infected when they visit homes with heavily infected family members. Coprophagous domestic animals have been reported to be important in the dissemination of the infection (Feachen et al., 1983).

2.5.2 **Hookworm disease**

Hookworm disease is caused by the genus Ancylostoma or Necator spp. It is mainly acquired by penetration of the skin by infective larvae. The infestation occurs more where sewage is used in irrigation farming

transferring the infection by direct contact in the field especially in paddy rice fields. Prevalence rates in rural areas are always higher than in urban areas. The infestation is also higher in lower socio-economic groups than amongst the higher socio-economic group (Feachem et al., 1983) The disease is an occupational disease of farmers being more prevalent on those working on their farms without shoes and also those using infested sewage or sludge for irrigation. The disease is more prevalent in the males than in the females in most parts of the world due to occupational differences and habits.

2.5.3 Schistosomiasis

Schistosomiasis is a debilitating disease in which the adult male and female worms live in the venous plexuses. Infection is acquired in rice cultivation, swimming or wading through fresh water that is infested with the cercariae of S. mansoni, S. haematobium or S. japonicum. Some snails are known to be intermediate hosts of these worms. Young et al. (1973) were able to demonstrate that S. paratyphi A could exist at favourable sites for their growth on the surface and within the tissues where Schistosoma spp were lodging in man. This means that infection by the former may complicate the infection by the latter as reported by Higashi et al. (1975) and Salih et al. (1977). Higashi et al. (1975) suggested that Salmonella infection might enhance the formation and deposition of immune complexes in the kidneys of patients with

schistosomiasis while Salih et al. (1977) showed that S. typhi and S. paratyphi A were isolated from the blood of 16 out of 21 Sudanese patients with prolonged fever of 1 - 10 month duration of hepatosplenic schistosomiasis with severe anaemia.

2.5.4 Disease of other worms

Diphyllobothriasis may be transmitted by the use of water in reservoir impoundments 'that are contaminated by untreated domestic sewage (Sologub, 1957). However, the disease is mainly transmitted through consumption of infected fish. Eggs of the dog tape worm, Echinococcus granulosus may be passed occasionally through contamination of unprotected drinking water supplies by dogs, wolves and other species of Canidae. Studies on the high rate of Echnicoccus infections in Yugoslavia have been reported and found in areas where lakes and streams are scarce and drinking water supplies come from open pools of rain water, run off trapped in ground depressions (Emili and Tomasic, 1954).

2.6 Interventions for the control of Diarrhoeal diseases

2.6.1 Improved water quality

The provision of improved water supplies is important to curb the escalating number of cases of diarrhoea. Improvements in water quality are more likely to reduce the incidence of diarrhoea than improvements in microbiological quality (Briscoe, 1978, Esrey et al., 1991). Disinfection with chlorinating agents have been used for long to control

bacterial agents of diarrhoea (White, 1986) but cysts of Amebae and Giardia, viruses and Legionella spp are known to be unaffected. Rubin et al. (1983) suggested that hypochlorous acid was the most effective form of chlorine for disinfection at the pH range of 5 - 9. Most studies on chlorine inactivation of protozoa cysts such as E.histolytica (Stringer and Kruse.,1970) Naegleria grubei and Giardia lamblia (Rubin et al., 1983; Hibler et al., 1987) demonstrated the increased inactivation at lower pH values. Ultra-violet light disinfection has been suggested by Qualls et al., (1983) as an attractive alternative to chlorination. Very low concentrations of chlorine residuals are toxic to aquatic life in receiving waters and the by-products are carcinogenic (National Research Council. 1980). However, particulate materials e.g clay affects ultra violet disinfection by scattering rather than absorbing ultra-violet light rays (Qualls et al., 1983). Qualls et al., (1983) also showed that disinfection was significantly better in a sand - anthracite filtered effluent than in the unfiltered secondary effluent. Coliforms associated with particles were also protected from uv disinfection.

2.6.2 **Fly control**

Many pathogens (Bacteria, protozoan cysts, viruses and helminth ova) known to cause diarrhoea have been recovered from flies (Gupta et al., 1972; Oyerinde, 1976). Pathogens may be dislodged when flies preen their wings and brush their heads and legs. Giardia lamblia and enteric

bacteria have been shown to survive for 1 - 10 days on the integument of flies (Oyerinde, 1976). Control of fly involves the use of biological measures such as the application of B. thurigiensis spores on animal excrement. (Abel-Gawaad and El-Gayar, 1972). Recent biological measures offer some potentional for controlling fly populations because a number of natural predators attack eggs, larvae, pupae or adult flies. Some micro-organisms may act as larvicides for instance, Bacillus thuringiensis when applied to animal excrement will act as a larvicide (Esrey et al,.1991). Sanitary measures are primary means of fly control, however preventing access to human excrement may be easier, but would require the provision of more disposal facilities of greater efficacy (Esrey et al., 1985). Other methods of fly control include the use of light traps and insecticidal measures (Feachem, et al., 1983) and toxic baits (Esrey, et al., 1991).

CHAPTER THREE

MATERIALS AND METHODS

3.1.1 **Study area**

Five(5) villages (Mando, Rigachukun, Katabu, Angwan - Dankale and Basawa) situated around Kaduna and Zaria were selected for the study.

Mando is a village that lies at 10°05′ N and 7°20′ E. It has an estimated population of 10,162 people. It is the last village enroute to Lagos from Kaduna. Peasant farmers engage in growing such crops as maize, sorghum, millet, beans and sugar-cane. Katabu lies at 10°10' N and 7'30' E. It has an estimated population of about 16,250 people. Crops similar to those in Mando village are also grown, Mando and Katabu villages are near Kaduna metropolis. Rigachukun is a village near Katabu and lies at 10°40' N and 7°30'E. It has an estimated population of 15,210 people engaged in farming such crops as maize, millet, beans and sorghum. Each village has a primary health centre with some bore holes and taps which breakdown due to lack of maintenance.

Basawa is another village near Samaru in Zaria which is situated at 10°10'N and 7°30'E. It has an estimated population of 9,000 people residing in it. Pigs are reared here and crops such as maize, millet, sorghum and sugarcane are grown here. Taps and boreholes are also provided. Angwan Dankale is a village near Wusasa in Zaria lies at 11° 05'N and 7°40'E. It has a population of 8,780. Crops such as sweet

potatoes , maize. sorghum and beans are grown here. There are a few taps but the main source of water is well water. These villages also have a public health centre. Most of the people in the villages depend more on well and surface waters as the taps may run dry for days or the boreholes breakdown as soon as they were commissioned.

The common rural water sources in these villages during the dry and wet season were assessed bacteriologically for faecal coliforms and Salmonella spp. A total of twenty five community wells with an average of five per village were assessed over a 12 month period. A total of 9 surface water samples were also analysed for faecal coliforms and Salmonella in the same period of time. The study area is shown in Fig. 1.

3.2 Collection, storage and analyses of water samples

The water samples were obtained from five wells and two surface water sources per village over a 12 month period. A sterile 500-ml screw-capped bottle was lowered into the well by means of a rope tied round the neck to collect water. The bottles were capped immediately after filling and kept in a cool box with ice packs until analysed. Surface water samples were collected by introduction of the bottle in the direction of the water current. Samples were analysed within two hours of collection. Where this was not possible, the samples were stored at 4°c in a refrigerator for a maximum of 6 hours.

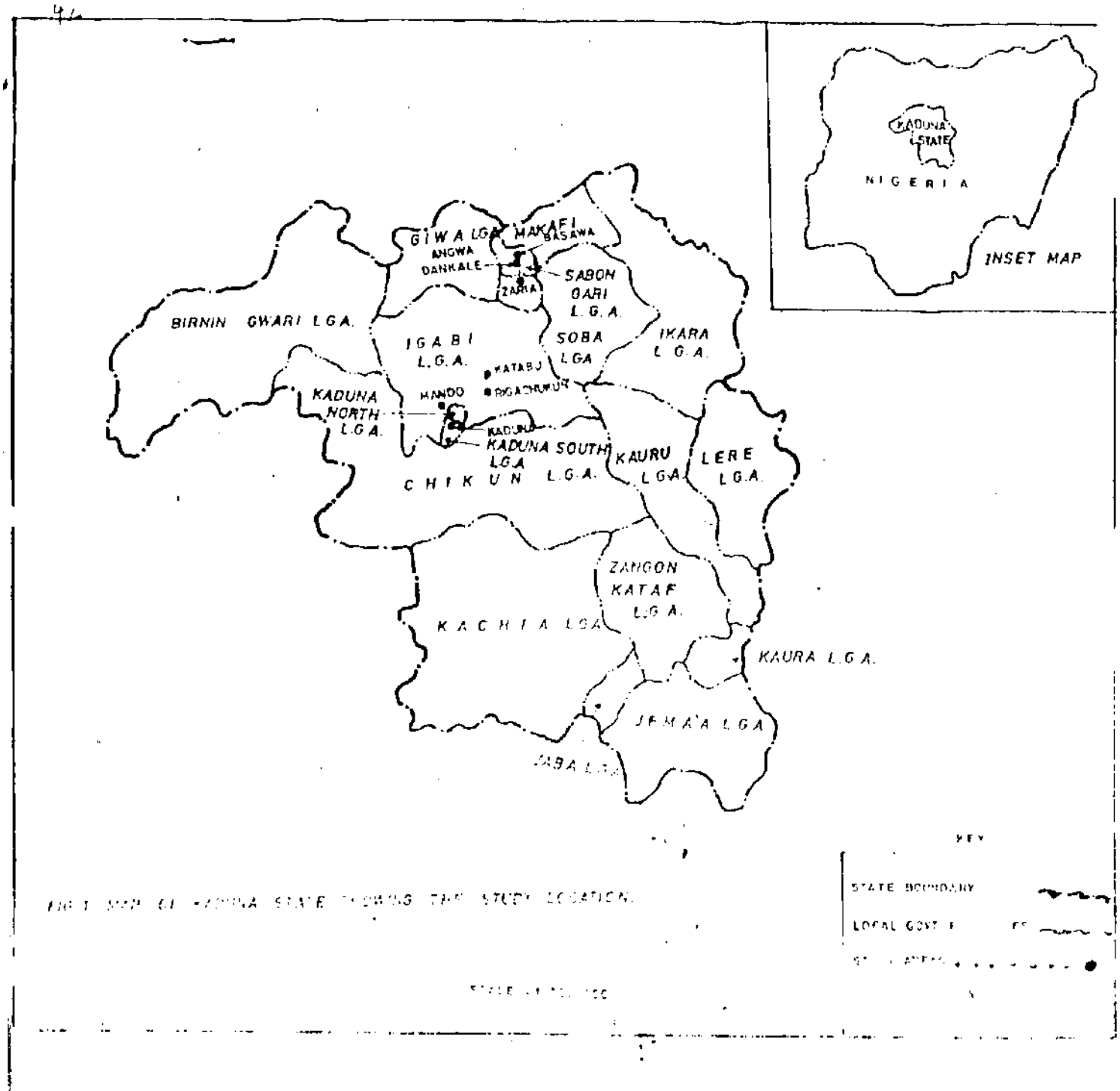


FIG 1 MAP OF KADUNA STATE SHOWING THE STUDY LOCATION.

3.3 Collection of stool samples

Ninety (90) stool samples were collected into wide - mouthed plastic clean containers. Eighteen samples were collected from each village with an average of three per class (1 - 6) per month. These stool samples were aseptically transported to the laboratory and were examined immediately. Where it was not possible to do this, samples were preserved in 10% formal saline.

3.4. Enumeration of faecal coliforms:-

The membrane filtration technique as described in APHA (1985) was used to determine the counts of the faecal coliforms in the water samples collected. Membrane filters were aseptically rolled onto the surfaces of M-Endo Agar LES by means of a pair of millipore forceps. The petri dishes were incubated in an Aluminium sink - block portable incubator (Millipore) set at 35°c for 2 hours and later changed to 44.5° for 22 hours. This gradual change in the incubation temperature was to enhance maximum recovery of faecal coliforms. Colonies with metallic sheen transmitted by light and dark purple in colour were counted and recorded. The mean geometric means of the faecal coliforms were calculated by using the general formula.

Geometric mean = $n\sqrt{\ }\ x^1\ x^2\ x^3 \ldots xn$

where n = no of well water sample per month

x = faecal coliform densities per 100ml in each well.

3.5 **Detection of Salmonella spp**

The membrane filtration technique was used to filter 50mls of water. Each filter was aseptically rolled and dropped in an enrichment broth (selenite broth base) with the aid of a sterile pair of forceps (millipore). The tubes were incubated at 37°c for 24 hours. One tenth of a millilitre of the broth was dropped and spread aseptically on the surfaces of well-dried plates of Deoxychocolate citrate Agar (DCA). Nonlactose fermenters were selected as presumptive Salmonella or Shigella species. Using tubes of Triple Sugar Iron agar, Shigella spp were screened out by their inability to produce hydrogen sulphide. Resistant Proteus spp and the paracolon group were equally screened out by inoculating the isolates onto urea agar slants. Evidence of urea hydrolysis (colour change from orange to pink or red due to ammonia release) leads to the confirmation of Proteus spp and members of the paracolon group. Salmonella isolates were then purified and stored on blood agar base slants for further biochemical identification and serological tests.

The stool samples were also examined for the presence of Salmonella by introducing about 1 - 2 grams of the stool in selenite broth. These were incubated at 37°c for 24 hours. Isolates were biochemically and serologically identified.

3.5.1 Biochemical identification of Salmonella isolates

All isolates which had typical Salmonella reactions in TSI and urease agars were tested according to the methods of Cowan and Steel (1974) and McFaddin (1979). The tests performed were production of indole, methyl red (MR), voges proskaeur (VP) production of hydrogen sulphide, motility, triple sugar iron agar reactions, citrate utilisation, lysine decarboxylation, growth in potassium cyanide, gelatin liquefaction, Acid and gas from glucose, fermentation of sugars such as lactose, mannose, xylose and glycerol and nitrate reduction. Isolates which gave reactions typical of Salmonella were identified.

3.5.2 Serological confirmation of Salmonella isolates

Isolates biochemically identified as Salmonella were confirmed serologically by the slide agglutination technique. Before being tested, isolates were transferred from agar slants of blood agar base through a series(4) of sterile tubes of brain heart infusion broth to attain growth of maximum vigour. They were transferred to agar slants of brain heart infusion which were incubated at 37°c for 24 hours.

Salmonella antisera set A - 1 containing 16 monovalent '0', 1 Vi and 1 Ha antisera (Sifin Ltd. Berlin) was used for the serotyping. A pooled antiserum was made using a drop of the 18 monovalent antisera. Isolates were tested for the reaction to this antiserum before further testing with individual single factor. In each case, a drop of the antiserum was placed

on a microslide and using a wire loop, a pure colony of the isolate was mixed thoroughly with the antiserum. The slide was observed for agglutination. Those showing agglutination were recorded. A polyvalent antiserum was not included in the kit, however, isolates earlier confirmed by biochemical tests which did not show any agglutination may contain other single factors not present in the kit used.

3.6 **Parasitological studies**

3.6.1. **Direct microscopy**

A drop of physiological saline was used to emulsify the formed stool. Where the stool was fluid, a little quantity of physiological saline was added. The slide in each case was blotted and by rubbing the faeces with an applicator stick, emulsification of the faeces was achieved. The slide was covered with a cover slip and examined under the x 10 magnification objective. Trophozoites and cysts of protozoa and ova of intestinal helminths were recorded. This method was used for heavy infections with parasites.

3.6.2 **Iodine preparation of stool for microscopy**

A 2 percent (2%) solution of iodine with four percent (4%) of potassium iodide per 100mls of distilled water was prepared. A drop of this iodine solution was used to emulsify about 1- 2 grams of the stool sample. This was covered with a coverslip and examined under the x40 magnification objective. This method stains intracellular granules and nuclei and

facilitates identification of cysts of protozoa. It can be used in both light and heavy infections.

3.6.3 **Formol - Ether concentration method**

This is a concentration technique for detecting light infections. One to two grams of faeces was emulsified in 10ml of 10% formol saline. This was strained through a wire sieve into a centrifuge tube. Three (3mls) of ether was added, shaken and centrifuged at increasing speed to a maximum of 2,000rpm for 2 minutes. The fatty debris was removed and the supernatant poured off leaving only a drop. The inside of the tube was cleaned with a swab and the small deposit at the bottom of the tube was shaken and transferred to a slide, covered with a coverslip and examined under the x 40 magnification objective.

3.6.4 **Identification of Parasites**

Ova of helminths and cysts of protozoans were identified using the criteria of Cross and Yomaguchi (1992)

3.7. **Incidence of Diarrhoea and Malnutrition**

Data relating to the incidence of Diarrhoea and Malnutrition according to the age groups viz: < 1 year, 1-4 years, > 4 - 15 years and > 15 years were collected from primary health care (PHC) centres in the study location. These data were collected monthly over a period of 12 months for the

purpose of comparative studies with the prevalence of Salmonella and other intestinal parasitic helminths and protozoa isolated.

3.8. **Statistical analysis of data**

All data collected during the 12- month period were analysed statistically by the method of the contingency table for independence using the chi-square (X2)distribution. Results obtained were used to explain significant differences between the variables tested. These included the relationship between age, sex and distribution of the intestinal parasites as well as the dependence of the prevalence of the parasites, Salmonella spp, diarrhoea and malnutrition cases on location and season.

CHAPTER FOUR

RESULTS

A total of 1,080 stool samples from primary school pupils obtained over a 12 month period were examined for the presence of Salmonella infection. Table I shows the distribution of the infection among primary school children in the study area in both the dry and rainy seasons. there were only one positive case in the dry season(Rigachukun). In the rainy season. Salmonella spp were isolated from all five villages out of a total of 540 samples. 43 (7.96%) were positive. Katabu had the highest number of positive isolates: viz.10 (9.2%) while Rigachukun and Basawa had 9 (8. 3 %) each. A total of 8 (7.4%) Salmonella isolates were recovered in Mando and Angwan - Dankale.

The difference between the wet and dry season signifies that Salmonella infection was dependent on season at p = 0.05 ; being more common in the wet than in the dry season. The occurrence of Salmonella spp in water and stool samples by season is shown in Table 2. A total of 71 (61.7%) isolates were found in water while 44 (38.3%) were recovered from stool samples. On the other hand. 29 (19%) out of the 152 dry season water samples contained Salmonella serotypes as against 42 (27.6%) in the rainy season (Appendix 3). When the isolates were subjected to biochemical tests, typical S. typhi reactions were observed (Appendix 5).

Table 1 Prevalence of salmonella infection in primary school pupils in the dry and wet seasons

	Location	Dry season No. of puipils examined (n)	No. positive	% positve	Wet season (n)	No positive	% positive
1.	Katabu	108	-	-	108	10	9.2
2.	Rigachukun	108	1	0.92	108	9	8.3
3.	Mando	108	-	-	108	8	7.4
4.	Angwan Dankale	108	-	-	108	8	7.4
5.	Basawa	108	-	-	108	9	8.3
	Total	540	1		540	43	

$x^2 = 0.4510$; $P = 0.05$

Table 2 Occurence of salmonella spp in water and stool samples by season

	Location	Dry season No. examined (n)		No. positive		Wet Season No. examined (n)		No. positive	
		Water	Stool	Water	Stool	Water	Stool	Water	Stool
1.	Katabu	30	108	5	-	33	108	10	10
2.	Rigachukun	31	108	8	1	32	108	9	9
3.	Mando	31	108	6	-	32	108	9	8
4.	Angwan Dankale	30	108	4	-	32	108	10	8
5.	Basawa	30	108	6	-	30	108	5	5
	Total	152	540	29	1	159	540	42	43
		$x^2 = 0.6883$;		$P = 0.05$					

In all, 34 out of the 115 isolates obtained were biochemically identified as S.typhi. The other 81 isolates were merely identified as Salmonella spp. Most of them did not produce hydrogen sulphide on TSIA. More Salmonella were isolated from water than in stool samples.

The 115 isolates were serologically typed with an array of 16 '0' monovalent antisera and one each of V_i and H_a antisera (see Table 3). Out of the 115 isolates characterised biochemically, 40 (34.7.%) showed agglutination with the single factor antisera while 60 did not react with any of the 18 monovalent antisera. They may however contain other antigens that did not have corresponding antisera in the kit used. 15 isolates were also lost in storage while awaiting the arrival of the kit from West Germany between October, 1994 and June, 1995. Of the 40 Salmonella isolates showing positive agglutination, 14 (9.35%) were identified as S. typhi (v_i , 9, 12). 8 (20%) were classified on serogroup B and identified as Salmonella enteritidis: 5 (12.5,%) in serogroup c_1, 3 (10%) in serogroup C_2. Others included 5 isolates in serogroup D in addition to the 14 S. typhi isolates, also classified in this group. There were 5(12.5%) in serogroup E. This shows S. typhi as the predominant serotype isolated. It was also observed that 26 out of the 40 Salmonella isolates serotyped were from water while 14 were from stool samples Out of the 14 S. typhi isolates serotyped, 9 were recovered

TABLE 3: SEROTYPING OF SALMONELLA ISOLATES

MONOV ALENT ANTISERASET A - 1

S/NO.	Source and No.	V_i	O_2	O_4	O_5	06,6257	07 08 09 010	012 014 015 019	020 027 034	046 H g	Antigenic formula	Sero group	Inference
1.	AD3	+				-	- - + -	+ - - -	- - - -	- -	([V , 9, 12)	D_1	S. typhi
2.	M2		-	+	+	-	- - - -	+ - - -	- - - -	- -	(04, 05, 12:-)	B	S. Mando
3.	R4	+	-	-	-	-	- - + -	+ - - -	- - - -	- -	([V;. 9,12)	D_1	S. typhi
4.	AD_{12}		-	-	-	+	+ - - -	- - - -	- - - -	- -	(06, 07 : -)	C_1	S. angwan-dankale
5.	AD_{51}	+	-	-	-	-	- - + -	+ - - -	- - - -	- -	(Vi, 9, 12)	D_1	S. typhi
6.	K_{54}	+	-	-	-	-	- - + -	+ - - -	- - - -	- -	(Vi, 9, 12)	D_1	S. typhi
7.	AD_{56}	+	-	-	-	-	- - + -	+ - - -	- - - -	- -	(Vi, 9, 12)	D_1	S. typhi
8.	M_{70}	-	-	-	-	+	+ - - -	- - - -	- - - -	- -	(06, 07 :-)	C_1	S. mando
9.	M_{71}	-	-	-	-	+	+ - - -	- - - -	- - - -	- -	(06, 7 :-)	C_1	S. mando
10.	K_{57}	-	-	+	+	-	- - - -	+ - - -	- - - -	- -	(04, 05,012 :-)	B	S. katabu
11.	K_{58}	+	-	-	-	-	- - + -	+ - - -	- - - -	- -	(vi, 9, 12)	D_1	S. typhi
12.	B_{20}	-	-	-	-	-	- - - +	- - + +	- - + -	- -	(10, 51, 19, 34)	E	S. basawa
13.	B_{40}	+	-	-	-	-	- - + -	+ - - -	- - - -	- -	(vi, 9, 12)	D_1	S. typhi
14.	M_{62}	-	-	-	-	-	- - - +	- - + +	- - + -	- -	(10, 15, 19, 34)	E	S. mando
15.	M_{64}	-	-	-	-	-	- - - +	- - + +	- - + -	- -	(10, 15, 19, 34)	E	S. mando
16.	Ab_{35}	-	-	+	+	-	- - - -	+ - - -	- - - -	- -	(04, 05, 012 :)	B	S. angwa-dankele
17.	B_{42}	+	-	-	-	-	- - + -	+ - - -	- - - -	- -	(Vi, 9, 12)	D_1	S. typhi
18.	B_{43}	-	-	-	-	-	- - + -	- - - -	- - - -	+ -	(9, 46)	D_2	S. basawa
19.	M_{67}	-	-	-	-	-	- - + -	- - - -	- - - -	+ -	(9, 46)	D_2	S. mando
20.	M_{68}	-	-	-	-	-	- - + -	- - - -	- - - -	+ -	(9, 46)	D_2	S. mando
21.	R_{44}	-	-	-	-	-	- - - -	- - - -	+ - - -	- -	(20)	C_2 ?	S. rigachukun
22.	K_{60}	-	-	-	-	-	- - + -	- - - -	- - - -	+ -	(9, 46)	D_2	S. katabu
23.	K_{61}	-	-	+	+	-	- - - -	+ - - -	- - - -	- -	(04, 05, 12 :-)	B	S. katabu
24.	M_{32}	-	-	-	-	-	- - - -	- - - -	+ - - -	- -	(20)	C_2?	S. mando
25.	M_{33}	+	-	-	-	-	- - + -	+ - - -	- - - -	- -	((Vi, 9, 12)	D_1	S. typhi
26.	K_{51}	-	-	+	+	-	- - + -	+ - - -	- - - -	- -	(04, 05, 12 :-)	B	S. katabu
27	B_{10}	-	-	-	-	+	+ - - -	- - - -	- - - -	- -	(06, 07 :-)	C_1	S. basawa
28.	B_{15}	+	-	-	-	-	- - + -	+ - - -	- - - -	- -	(Vi, 9, 12)	D_1	S. typhi
29.	M_{18}	-	-	-	-	+	+ - - -	- - - -	- - - -	- -	(06, 07 :-)	C_1	S. mando
30.	R_{19}	+	-	-	-	-	- - + -	+ - - -	- - - -	- -	(Vi, 9, 12)	D_1	S. typhi
31.	B_{24}	+	-	-	-	-	- - + -	+ - - -	- - - -	- -	(Vi, 9, 12)	D_1	S. typhi
32	R_{34}	-	-	-	-	-	- - - +	- - + +	- - + -	- -	(10, 15, 19, 34)	E	S. rigachukun
33.	M_{50}	+	-	-	-	-	- - + -	+ - - -	- - - -	- -	(Vi, 9, 12)	D_1	S. typhi
34.	B_{23}	-	+	+	+	-	- - - -	+ - - -	- - - -	- -	(04, 05, 12 :-)	B	S. basawa
35.	AD_{30}	-	-	+	+	-	- - - -	+ - - -	- - - -	- -	(04, 05, 12 :)	B	S. angwa-dankale
36.	AD_{31}	-	-	-	-	-	- - + -	- - - -	- - - -	+	(9, 46)	D_2	S. angwa-dankale
37.	B_{41}	+	-	-	-	-	- - + -	- - - -	- - - -	- -	(Vi, 9, 12)	D_1	S. typhi
38.	B_{22}	-	-	-	-	-	- - - +	- - + +	- - + -	- -	(10, 15, 19, 34)	E	S. basawa
39.	AD_{36}	-	-	+	+	-	- - - -	+ - - -	- - - -	- -	(04, 05, 012 :)	B	S. angwa-dankale
40	R_{45}	-	-	-	-	-	- - - -	- - - -	- - - -	- -	(20)	C2 ?	S. rigachikun
41 100	Others	-	-	-	-	-	- - - -	- - - -	- - - -	- -	Other factors present	F –Z	Salmonella spp

Foot note: (A) No. 1 - 26 were isolated from water
No. 27 - 40 were isolated from stool
No. 41 - 100 were isolated from both water & stool

(B) Isolate codes were, B - Basawa
M - Mando
R - Rigachukun
AD - Angwan dankale
K - Katabu

from water while 5 were obtained from stool samples. Four isolates each in serogroup B were obtained from water and stool.

Three out of five isolates in serogroup C_1 were recovered from water while two isolates in serogroup C_2 were recovered from water. Three isolates in serogroup D_2 and two in serogroup E were isolated from water.(see table 3). These show that the serotypes of Salmonella were more abundant in water but may find their way to human hosts when such contaminated water is consumed. Cross-agglutination reactions may occur where serotypes share similar 'O' factors.

Faecal coliforms

Faecal coliforms were recovered from the surface waters examined in the locations studied. Most surface water sources however dried up during the dry season hence no water samples from these sources were collected during that period (Table 4). The dams in Mando (M_1) and Rigachukun (D_1) were available all year round for analysis. Results showed that both dams had FC counts of between 1.0 - 2.0 x 10^2 faecal coliforms 100ml- The density of the faecal coliforms rose at the beginning of the rainy season (May) reaching a peak in August and declining gradually to lower densities in October. None of the surface waters met the WHO drinking water standard (see Table 4). Figure 2 shows the results obtained when coliforms were isolated from 25 rural

Table 4: Faecal coliform count per 100ml of surface waters in five villages around Kaduna and Zaria

	Location	Type and No. of surface water	Dry season x 10^1						Wet season x 10^2					
			Nov.	Dec	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.
1.	Katabu	Pond 1	*	*	*	*	*	*	5.2	5.5	6.8	8.0	7.2	4.0
	Pond 2	Pond 2	*	*	*	*	*	*	4.0	4.6	5.4	7.0	6.5	3.2
		Pond 3	*	*	*	*	*	*	4.3	4.8	5.2	76.7	5.0	4.0
2.	Rigachukun	Dam (1)	1.0	1.3	1.1	1.5	1.8	2.0	6.0	5.1	6.2	7.5	5.7	2.0
		Pond (1)	*	*	*	*	*	*	4.6	5.3	6.0	6.8	4.3	1.5
3.	Mando	Pond (1)	*	*	*	*	*	*	3.2	4.0	4.6	5.5	4.8	2.3
		Dam (1)	1.1	1.5	1.3	1.7	2.0	1.8	3.6	4.3	4.8	5.2	4.2	2.0
4.	Angwan dankale	Pond (1)	*	*	*	*	*	*	4.5	4.7	6.3	7.2	3.5	1.5
		Pond (1)	*	*	*	*	*	*	5.0	5.3	5.7	7.8	4.2	2.4
5.	Basawa	-	*[1]	*[1]	*[1]	*[1]	*[1]	*[1]	*[1]	*[1]	*[1]	*[1]	*[1]	*[1]

Foot Note:

1) * No surface water available for Analysis in the dry season
2) * No surface water available in both seasons.

Table 5: Incidences of Diarrhoea and Malnutrition cases in the Primary Health Care (PHC) Centres of the study location.

VILLAGE	NOV.		DEC.		JAN.		FEB.		MAR.		APR.		MAY		JUN.		JUL.		AUG.		SEP.		OCT.	
1) Katabu	D	M	D	M	D	M	D	M	D	M	D	M	D	M	D	M	D	M	D	M	D	M	D	M
i)	13	10	8	4	7	2	10	5	6	2	4	1	5	2	10	5	8	3	7	3	5	2	6	2
ii)	6	3	3	-	3	1	8	4	5	2	2	-	2	1	3	1	5	2	5	1	3	1	4	1
iii)	3	-	2	-	2	-	3	-	3	-	1	-	1	-	-	-	2	-	-	-	-	-	-	-
iv)	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Monthly	22	13	13	4	12	3	23	9	14	4	7	1	8	3	13	6	15	5	12	4	8	3	10	3
2) Rigachukun																								
i)	50	5	48	10	44	8	29	5	25	4	30	6	48	7	60	5	72	8	40	6	25	4	18	6
ii)	20	-	28	-	22	2	5	-	-	-	10	2	25	5	55	5	60	2	20	-	14	2	12	2
iii)	10	-	18	-	12	-	10	-	-	-	5	-	15	-	40	-	30	1	18	-	10	-	8	2
iv)	21	-	5	-	10	-	-	-	-	-	-	-	10	-	12	-	14	-	13	-	-	-	-	-
Total Monthly	101	5	99	10	88	10	44	5	25	4	45	8	98	12	167	10	176	11	93	6	49	6	38	10
3) Mando																								
i)	14	2	12	1	10	2	8	3	6	2	4	1	8	2	10	2	14	2	16	2	10	1	8	2
ii)	10	-	8	-	7	1	5	2	4	1	4	-	6	3	7	3	9	1	10	1	8	1	6	1
iii)	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
iv)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Monthly	15	2	20	1	17	3	13	5	10	3	8	1	14	5	17	5	23	3	26	3	18	2	14	3
4) Angwan dankale																								
i)	10	5	7	3	6	2	8	4	6	3	15	2	14	5	10	2	12	2	16	5	14	4	8	2
ii)	5	3	4	-	3	-	5	2	3	1	10	3	12	3	5	2	6	1	8	3	7	3	5	3
iii)	2	-	1	-	4	-	3	-	5	-	8	-	8	-	6	-	6	-	6	-	-	-	-	-
iv)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Monthly	19	8	12	3	13	2	16	6	14	4	33	5	34	8	21	4	24	3	36	8	21	7	13	5
5) Basawa																								
i)	15	3	12	2	16	5	12	4	14	2	20	5	14	3	22	5	14	1	12	1	13	5	15	2
ii)	7	2	8	1	10	3	7	1	10	2	16	4	11	1	16	2	10	1	10	2	11	1	10	2
iii)	3	1	-	-	2	1	6	-	8	-	6	1	5	-	7	-	9	-	9	-	8	-	6	1
iv)	-	-	-	-	-	-	-	-	-	-	-	-	4	-	6	-	3	-	5	-	6	-	8	-
Total Monthly	25	6	20	3	28	9	25	5	32	4	42	10	34	4	51	7	36	2	36	3	38	6	39	5

<——— x2 = 9.49 ———> <——— x2 = 6.86 ———>

Foot Note: 1. i) < 1 year
ii) 1 - 4 years
iii) 4 - 15 years
iv) > 15 years
2. D - Diarrhoea Cases
M - Malnutrition cases

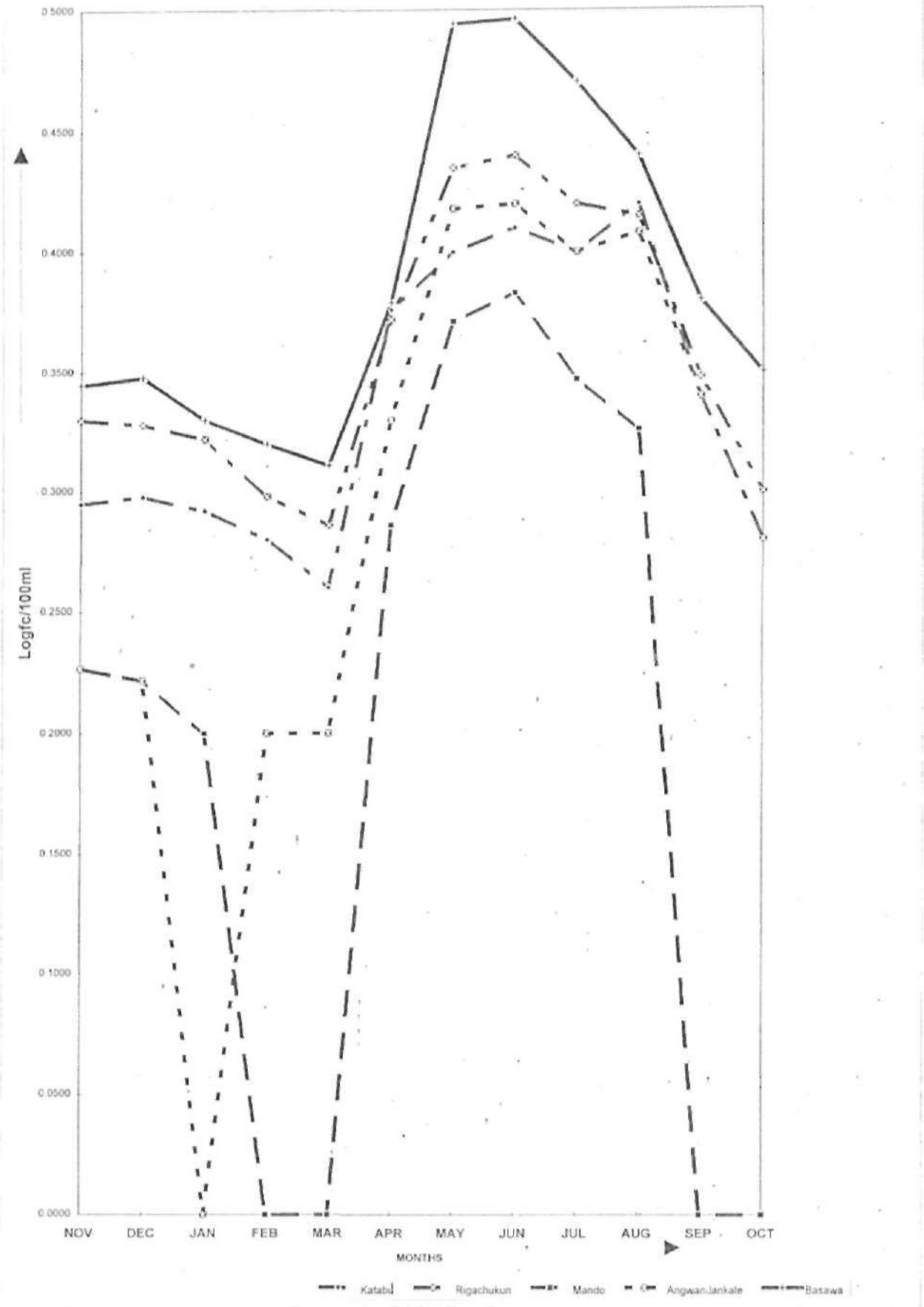


Fig. 2 Mean Level of Faecal Coliforms/100ml in Community Well waters from five Villages in Kaduna and Zaria Cities in Nigeria

wells in Kaduna State. Peak levels of faecal coliform were observed in the month of May. The number gradually fell from then. Results showed that wells in Basawa had higher faecal coliform densities while those in Mando had the least. The detailed results of faecal coliforms can be found in Appendix 2. Two wells (one each in Katabu and Mando) had FC densities of between 0 and 10/100mls. These wells had casings and covers. Nevertheless, the water in them did not meet the WHO drinking water quality standard. Generally, the ranges of faecal coliform counts in the wells were as follows: Katabu (O - 2.3 x 10^2); Rigachukun (1.0 - 1.8 x 10^1); Mando,(O 7.5 x 10^1); Angwan-dankale (2.0 x 10^1 1.62 x 10^2) and Basawa (2.0 - 3.4 x 10^2)

Intestinal Parasitic helminths and protozoa

Parasitological examination of the stool samples led to the detection of a variety of intestinal helminths and protozoa (see Appendix 6). Out of a total of 1,080 stool samples examined, over a 12 month period, 621 or 57.5% were positive for ova or cysts of parasites. A breakdown of this figure showed that 226 (20.92%) had eggs of Ascaris lumbricoides, 143 (13.24%) had hook worm eggs, 92 (8.51%) had E. histolytica and 43 (3.984:) had G. lamblia. In addition to these, 31 (2.8%) had S. mansoni; 14 (1.29%) had S. bovis and 16(1.48%) had Entamoeba coli. The prevalence exhibited by some of the parasites were very low. Also detected were Taenia, Trichuris, Enterobius and Balantidium coli

which had only one case (0.92%) each. Polyparasitism was observed in some cases. The combination of A. lumbricoides and hookworm was the commonest in all the locations (see Appendix 7). Results showed that intestinal helminths were more abundant with A. lumbricoides as the commonest. The incidence of an infection refers to the appearance of organisms in a community while the prevalence of the infection refers to the percentage of reported parasites at a given period of time in a community. Figure 3 illustrates the monthly prevalence of A. lumbricoides and hookworm in primary school pupils in three villages around Kaduna. In Katabu, the initial prevalence of A.lumbricoides was 22.25% in November, but it dropped to 16.5% in December and later rose to a peak in the months of April and May. (33.3%) Hookworm infestation was less pronounced than that of A. lumbricoides. Results showed that the prevalence in Mando rose steadily from - 0% in November to 27.7% in February. In Rigachukun, however, infestation with hookworm was more common in April. Fig. 4 is a graphical illustration of the monthly prevalence of A. lumbricoides and Hook-worm in two villages around Zaria. A. lumbricoides was more common than hookworm in both villages as was earlier observed with the three villages around Kaduna. Infestation by A. lumbricoides was more common in April in both villages while that of hookworm was in February (Basawa) and April (Angwan - Dankale).

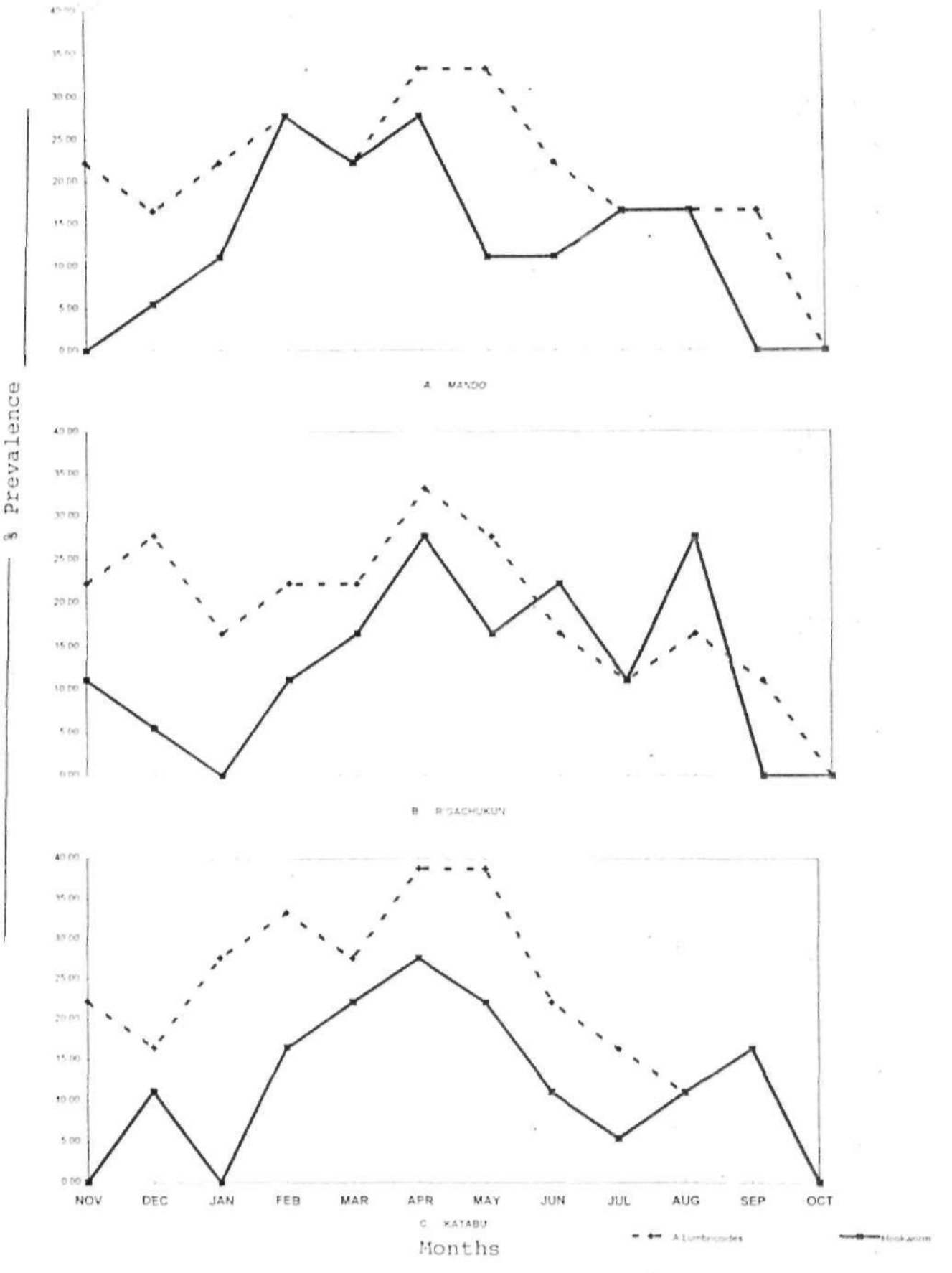


Fig. 3 Monthly Prevalence of Ascaris lumbricoides and Hookworm in Primary School Pupils in Three Villages Around Kaduna City in Nigeria

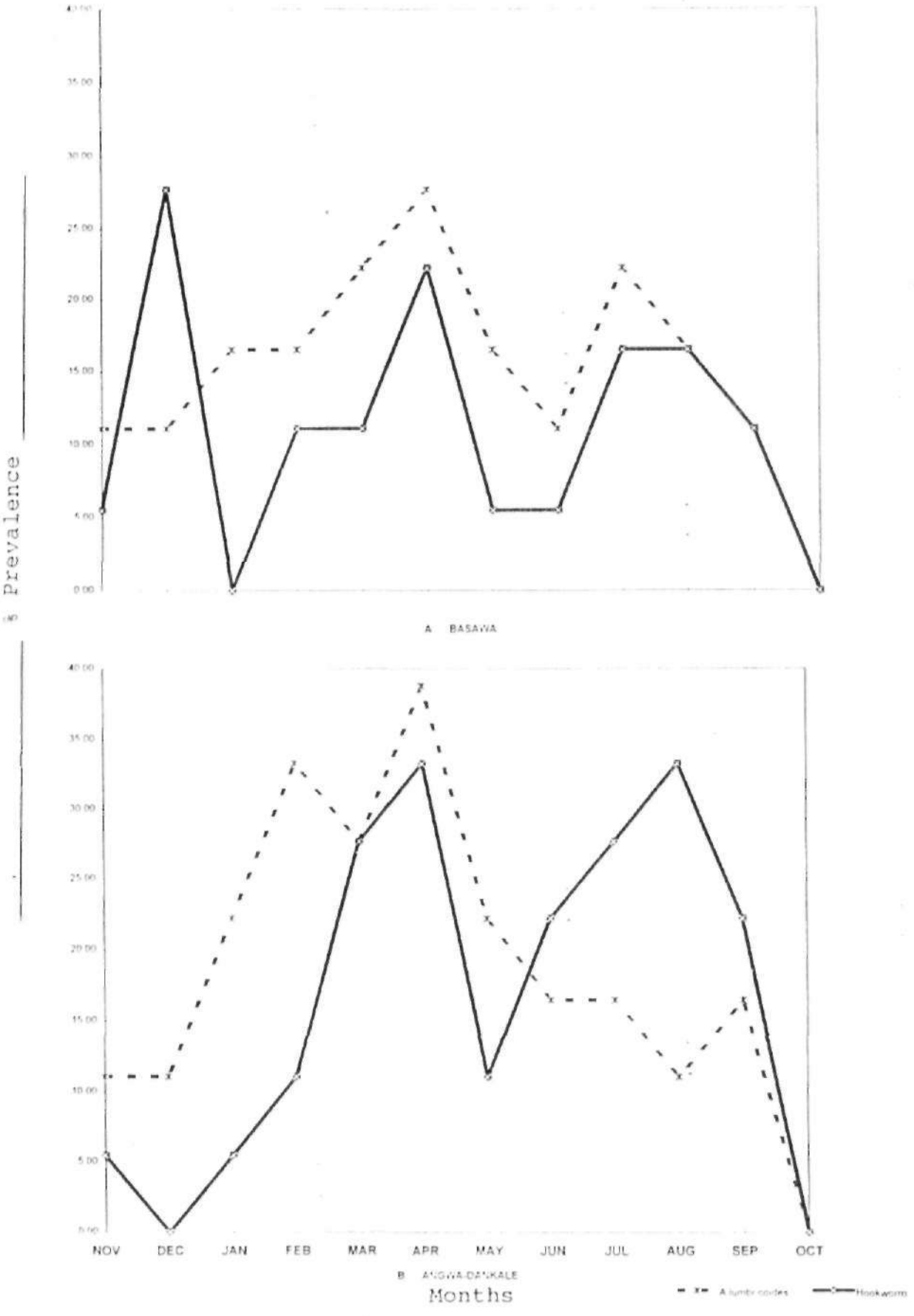


Fig. 4 Monthly Prevalence of Ascaris lumbricoides and Hookworm in Primary School Pupils in Two Villages Around Zaria Citiy in Nigeria

The relationship between sex and the prevalence of A. lumbricoides was also studied. In Fig. 5 it is revealed that males were more prone to infection than the females. The relationship between age and prevalence of A. lumbricoides is shown graphically in Fig. 6 . The 5 - 9 year age group were more prone to infestation than the 10 - 15 years age group. The results depicted in Fig. 7 show that males were more prone to hookworm infestation than females. The relationship between age and the prevalence of hookworm in pupils in the study areas showed that the 10 -15 year age group were more prone to infestation than the 5 - 9 years (fig 8). Investigation of the types of parasitic intestinal protozoa was studied. In fig 9, the relationship between the prevalence of E. histolytica and sex of the pupils is shown. Females appeared to be more prone to infection than males. A study of the relationship between age and the prevalence of E. Histolytica revealed that the 5 - 9 year age group were more prone to infection that the 10 - 15 year age group see fig. 10. Comparison of the prevalence of E. Histolytica and G. lamblia is shown in figure 11. The former was more prevalent than the latter. The infections were more common in the dry season than the rainy season.

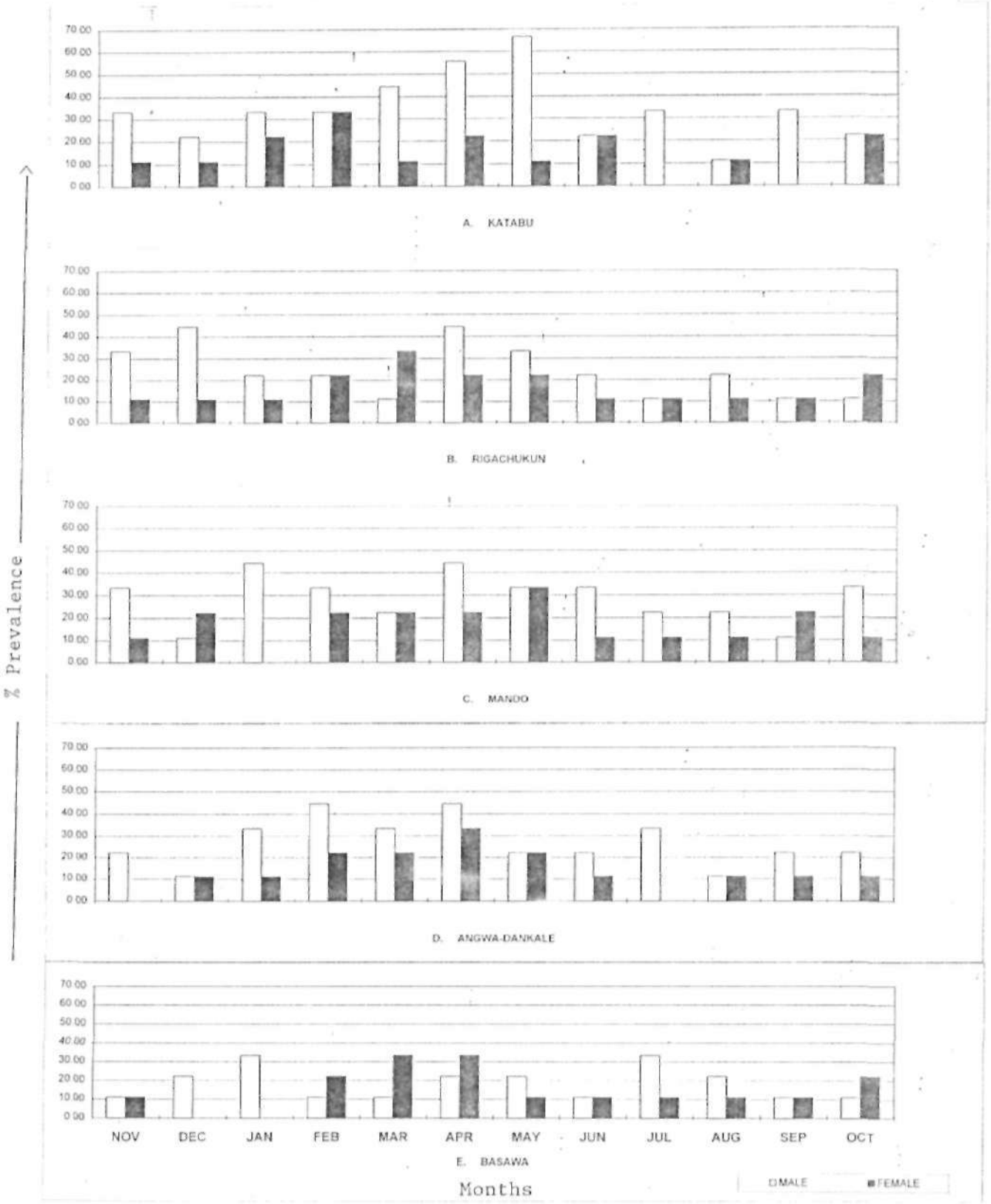


Fig. 5 Monthly Prevalence of Ascaris lumbricoides in Male and Female Pupils in Five Villages Around Kaduna and Zaria Cities in Nigeria

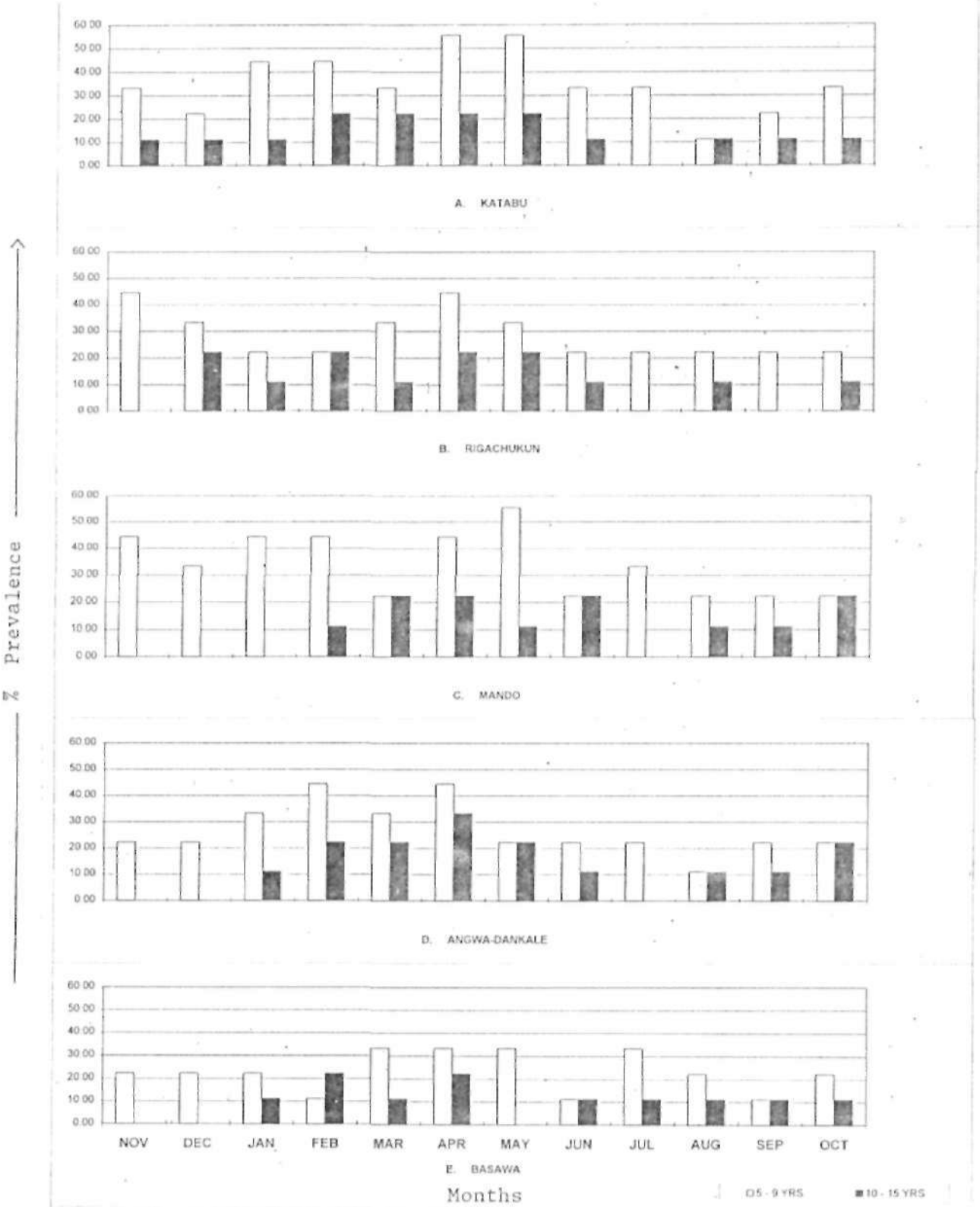


Fig. 6 Monthly Prevalence of Ascaris lumbricoides in Primary School Pupils Aged 5 -- 9 and 10 -- 15 Years in Five Villages Around Kaduna and Zaria Cities in Nigeria

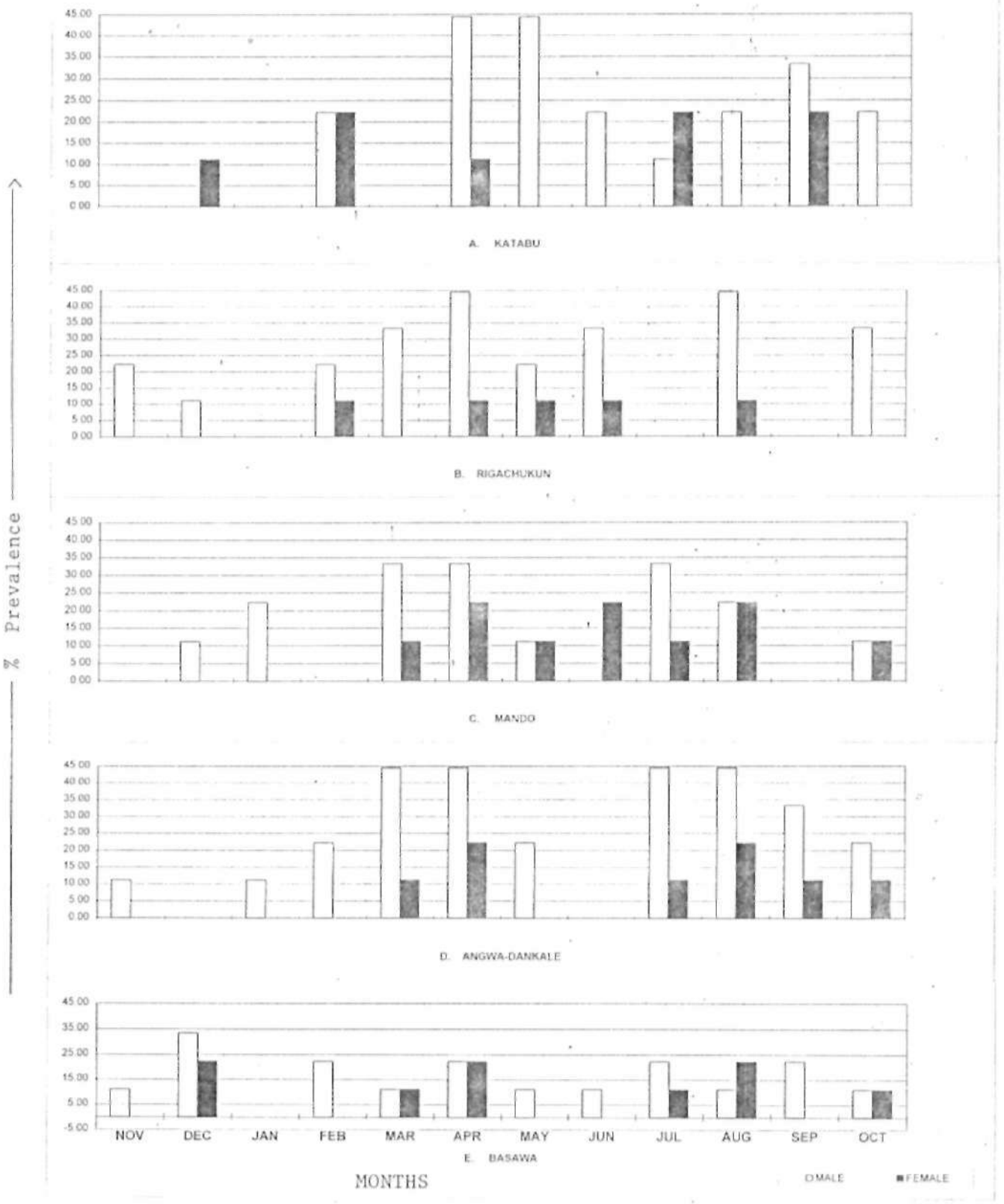


Fig. 7 Monthly Prevalence of Hookworm in Male and Female Pupils in Five Villages Around Kaduna and Zaria Cities in Nigeria

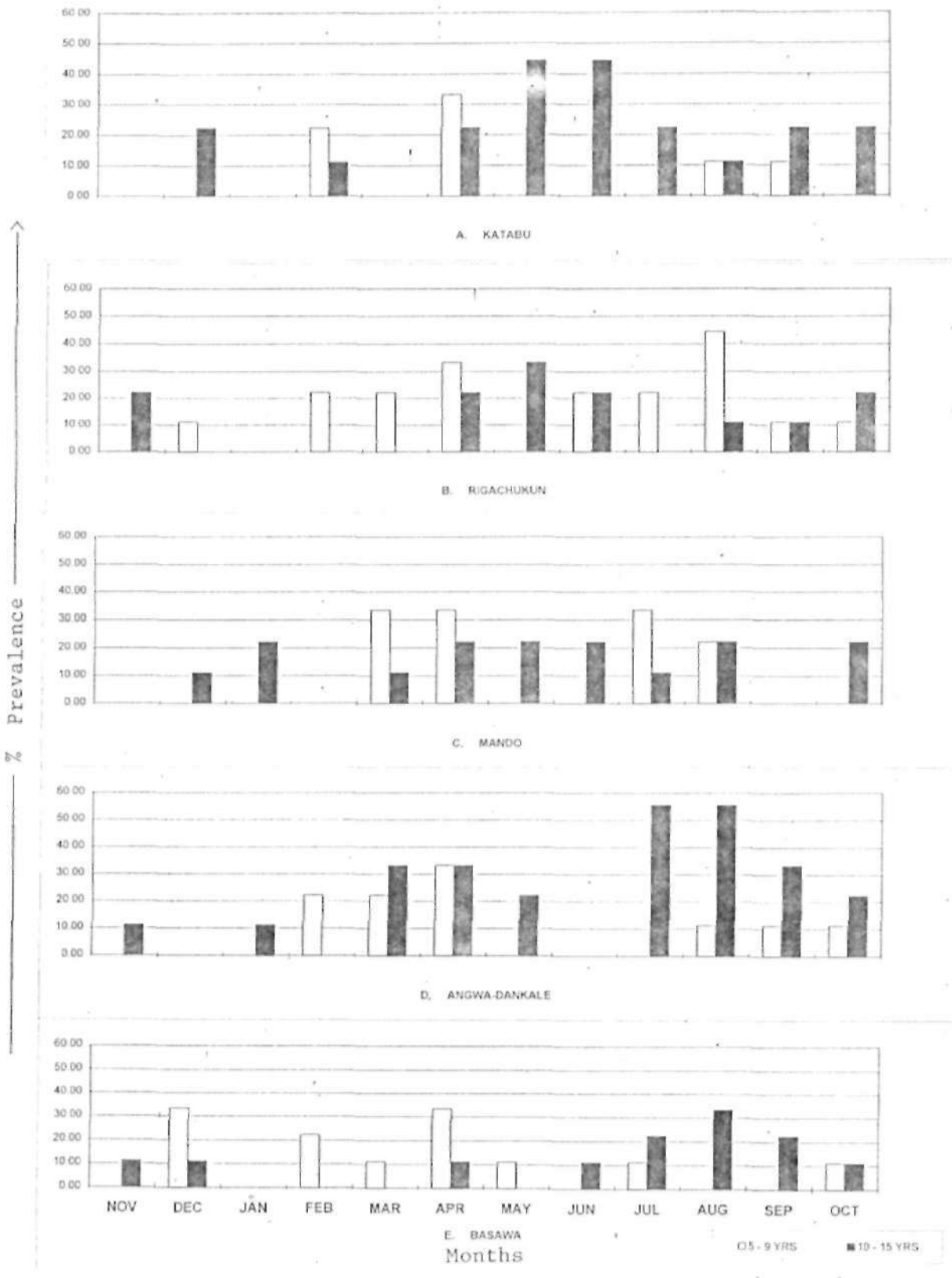


Fig. 8 Monthly Prevalence of Hookworm in Male and Female Pupils Aged 5 - 9 and 10 - 15 Years in Five Villages Around Kaduna and Zaria Cities in Nigeria

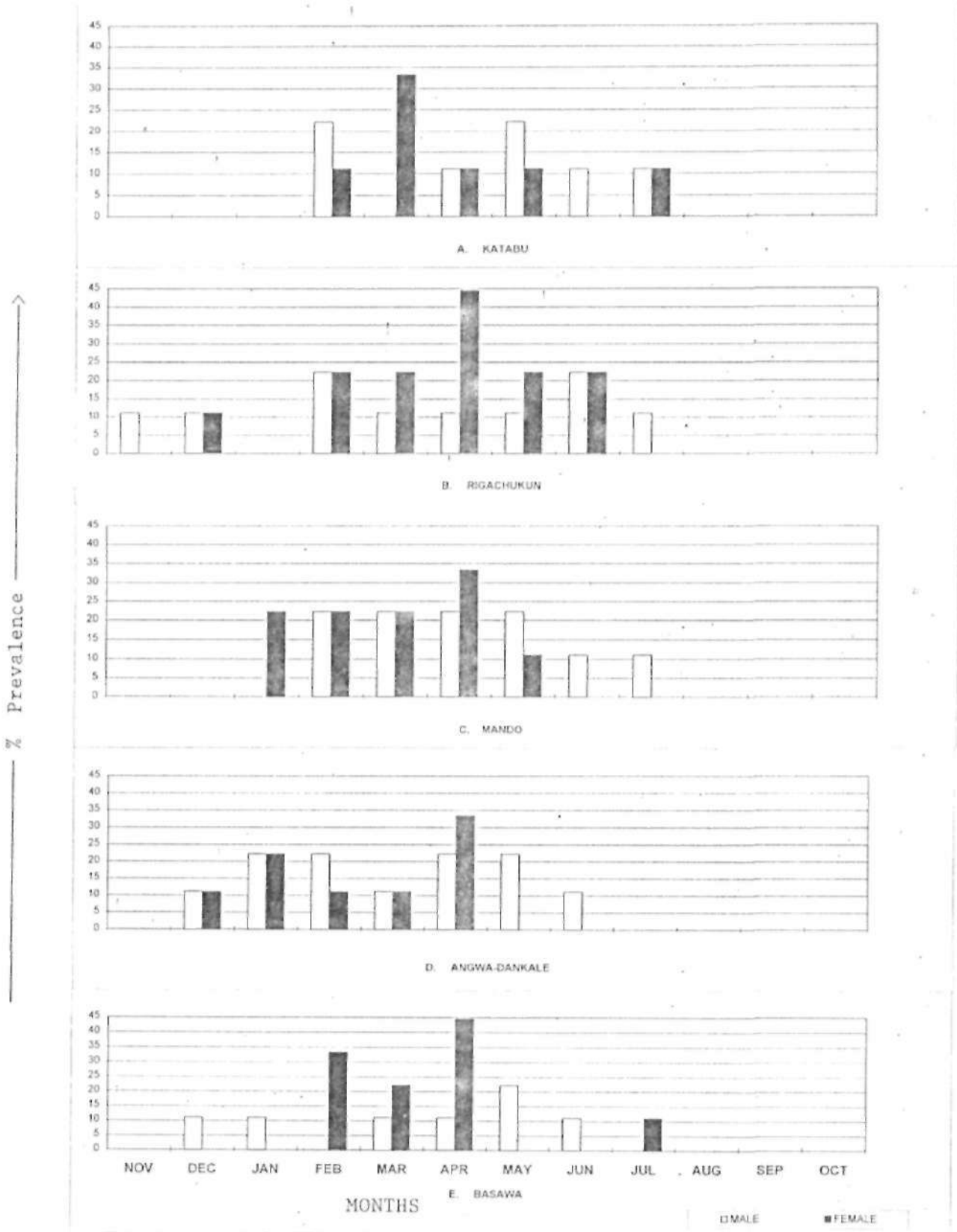


FIG. 9 MONTHLY PREVALENCE OF E. histolytica IN MALE AND FEMALE PUPILS IN FIVE VILLAGE AROUND KADUNA AND ZARIA CITIES IN NIGERIA.

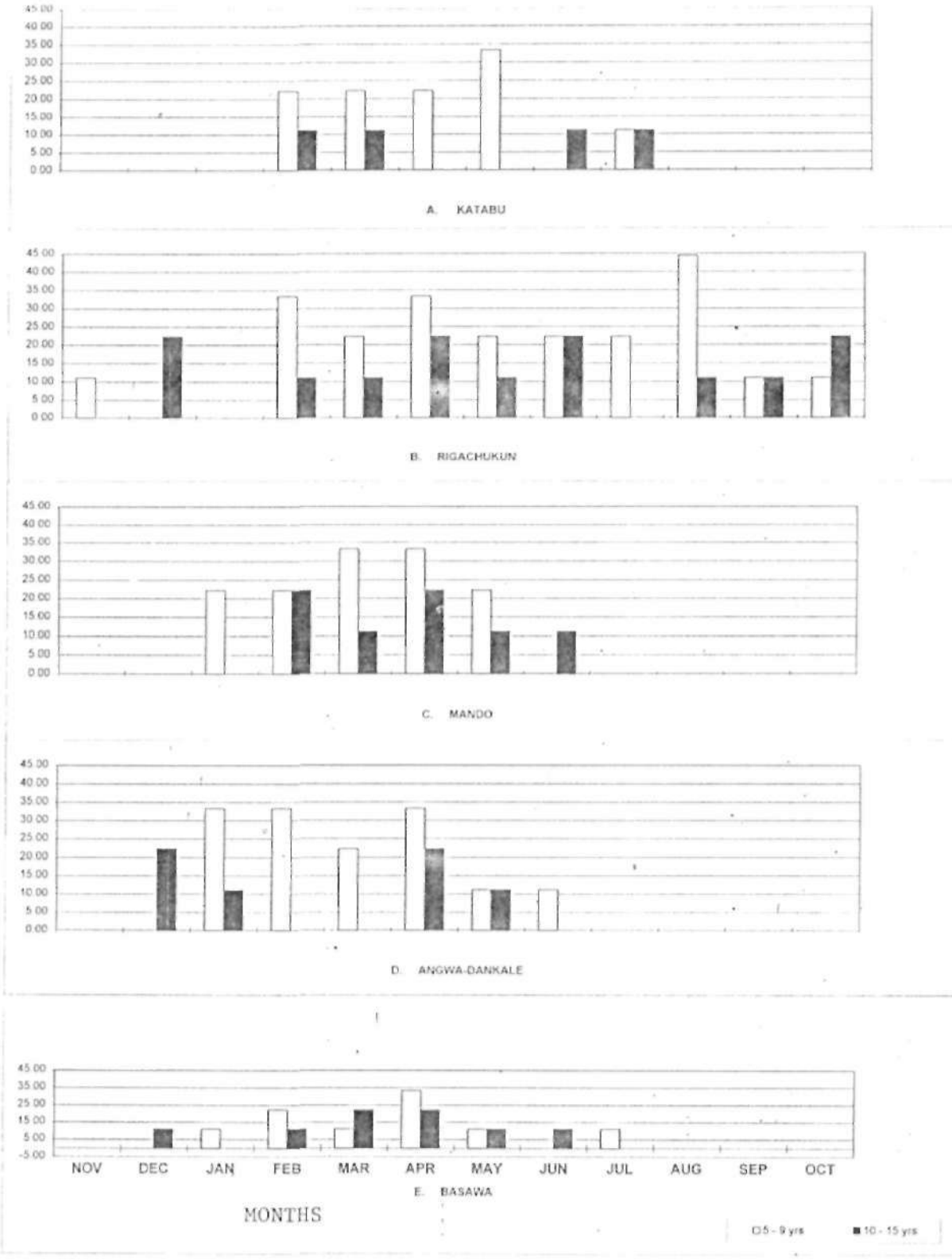


Fig. 10 Monthly Prevalence of E. histolytica in Primary School Pupils Aged 5 -- 9 and 10 -- 15 years in Five Villages Around Kaduna and Zaria Cities in Nigeria

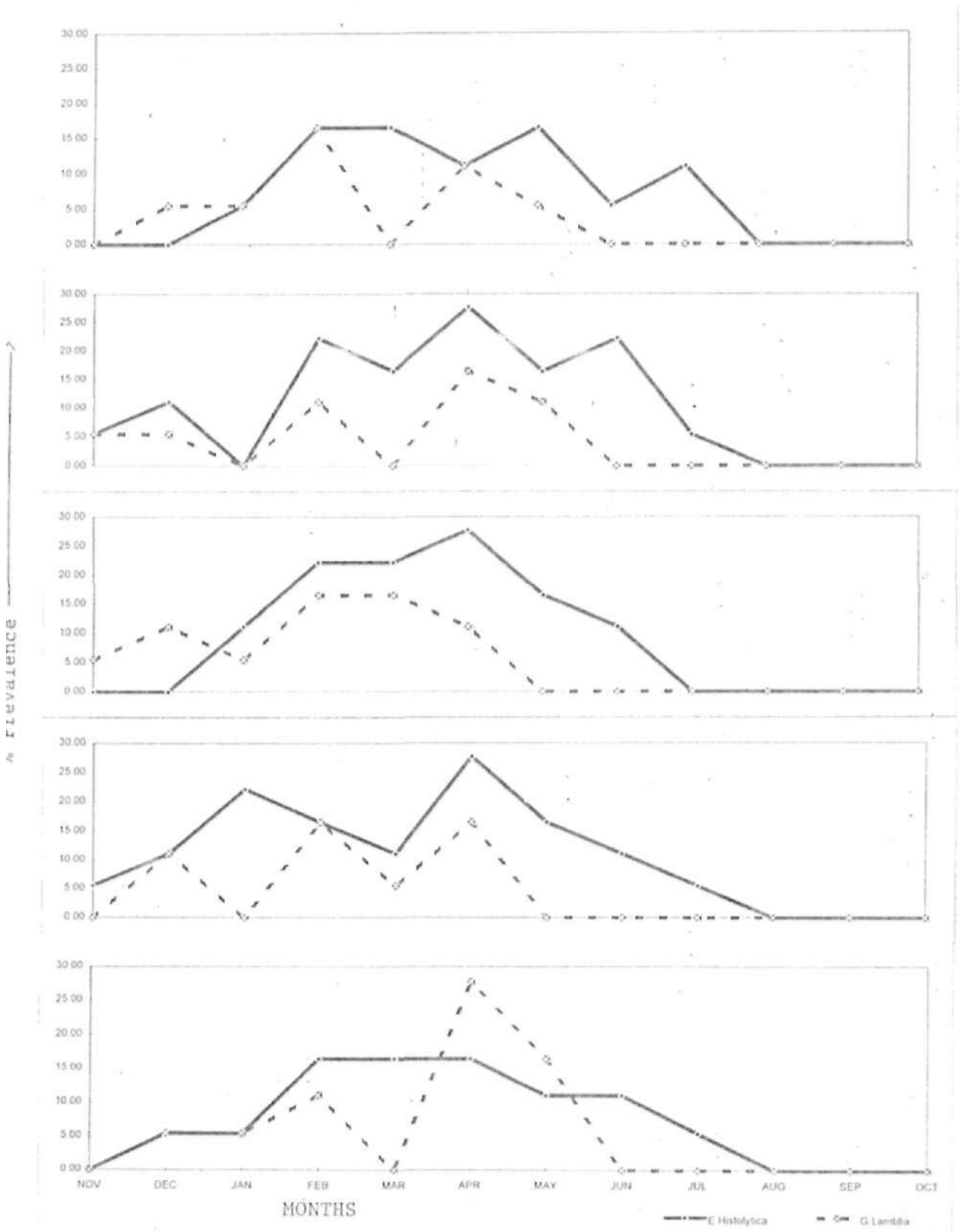


Fig . 11. A Comparison of Monthly Occurence of E. histolytica and G.lamblia in Five villages Around Kaduna and Zaria Cities in Nigeria

Incidences of Diarrhoea and Malnutrition cases.

The incidences of Diarrhoea and Malnutrition cases in the villages studied are shown in Table 5. Data on patients visiting the primary health care centres were recorded according to age group. The 0 - 4 year group were more prone to diarrhoea and malnutrition. A total of 157 diarrhoea cases and 58 malnutrition cases were recorded in Katabu. Out of the 157 diarrhoea cases, 91(57.9%) were recorded in the dry season while 66(42.1%) were recorded in the wet season. There were however more malnutrition cases in the dry season (34 out of 58) than in the wet season (24 out of 58). Analysis of these data show that more diarrhoea and malnutrition cases were observed in the dry season in Katabu and these were statistically significant at p=0.05. See Table 5. On the other hand in Rigachukun, more people were observed attending the PHC clinics than in other villages. Out of a total of 1,023 diarrhoea cases, 621(60.7%) were recorded in the dry season and 402(39.2%) in the wet season. This shows that more people had diarrhoea in the wet season that in the dry season, with the highest number (176) being recorded in July. Of the malnourished, 42 (43.3%) were reported in the wet season. Fewer cases of diarrhoea were recorded in Mando than the other four villages. Of the 195 diarrhoea cases observed, 83 (42.6.t) were recorded in the dry season while 112 (57.4%) were in the wet season. This shows a higher prevalence of diarrhoea in the wet season. Out of the 36

malnourished cases, 15 (41.6%) were recorded on the dry season while 21(58.4%) were noted in the wet season. Statistical analysis shows that diarrhoea and malnutrition cases were dependent on location and season in Rigachukwu and Mando . A total of 256 diarrhoea cases with 149(58.2%) in the wet season and 107(41.8%) in the dry season were recorded in Angwan - dankale. Of the 63 malnourished reporting to this clinic, 28 (44.4%) were recorded in the dry season and 35 (55.6%) observed in the wet Season. In Basawa, a total of 402 diarrhoea cases with 234 (57.6%) in the wet season and 172 (42.4%) in the dry season were noted. A total of 54 malnourished cases were recorded. Of this, 27 (42.2%) were observed in the wet season and 37.6(57.8%) in the dry season. Analysis of the data present shows that there is a significant difference in the diarrhoea cases than the malnutrition cases at $p = 0.05$.

DISCUSSION.

The sanitary quality of water is based on the quantities of indicator bacteria it contains: The bacteriological quality of drinking water must meet the WHO standard of less than 2.2 faecal coliforms per 100ml for the water to be acceptable for drinking.

The Bacteriological tests performed showed that there are lapses in the bacteriological qualities of the wells and surface water sources studied. Faecal coliforms are usually associated with polluted waters. Results in this study showed that the densities of faecal coliforms observed in all the locations except in a few wells were above the recommended level. This is not suprising since inadequate sanitation measures are not taken in the community. Children and even adults are know to defaecate in the bush and on the open soil surfaces. The faeces are then washed into the nearest body of body of drinking water. This explains rise in diarrhoea cases especially in communities with water scarcity. Some of the community wells are at the same level with the ground, uncemented with cracks and crevices harbouring frogs and other reptiles which are possible sources of Salmonella. These occasionally crawl to the surfaces and get faecally contaminated and the crawl back to the well. This scenario has been observed and reported earlier for wells in Port Harcourt (Ogan, 1988) and in Zaria (Okuofu et al., 1990). Some of the wells in the study were not covered and a general bucket used by all was found by a number of the

wells. In most cases, buckets were observed to be kept carelessly on muddy surfaces round the wells. It could also serve to introduce faecal materials in the environment into the well.

The surface waters (ponds and streams) examined were also contaminated with high levels of faecal coliforms in all the locations. Earlier work by Okoro (1986); Ogan (1988); Peters et al., (1989) and Okuofu et al., (1990) show that faecal coliforms do regularly contaminate water sources. In addition, run - off water carrying debris and faecal matter often drain into such bodies of water. Animals grazing and drinking water from the surface waters do contaminate the water with their faeces. It has been shown by Okuofu (1989) that when taps in Zaria ran dry, the cases of intestinal diseases arising from drinking poor quality well water rose at the A.B.U. Teaching Hospital, Zaria.

In the present study, the number of diarrhoea cases observed in the records at the Primary Health Centres also increased in times of water scarcity. There is an increasing demand for potable water in Nigeria and the inadequacy of the supply especially in semi-arid areas like Zaria and Kaduna makes it imperative that any available source is carefully protected and monitored. Infection with Salmonella spp was found to be higher in the wet season than the dry season. Drinking water sources may be contaminated with the organism from faeces entering the bodies of water. The presence of Salmonella spp may be due to rainbow lizards in

the wells. They are known to excrete Salmonella spp with little or no E. coli (Schubert and Scheiber, 1979). It has been shown by Ogan (1989) that many unprotected wells get contaminated during the rainy season by "washback" and spilled water draining from the platforms. The surface waters may be contaminated through the faeces of livestock wading through the ponds or stream. The results have revealed that the same serotypes of Salmonella spp present in the stool were also found in the water. This directly links some of the stool samples to the water and vice versa. Salmonella typhi was the commonest to all the locations studied being predominant in the water samples. It is known to be host specific for man. It causes malaise, diarrhoea, prolonged fever and extra-intestinal infection can lead to gall bladder invasion from were they are released occasionally to the blood stream. This explains why the organism can remain in the body for a long time leading to a carrier state. Death is usually due to the rupture of the intestines. It is pertinent to note that sewage waters draining into water channels pose a high risk as vehicle of transmission of Salmonella organisms. The other serotype identified was S. enteritidis. This is known to be involved in human gastroenteritis. Of major concern is the fact that members can infect both man and animals depending on the host, they suddenly find themselves. Though the antibiotic resistance pattern was not included in this study, it is imperative that the increasing number of cases of typhoid fever may be

due to decreased resistance of the hosts immune response to the bacterium or acquisition of resistance factors through the use of plasmids. Classification of Salmonella has been quite confusing with the main organisms not following the usual rules of nomenclature. The confusion is not helped by the fact that members are closely related biochemically and morphologically. No general agreement exists are regards taxonomy of Salmonella and most workers prefer to regard serotypes as sub-specific entities. Salmonella spp have several antigens but the ones of importance in classification are the flagella (H) antigen, the somatic (O) antigen and the capsular (V_i) antigen. Cross - agglutination may occur among serotypes within a particular group sharing the same single factors. Cross - agglutination may occur between species in serogroup B (04,05,12:-) and the following serotypes: S. paratyphi B (1,4,5,12.) S. derby (1,4,5,12:f:g) and S. java) (1,4,5,12,b).

The isolate in serogroup C1 (6,7:-) can cross react with the following: S. gombe, S. cholera - suis, S. typhi - suis and S. ohio . Members of the serogroup C2 identified may also have cross-agglutination reactions with S. labadi, S. paris, S. istanbul and S.pakistan. Those sharing similar single factors in serogroup D include S. calabar, S. maiduguri, S. liverpool . Those that did not react with the antisera used may have other antigens which may classify them further into serogroup F - Z.

Salmonella infection has been shown to aggravate the condition of patients with schistosomiasis. Only two cases of the latter with simultaneous presence of the former were encountered in two male children in Mando and Rigachukun. Though they were not physically ill at the time of collection of stool samples, the nutritional state as well as the immunological response may be factors that may precipitate this condition. It has been shown by Higashi et al (1975) that Salmonella infection might enhance the formation and deposition of immune complexes in the kidneys of patients with schistosomiasis. There appears to be some new serotypes which cannot be classified according to the Kauffman - White scheme. These include those with factor 20 only. This agrees with the work of Spiller (1967) that new serotypes are in the environment. Earlier work by Cherry et al (1972) showed the isolation of serotypes in the diverse serogroups some of which share common factors with the serotypes in this study. S. typhi and S. enteritidis have been reported in this study and also agrees with the works of Fair and Morrison (1967). Results in this study show that 80% of the water samples with elevated faecal coliforms show evidence of the presence of Salmonella. The prevalence of Salmonella in water during the wet season may be due to increased pollution of surface and well water. It has been shown by Cherry et al (1972) that Salmonella and other enteric bacteria can multiply in both polluted and unpolluted waters at temperatures as low as

10c. This fact may explain the ease with which a large number of serotypes were recovered from water samples.

This calls for comprehensive epidemiological studies relating disease exposure to polluted water. Simple means for detecting these organisms and their significance as pathogens may make them superior to coliforms as *indexes of water quality from the view point of public health.* Salmonella infection acquired by travellers especially tanker drivers that stopover in Katabu enroute to Jos and the far north as well as those that rest in Mando enroute to Lagos and the sourthen part of Nigeria may help to disseminate this infection on getting to their destinations. Inadequate treatment of typhoid fever in this group where the infection precipitate to an illness may also encourage the carrier state. The organism can then find their way to water if the faeces passed are not disposed off properly. Most of the time enroute to their destinations, many travellers and tanker drivers defecate in the bush. This can be washed off to the nearest body of water where the organism remains until another person drinks the untreated surface water. This vicious cycle encourages the spread of Salmonella serotypes across the country.

Intestinal Parasitic helminths and protozoa

The prevalence of the parasites in the stool sample showed that A. lumbricoides was the commonest while Taenia Spp. Trichuris spp were the least in occurrence. This agrees with the earlier works of Azubike and EneKwechi (1990) and Anderson et al. (1993). The impact of environment on the levels of parasitic infection has been recognised. The present study shows that pupils in the public schools have dirty environment and lack enough chairs to even sit on. Many were also seen defaecting and urinating near the School Compound despite the provision of latrines. This agrees with the earlier work of Stephenson (1985) that higher rates of re-infection with A. lumbricoides were observed in houses with dirty floors. Yohanna et al. (1990) also showed that pupils in public schools were more exposed to intestinal helminth infections than those in private schools. This may be the case here where pupils are continuously in a dirty environment at school.

The prevalence of some of the parasites were shown to increase with the rains (Hookworm and Schistosoma) while it decreased with A. lumbricoides. In contrast, Seo et al. (1977) showed that the prevalence of ascariaisis increased with the rains. Hookworm infestation however is mainly acquired by penetration of the skin by infective larvae. Wearing of shoes is a necessity in a country such as Nigeria since there is an overwhelming evidence that risk of infection by hookworm and

Strongyloides spp is greatest in persons that walk about bare-footed. It has been shown that severe anaemia may occur in a vast majority of those infected. It is also always difficult to know what significance to attach to the finding of hookworm Ova in stools since the people appear to be in good health (Nnochiri, 1965).

Though counts of hookworm Ova were not determined, most stools (96%) were positive by direct microscopy which at least is a measure of heavy infection. The relationship between the worm load and the production of anaemia is known to depend on the patient's dietary iron intake. When patients have a haemoglobin content of 6g or less 100ml and the faeces contained more than 200 X 10^4 hookworm Ova gram, then there is evidence of hookworm anaemia.

(Nnochrir, 1965).

Monoparasitism appears to be more prevalent than polyparasitism. It was observed that Ascaris lumbricoides and Hookworm accounted for the major pairwise combination of polyparasitism. This is in contrast to the work of Anderson et al. (1993) who showed that Ascaris and Trichuris pairwise combination was the major form of polyparasitism. The prevalence of these two helminths in the rural areas include factors such as ignorance about environmental hygiene and health matters on one hand and social practices inspired by tradition. These are overcrowding, poor housing, street - hawking of food under unsanitary conditions. Multiple parasite infection have also been reported by Adesiyun

et al (1987) of which Ascaris and hookworm combination was observed. Other parasite intestinal helminths of sporadic occurrences were Taenia, Strongyloides, Trichuris, Enterobius. The low incidences may be due to minimal exposure to infective material of the helminths.

However, infestations with schistosome was observed to be higher in the wet season than the dry season. This may be due to the fact that there were ponds available for the intermediate hosts to breed. Male children were particularly seen to be swimming in these ponds and streams as the various times of sampling. Statistical analysis of the relationship of sex and the prevalence of schistosomiasis shows that they were independent entities, however, the prevalence rates shows that males were more affected. This may be due to the fact that males in general have greater freedom of movement than females. Earlier work by Abubakar et al (1990) showed that males were also more prone. Infestation was more prevalent in the 10-15 year group than the 5-9 year group because they are freer to swim than the latter.

Schistosomiasis is more severe in children and young adults in whom anorexia, wasting, anaemia, hepatomegaly, irregular fever splenomegaly and ascites are common findings. . Numerous complications can result from intestinal schistosomiasis. These include ectopic deposition of Ova in various organs. Terminal Spined eggs suspected to the Ova of "S. bovis" or "S. matthaei" were found in the stool specimens. These might be Zoonotic infections from

cattle to man. Earlier work by Taylor (1970) showed that S. matthei eggs seen in human faeces may be of parthenogenetic origin or hybrids of S. matthei and S. haematobium. Ova of S. haematobium are hardly found in stool. It may be possible that those infected have contact with cattle dung. This has been proved in S. Africa where Ova of S. bovis and S. matthei are implicated in human infections in cattle-raising populations. This may be the case here as the study location covered the cattle-raising areas in Nigeria. Iodine preparation of Stoll smears gave a better background for identification of the Ova of intestinal helminths than direct saline microscopy.

Intestinal Parasitic Protozoa

These included Entamoeba histolytica, G. lamblia, Ent. coli and Balantidium coli. Trophozoites of these intestinal protozoa were sporadically found using the direct saline microscopy. Most of the isolation were due to formolether concentration and iodine preparations. This suggests that the infections were light. There was no consistent pattern of infection in both sexes and age groups used. Infections by E. histolytica and G. lamblia were more prevalent in the dry season. This may be due to their ability to remain in the encysted form. More people are known to depend on polluted well water during the dry season. These cysts are also known to persist in clean water for weeks or months. It appears from the data presented here that females were more prone to

infection with E. histolytica. Earlier studies by Chacin - Bonialla et al., (1992) showed that females were more prone to infection than males. Most Giardia infections are asymptomatic. Some factors in the host can however convert the asymptomatic state to symptomatic state. These include reduced gastric acidity, blood group and competition for nutrients. Giardia infection has also been shown to be symptomatic in patients with achlorhydria after gastric resection (Meyer and Radulescu, 1979).

E. histolytica and G.lamblia are excreted protozoal pathogens of major public health importance, in communities of low standards of sanitary practice, the prevalence rate can reach up to 30%. Results showed that the overall prevalence rates of E. histolytica and G.lambia were 8.5% and 3.9% respectively.

These infections are relatively low compared to that reported by Abdullahi et al. (1995) in which a prevalence rate of 43% was recorded. In this study most of the pupils (80%) with positive cases did not show symptoms of Giardiasis. Protein - calorie malnutrition in association with Amoebiasis/Giardiasis is known to result in malabsorption and growth retardation. There may be other intestinal changes along with depression of intestinal disaccharidases. Most of the school children attending the school in the study location were of the lower socio-economic status. This agrees with the work of Yohanna et al (1990).

DIARRHOEA AND MALNUTRITION CASES

The incidence of diarrhoea and malnutrition cases were higher in the rainy season than in the dry season in four villages except in Katabu. This shows that more water sources are contaminated with faeces. The picture presented in Katabu may be due to increased usage of open wells as most ponds dried up in the dry season. The well water may deplete rapidly with more usage. If previously contaminated with bacteria; pathogens and eggs of helminths and protozoal parasites, then more people are likely to experience diarrhoea. The alternative source of water which is piped water supply is not regular and as such people depend on the well water, at not great a distance from their compounds.

Diarrhoea tends to affect the children of less that 1 year and the 1 - 4 year age group more than the other age groups (4 - 15 yrs and +15yrs). This may be due to lack of immunity and tolerance and to the incomplete development of their natural bodily defense mechanism or to the coexistence in the child of other disease processes or nutritional deficiency weakening their resistance to diseases.

There is some evidence that nutritional status does influence the duration and severity of diarrhoeal attacks (Black et al., 1982). Diarrhoea is multifactorial in origin, hence drinking water constitutes only one of the many sources of pathogen transmission when exposure is high. (Esrey et al. 1983 ; Esrey and Habicht, 1986).

A further complication is that a single long period of diarrhoea may be due to several sequential infections with one or more pathogens. Children used for this study were of the 5 - 15 year group. Comparative study of the diarrhoea cases with the incidence of Salmonella and the intestinal, protozoa showed that this age group (5 - 15)years were more exposed than the adults reporting diarrhoea in the primary health centres. The primary justification for the decade is to improve the health of people, especially children who suffer because of inadequate and contaminated water supplies and poor sanitation (Kowal and Pahren, 1982). A reduction in diarrhoea may be associated with improved water conditions. The baseline data collected to assess the bacteriological quality of water sources may be used as a basis for establishing the possibility of outbreak of water related diseases with the continued use of such polluted water.

Health education and sanitation measures appear to consistently play more important roles in determining children's health in developing areas. The provision of sanitation facilities produces larger health impacts and hence should be emphasised. The use of ventilated improve pit latrines may reduce the risk of exposure to water - related diseases.

Water and sanitation interventions can markedly improve the health of children and tailoring the intervention to the particular setting maximizes health benefits.

CONCLUSION.

1. Faecal coliform densities were low in well and surface waters but increased with the onset of the rains showing possible presence of intestinal pathogens. The level of faecal coliforms were above the WHO drinking water standard.

2. Salmonella isolated from both water and stool samples were named according to location. S typhi was the predominant serotype isolated. More serotypes of Salmonella were isolated from water.

3. Intestinal parasitic helminths and protozoa were recovered in more than half of the stool samples with Ascaris lumbricoides as the commonest.

4. Diarrhoea and Malnutrition cases were more prevalent in the community during the wet season than the dry season. These were more prevalent in the age group 0 -4 yrs than the 5 - yrs and the adults.

RECOMMENDATIONS.

There is a need to address the undesirable situation in which people drink filthy water. This can be achieved by providing an alternative potable water supply to the communities. The designs of the wells should be specified and be made to meet sanitary requirements. There is also the need to educate the people on the dangers of drinking apparently clean but polluted water. They should be taught simple means of improving the quality of water. People should be taught of the dangers of defaecating in the environment as water-borne diseases are increased when these faeces are washed to the nearest body of water.

The economic implications of having increased number of cases of typhoid fever and gastroenteritis are obvious. Typhoid fever, if not properly managed can lead to death. In less severe cases, the person looses a lot of man hours in whatever occupation he is engaged in, because of the weakness of the body.

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Appendix I

Survial times of excerted pathogens

in fresh water and sewage at 20 - 30°C

Pathogen	Survival times (days)
1 Viruses:	
a) Entero viruses	< 120 but usually 50
2 Bacteria	
a) Faecal Coliforms	< 60 but usually > 30
b) Salmonella Spp	do
c) Shigella Spp	< 30 but usually > 10
d) Vibrio cholerae	do
3 Protozoa	
a) Entamoeba histolytica	< 30 but usually > 15
4 Helminths	
a) Ascaris lumbricoides	Many months

Adopted from Feachem et al, (1983)

Appendix 2: Monthly Faecal Coliform Count (Per 100ml) of Community well Waters in five Villages around Kaduna and Zaria.

VILLAGE	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT
	$x10^1$/100ml.						$x10^2$/100ml.					
1) Katabu												
KT1	[illegible]	6.3	6.0	5.2	4.0	12	150	2.02	180	2.30	100	4.0
KT2	2.2	1.8	1.4	1.2	1.6	7.4	9.8	115	8.6	100	6.0	3.0
KT3	2.4	2.8	3.5	3.0	2.0	8.00	105	1.24	112			
KT4	6	4		4	2	10	19	15	12	2.0		
KT5	3.6	4.0	3.8	3.0	2.4	9.6	134	150	121	132	4.0	3.2
2) Bigachukun												
BG1	3.4	3.7	4.0	3.4	3.0	6.8	165	178	132	160	8.0	4.2
BG2	7.0	7.2	6.7	5.2	4.6	8.2	103	118	9.7	100	4.5	3.7
BG3	4.0	4.4	3.6	2.6	2.0	7.0	137	160	130	7.0	12	2.0
BG4	2.6	1.8	2.0	1.2	1.4	6.2	155	150	110	9.0	1.8	1.0
BG5	5.5	4.8	4.2	3.1	2.7	8.1	1.94	190	160	180	120	6.2
3) Mando												
MD1	0.4	0.5	0.3	0.2	0.4	1.5	6.2	8.0	4.8	1.5		1
MD2	1.0	1.2	0.8	0.7	0.5	2.6	6.0	8.6	5.6	8.0	10	5
MD3	4.0	4.1	3.5	3.0	2.8	6.2	1.16	128	7.5	4.0	2	
MD4		1			0.2	1.0	5.4	4.8	3.0	1.0		4
MD5	1.0	0.8	0.6	0.5	0.7	2.2	6.7	7.5	4.6	7.0	12	5
4) Angwa - denkale												
AD1	1.0	1.2	8	1.0	1.0	4.5	1.36	1.44	1.25	1.38	5.2	2.0
AD2	2	4	3	2	4	1.8	8.2	8.6	5.0	7.8	3.6	1.2
AD3	2.0	1.8	1.0	1.2	1.4	5.0	1.09	1.21	7.8	9.5	4.2	3.0
AD4	1.8	1.7	1.2	1.6	1.3	6.2	1.58	1.62	1.40	1.50	1.00	5.0
AD5	1.3	1.5	1.0	1.2	1.0	5.2	1.38	1.43	1.10	9.0	3.0	2.0
5) Basawa												
BS1	4.5	5.0	3.5	2.5	2.0	6.4	2.89	2.75	2.12	1.05	8.0	6.0
BS2	5.0	5.5	4.2	4.5	4.2	7.8	3.20	3.40	3.00	2.36	7.2	5.6
BS3	6.8	7.0	5.8	4.0	3.7	8.0	3.01	3.25	2.66	1.88	6.0	4.0
BS4	3.0	2.8	2.2	2.4	2.0	7.5	2.56	2.80	2.00	1.30	1.20	8.4
BS5	7.2	7.4	7.0	6.6	6.0	1.00	3.16	3.00	1.50	1.50	1.00	6.4

Appendix 3

Monthly Salmonella detection in well and surface Waters in five Villages around Kaduna and Zaria.

VILLAGE		NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.
1 Katabu													
a) Well Water	(W1)			+				+	+	+	+		
	W2	+						-	-				
	W3							-	-	-			
	W4				+				-	+	+		
	W5		-	-	-				+				
b) Surface Water	(S1)	+						+			-		
	S2				-			-	-	+			
	S3								+				
2 Rigachukun													
a) Well Water	(W1)	+				+		+	+	+			
	W2		+		-								
	W3										+		
	W4						-			+	+		
	W5							+		-	-		
b) Surface Water	(S1)	-		+						+			
	S2			+									
3 Mando													
a) Well Water	(W1)		+				+	+	+	+			
	W2					-			-	+			
	W3	+							+	+	+		
	W4			-					+		+		
	W5								+	-	-		
b) Surface Water	(S1)								-				
	S2	+	+							-	-		
4. Angwa Dankale													
a) Well Water	(W1)	+						+		+	+		
	W2	-	-	+	-				+	+			
	W3			-				-	+	+			
	W4	-	-	-		-	+	-		-	-		
	W5		+	-	-				-	-	-	-	
b) Surface Water	(S1)	+	-	-	-		-	-	-				
	S2	+					-	-	-	+	-		
5 Basawa													
	(W1)	+		+					-	+	+		
	W2							+	+		+		
	W3				+		+	-		+			
	W4				-					+			
	W5				+				-	+			
No Surface Water for analysis		Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Appendix 4: Monthly Salmonella detect ion in stool samples of Primary School Pupils in five Villages around Kaduna and Zaria.

VILLAGE	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.
1) Katabu												
No. of Pupils	18	18	18	18	18	18	18	18	18	18	18	18
No. Positive							2	2	2	2	2	1
% Positive	0	0	0	0	0	0	11.1	11.1	11.1	11.1	11.1	5.5
2) Bigachukun												
No. of Pupils	18	18	18	18	18	18	18	18	18	18	18	18
No Positive						1	1	1		5	1	
% Positive	0	0	0	0	0	5 5	5.5	5.5		27 7	5 5	
3) Mando												
No of Pupils	18	18	18	18	18	18	18	18	18	18	18	18
No Positive								2	1	3	1	
% Positive	0	0	0	0	0	0	0	11 1	5 5	16 6	5.5	
4) Angwa dankale												
No. of Pupils	18	18	18	18	18	18	18	18	18	18	18	18
No. Positive		-		-	-		-	1	1	3	2	
% Positive	0	0	0	0	0	0	0	5.5	5.5	16.6	11.1	-
5) Basawa												
No. of Pupils	18	18	18	18	18	18	18	18	18	18	18	18
No. Positive		-		-	-	-	2	1	1	2	1	
% Positive	0	0	0	0	0	0	11.1	5.5	5.5	11.1	5.5	

Appendix 5 Biochemical Characterisation of Salmonella Isolates.

Isolates	Biochemical Tests.										
1) Water isolates (N 71)	TSI	Urease	Motility	Citrate	Gelatin	Indole	MR	Vp	KCN Tolerance	Acid from sugars Mann. lac Xyl Gly	Lys. decarbo
a 1,2,3,14 24,60,62	K A H2S		+	−						A A A	+
b 4,9,13,15 20,63,65	K A H2S		+	−					+	A AG + AG	+
c 25,26,29 30,31,64	K A H2S		+	−						A A + A	+
d 22,27,33 34,41,69,70	K A		+							A AG AG	+
e 5,6,8,11,12 21,23,48,49,68	K A		+							A AG + AG	+
f 10,16,17,18,19 35,36,37,66	K A		+							A AG + AG	+
g 7,32,40,42,54 59,61,67,71	K A		+							A AG AG	+
h 38,39,43 52,56,57,58	K A		+	+						A AG + AG	+
i 44,45,46 47,50,53	K/A H2S		+	−						A AG AG	+
2) Stool isolates N 44											
a 6,8,10,12,13 18,40	K/A H2S		+	−						A A + A	+
b 1,3,5,9,14, 15,25,26,29	K/A		+	+					+	A AG + AG	+
c 4,7,11,16,19 20,31,34	K A H2S		+	−					+	A A + A	+
d 2,21,22,27 28,42,43	K A		+	+					+	A AG AG	+
e 23,24,30,32,33,35 36,37,58,39,41,44	K A		+	+					+	A AG AG	+

Appendix 6: Incidences of intestinal Parasitic Heminths and Protozoa in Pimary School Pupils in five Villages around Kaduna and Zaria.

	NO and Percentages of Isolations.														
	Location A.		Location B.		Location C.		Location D.		Location E.		Total	Total	Total
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Both
1. Ascaris	30(27.7)	23(21.3)	26(24.0)	18(16.6)	26(24.0)	23(21.3)	26(24.0)	18(16.6)	19(17.6)	17(15.7)	127	99	226
2. Hookworm	10(9.25)	14(12.9)	13(12.0)	18(17.6)	12(11.1)	14(12.9)	15(13.8)	20(18.5)	14(12.9)	12(11.1)	64	79	143
3. D. latum	10(9.25)	-	4(3.70)	-	4(3.70)	1(0.92)	1(0.92)	-	3(2.7)	-	15	1	16
4. H. nana	7(6.48)	-	5(4.62)	1(0.92)	3(2.7)	1(0.92)	3(2.7)	-	3(2.7)	-	21	2	23
5. Taenia	-	1(0.92)	-	1(0.92)	1(0.92)	1(0.92)	-	-	-	-	1	3	4
6. Enterobius	-	-	-	-	-	-	1(0.92)	-	-	-	1	-	1
7. Trichuris	-	1(0.92)	-	1(0.92)	1(0.92)	1(0.92)	1(0.92)	-	-	-	1	3	4
8. S. mansoni	-	4(3.70)	-	6(5.6)	-	5(4.6)	-	7(6.48)	-	9(8.3)	-	31	31
9. S. bovis	-	4(3.70)	-	2(1.85)	-	3(2.7)	-	2(1.85)	-	3(2.7)	-	14	14
10. S. stercoralis	-	1(0.92)	-	1(0.92)	1(0.92)	-	-	2(1.85)	-	-	1	4	5
11. G. lamblia	7(6.48)	1(0.92)	7(6.48)	2(1.85)	16(14.8)	-	9(8.3)	-	9(8.3)	2(1.85)	38	5	43
						4(3.70)	16(14.8)	3(2.7)	13(12.0)	4(3.70)	67	25	92

Appendix 7 Type and Number of Polyparasitism observed in Primary School Pupils in five Villages around Kaduna and Zaria.

VILLAGE	NO.	%	Location.
1. Ascaris+Hookworm.	35	47.9	A-E
2. Ascaris + H. nana	12	16.4	A, B, C,
3. Ascaris + D.Latum	5	6.8	B, C, D, E
4. Hookworm + D. latum	2	2.7	C
5. Ascaris+Irichuris	1	1.36	C
6. Taenia+S stercoralis	1	1.36	C
7. Hookworm + H nana	1	1.36	D
8. Ascaris+Hookworm+ S. Steroralis	1	1.36	B
9. Ascaris + S mansons	1	1.36	E
10. Hookworm + bivis	5	6.8	A,D
11. S. mansoni + Hookworm	8	10.9	D
Total	73		

Appendix 8

Relationship between Sex and Prevalences of Parasites isolated from stool samples of Primary School Pupils around Minduna Zara.

Number and Percentages of Isolations

		Location A		Location B		Location C		Location D		Location E		Total	Total	Total
		Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	M+F
1. A. lumbricoides	a.	20(18.5)	10(9.2)	16(14.8)	10(9.2)	17(15.7)	9(8.3)	17(15.7)	9(8.3)	10(9.2)	9(8.3)	99	47	127
	b.	17(15.7)	6(5.6)	10(12.9)	8(7.4)	14(12.9)	9(8.3)	12(11.1)	6(5.6)	10(9.2)	7(6.48)	63	36	99
2. Hookworm	a.	6(5.6)	4(3.7)	12(11.1)	1(0.92)	9(8.3)	3(2.7)	12(11.1)	3(2.7)	9(8.3)	5(4.6)	48	16	64
	b.	14(12.9)		16(14.8)	3(2.7)	7(6.48)	7(6.48)	15(13.8)	5(4.6)	8(7.4)	4(3.70)	60	19	79
3. H. nana	a.	2(1.85)	5(4.6)	4(3.70)	1(0.92)	3(2.7)	1(0.92)	3(2.7)		3(2.7)	-	15	7	22
	b.			1(.92)	-	-	-	-	-	-	-	1	-	1
4. T. trichiura	a.	1(0.92)	2(1.85)	2(1.85)	2(1.85)	3(2.7)	1(0.92)	1(0.92)	-	2(1.85)	-	9	5	14
	b.	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Taenia	a.			-	-	1(0.92)	-	-	-	-	-	1	-	1
	b.			1(0.92)	-	1(0.92)	-	-	-	-	-	2	-	-
6. Enterobius	a.	-	-	-	-	-	-	1(0.92)	-	-	-	1	-	1
	b.	-	-	-	-	-	-	-	-	-	-	-	-	-
7. Ascaris	a.			-	-	1(0.92)	-	1(0.92)	-	-	-	2	-	2
	b.	1(0.92)	1(0.92)	1(0.92)	-	1(0.92)	-	-	-	1(0.92)	-	4	1	5
8. S. mansoni	a.	-	-	-	-	-	-	-	-	-	-	-	-	-
	b.	4(3.70)		5(5.6)		5(4.6)		7(6.48)		8(7.4)	1(0.92)	29	1	30
9. S. bovis	a.	-	-	-	-	-	-	-	-	-	-	-	-	-
	b.	4(3.70)		2(1.85)		3(2.7)		2(1.85)		3(2.7)	1(0.92)	14	1	15
10. S. intercalatus	a.	-	-	-	-	-	-	1(0.92)	-	-	-	1	-	1
	b.	1(0.92)		1(0.92)	-	3(2.7)	-	1(0.92)	-	-	-	6	-	6
11. E. histolytica	a.	3(2.7)	5(4.6)	6(5.5)	9(8.3)	6(5.6)	9(8.3)	8(7.4)	937.4)	4(3.7)	9(8.3)	27	40	67
	b.	4(3.7)	-	4(3.7)	4(3.7)		1(0.92)	3(2.70	-	2(1.85)	-	17	1	18
12. B. coli	a.	1(0.92)	-	-	-	-	-	-	-	1(0.92)	-	2	-	2
	b.	-	-	-	-	-	-	-	-	-	-	-	-	-

Appendix 9: Relationship between Age and Prevalences of intestinal parasites in Primary School Pupils around Kaduna Zaira

Number and Percentages of Isolations

		Age group 5 - 9 years						Age group 10 - 10 years					
		Locations A	B	C	D	E	Total	A	B	C	D	E	Total
1. A. Lumbricoides	a	21(19.4)	18(16.6)	17(15.7)	17(15.7)	10(9.2)	83	9(8.3)	8(7.40)	9(8.3)	9(8.3)	9(8.3)	44
	b	17(15.7)	13(12.0)	16(14.8)	12(11.1)	12(11.1)	70	6(5.6)	5(4.6)	7(6.48)	6(5.6)	5(4.6)	29
2. Hookworm	a	5(4.6)	8(7.40)	6(5.6)	7(6.48)	9(8.3)	35	5(4.6)	5(4.6)	6(5.6)	8(7.40)	5(4.6)	29
	b	3(2.4)	1(0.92)	5(4.5)	3(2.7)	3(2.7)	24	11(10.1)	9(8.3)	9(8.3)	17(15.7)	9(8.3)	55
3. H. nana	a	3(2.7)	1(0.92)	3(2.7)	2(1.85)	3(2.7)	12	4(3.7)	4(3.7)	1(0.92)	1(0.92)	-	10
	b	-	1(0.92)	1(0.92)	-	-	2	-	-	-	-	-	-
4. D. latum	a	-	2(1.85)	2(1.85)	1(0.92)	2(1.85)	7	3(2.7)	2(1.85)	2(1.85)	2(1.85)	-	9
	b	-	-	-	-	-	-	-	-	-	-	-	-
5. Taen. S.	a	1(0.92)	-	-	1(0.92)	-	1	-	1(0.92)	1(0.92)	1(0.92)	-	2
	b	-	-	-	2(1.85)	-	2	-	1(0.92)	1(0.92)	-	-	-
6. T. microbuc	a	-	-	1(0.92)	2(1.85)	1(0.92)	3	-	-	-	-	-	-
	b	-	-	2(1.85)	2(1.85)	1(0.92)	3	4(3.7)	4(3.7)	5(4.6)	8(7.4)	-	21
7. T. trichi	a	1(0.92)	-	-	-	-	-	-	-	-	-	-	-
	b	-	-	1(185)	2(1.85)	1(0.92)	10	2(1.85)	-	2(1.85)	3(2.7)	-	10
8. S. Mansoni	a	4(3.7)	2(1.85)	-	-	-	4	-	-	-	-	-	1
	b	-	-	-	-	-	-	-	1(0.92)	1(0.92)	-	-	2
9. S. bovis	a	4(3.70)	-	-	-	-	-	-	-	-	-	-	-
	b	-	-	-	-	-	-	1(0.92)	-	-	-	-	-
10. S. stercor	a	-	1(0.92)	1(0.92)	-	-	2	2(1.85)	6(5.6)	5(4.6)	5(4.6)	6(5.6)	24
	b	-	-	-	-	-	-	2(1.85)	3(2.70)	2(1.85)	1(0.92)	2(1.85)	10
11. S. haematica	a	6(5.6)	9(8.3)	10(9.2)	11(10.1)	7(6.48)	43	3(2.7)	5(4.6)	3(2.7)	4(3.7)	2(1.85)	47
	b	4(3.7)	5(4.6)	2(1.85)	2(1.85)	2(1.85)	15	1(0.92)	1(0.92)	-	-	-	2
12. H. co.	a	4(3.7)	2(1.85)	3(2.7)	5(4.6)	7(6.48)	21						
	b	-	1(0.92)	-	-	-	1						