PREVALENCE OF *GIARDIA* CYSTS IN DOG FAECES AND WATER SOURCES IN ZARIA, KADUNA STATE, NIGERIA.

BY

BASHIRU SHAFA ABUBAKAR

DEPARTMENT OF VETERINARY PUBLIC HEALTH AND PREVENTIVE MEDICINE,
FACULTY OF VETERINARY MEDICINE
AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA

SEPTEMBER, 2014

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BY

Bashiru Shafa ABUBAKAR (BSc, Zoo ABU 2010)
(MSc/VET-MED/16168/11-12)

A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA,
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN VETERINARY PUBLIC HEALTH AND PREVENTIVE MEDICINE
DEPARTMENT OF VETERINARY PUBLIC HEALTH AND PREVENTIVE MEDICINE
AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA

SEPTEMBER, 2014

DECLARATION

I declare that the work in this thesis titled**"Prevalence of *Giardia* Cysts in Dog Faeces and Water Sources in Zaria, Kaduna State, Nigeria"**has been performed by me in the Department of Public Health and Preventive Medicine under the supervision of Late Professor I. Ajogi and Doctor B. V. Maikai. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at any university.

BashiruShafa ABUBAKAR _____ _____
Name of Student **Signature** **Date**

CERTIFICATION

This thesis titled **"PREVALENCE OF *GIARDIA* CYSTS IN DOG FAECES AND WATER SOURCES IN ZARIA, KADUNA STATE, NIGERIA"** by Bashiru Shafa ABUBAKAR meets the regulations governing the award of the degree of Master of Science in Veterinary Public Health of Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

Prof. I. Ajogi …… …….....

Chairman, Supervisory Committee Signature Date

Dr B. V. Maikai …….. …….....

Member, Supervisory Committee Signature Date

Dr E. C. Okolocha…… ……...

Head, Signature Date

Department of Veterinary Public Health

and Preventive Medicine

Prof. A. Z. Hassan …….. ……...

Dean, Signature Date

School of Post Graduate Studies

Ahmadu Bello University, Zaria

DEDICATION

This work is dedicated to Almighty Allah for providing all I needed throughout the course of this study.

It is also dedicated to my parents Mr and Mrs Abubakar Abdullahi Shafa for giving me the basic training, my beloved wife Maimuna Abdullahi and members of my family for their moral support and prayers.

ACKNOWLEDGEMENT

I thank God Almighty for his protection, guidance and providence during the period of my study. My sincere appreciation goes to my supervisors; Late Professor I. Ajogi and Dr (Mrs) B. V. Maikai for their immeasurable advice and patience during the course of my study. Also thank my beloved parents for their love, understanding, moral and financial support.

My unreserved gratitude goes to my dear beloved Dad, 'TAFIDA' of Shafan-kwatto, Alhaji Abubakar A. Shafa for giving me support, love and advice which propelled me to this enviable height and to my Mum, Salamatu A. Shafa, for her encouragement and support. Also, special thanks goes to my parent in-law Alhaji Abdullahi Hussaini Ruba and Hajiya Hadiza Abdullahi, my uncle Yakubu Abdullahi Shafa who accommodated me throughout the program. My parents and parents' in-law Alhaji Abdullahi Hussain and Hajia Khadija, wife Maimuna Abdullahi Hussain, brothers Mikail H. Shafa, Abdulshakur, Abdullahi, Salihu and sisters are appreciated for their immense moral support.

I also thank Professors J. U. Umoh, C. A Kudi, J. K. P. Kwaga, Drs J. Kabir, E. C. Okolocha and M. Bello for their guidance. I wish to extend my thanks to all staff and students of Veterinary Public Health and Preventive Medicine for their immense support and contribution to the success of this study. I would also like to thank all the laboratory attendants that gave their time to see the end of this work during my laboratory procedures.

I would not forget my good friends whom we always joke together Nassouradine Adam,Dahiru Dauda, Sirajo Idris, Dauda H. Shuaibu, Buhari Summary, Rabiu Hamza, Kabiru Jakusko, Abdulwahab Aliyu, Abdul Niger, Sayyadi Sanda, Baba abu, Sulaiman Dauda, Ibn Umar, Alhaji koko, Bilal, Imam Sulaiman, Gidado, Abdurrasheed Sa'eed, Mustapha Akpaki, Mustapha Sabo and Modibbo. Finally, I want to express my immense pleasure to all my colleagues at masters.

ABSTRACT

Giardiasis is a major cause of diarrhoea in both humans and animals. This study determined the prevalence of *Giardia* cysts in dog faeces and water sources in Zaria, Kaduna State, Nigeria. Four hundred and two (402) dog faecal samples and 120 water source samples were collected and examined for *Giardia* cysts using zinc sulphate flotation technique. Of the 402 dog faecal samples examined, 70 (17.4%) were positive for*Giardia* cysts. The highest prevalence of*Giardia* cysts was15 (3.7%) in Tudun-wada, followed by Kwangila 14(3.5%), Samaru 13(3.2%), Zaria city 11(2.7%), Dan-magaji 10 (2.5%) and Sabo 7(1.7%). There was no statistical association (P=0.480) between*Giardia*cysts in dogs and districts sampled. There were other parasite eggs/oocysts seen among the 402 dog faeces examined. These were eggs of *Taenia*28(7.0%), *Ancylostoma*20(5.0%), *Toxocara*20(5.0%), *Dipylidium*7(1.7%),*Capillaria* 6(1.5%) and*Isospora*13(3.2%). Of a total of 364 dogs that had diarrhoea, 64(17.6%) were positive for *Giardia* cysts. *Giardia* cystswere higher in male dogs 42 (18.9%)than in females 28(15.6%). Higherprevalence of *Giardia*cysts was observed in puppies (<6months) 37(18.1%) than adults (>6months) 33(16.7%).Higherprevalence of *Giardia*cysts was observed in cross/exotic breeds 19(20.9%) as compared to local breeds 51(16.4%). There was no statistical association between the prevalence of *Giardia* cysts and dogs with diarrhoea (P=0.782), sex (P=0.37), age (P=0.697) and breed (P=0.322). There was ahigher prevalence63(15.7%) of *Giardia* cysts in strayed dogs than in confined dogs 7(14.6%). However, there was significant association (P=0.01) between *Giardia* cysts and straying of dogs. Two (1.7%) out of the 120 water source samples examined were positive for *Giardia* cysts. The positive samples werefrom Samaru,1 (5.0%) and Sabo, 1 (5.0%). No *Giardia* cysts were identified indrinking water samples collected from Kwangila, Tudunwada, Danmagaji and Zaria city. All the positive samples were from streamwater 2(6.7%). There was no *Giardia* cyst in samples collected from tap, well and borehole.The

overall prevalence of other parasite eggs/oocysts in all water sourceswas 7(5.8%)with *Ancylostoma* eggs having the higher prevalence 5(4.2%), followed by *Isospora*oocysts 2(1.7%). The total number of respondents who were the dog owners was 402. The prevalence of *Giardia* cysts was highest 2(20.0%) among those respondents that had greater than 3 dogs in households as compared to 65 (18.7%) and 3(6.7%) among 1 and 2 dogs per household respectively. Of the 68(16.9%) pet dogs, 148(36.8%) security, 139(34.6%) for food and 47(11.7%) for hunting, the prevalence of *Giardia* cysts were 9(13.2%), 23(15.5%), 24(17.3%) and 14(29.8%) respectively. Thirty five (17.5%) out of the 200(49.8%) dogs that received veterinary care were positive for *Giardia* cysts. Pet (OR: 0.36; 95% C I on OR< 0.14 < 0.92) and security (OR: 0.43; 95% C I on OR < 0.20 < 0.93) use of the dogs were the identified risk factors while type of feed, number of dogs per household and veterinary care were not risk factors (P>0.05). Straying of dogs should be regulated by owners to avoid indiscriminate faecal contamination and water sourced from streams, wells and boreholes should be filtered and boiled properly before drinking.This study established the prevalence of *Giardia* cysts in dog faeces and water sources in Zaria.

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CHAPTER ONE

INTRODUCTION

1.1 Background of theStudy

Giardiasis is a parasitic disease caused by the flagellate protozoan *Giardia lamblia* (formally called *Giardia intestinalis* and *Giardia duodenalis*) (Huang and White, 2006). It has been isolated from the stools of various animals including cats, dogs, sheep, cattle and various rodents. It does not strongly bind to soil particles and so in the event of rainfall leading to overland flow, the protozoan is easily washed away and so can be transported for long distances in all sources of drinking water (Dai and Boll, 2006).*Giardia* species inhabits the digestive tract of a variety of domestic and wild animal species, as well as humans. It is a common cause of gastroenteritis in humans, infecting approximately 200 million people worldwide (WHO, 2010).

The life cycle of *Giardia* is direct, and the infective stage of the parasite, the cyst, is encysted when released into the feces and is immediately infectious (Huangand White, 2006). Cysts remain infectious for months in cool, damp areas and rapidly accumulate in the environment. In soil, cyst infectivity was reduced by only 11% after 49 days at 4°C and was non-infective after 7 days at 25°C (Erickson and Ortega. 2006).*Giardia* Cysts are capable of surviving for up to 3 months in water at 4°C (Sattar, 1999).

The most commonly recognized routes of transmission of the disease are ingestion of contaminated drinking water and food, recreational exposure to contaminated surface water and person to person contact (Levy *et al.*, 1998; Stuart *et al.*, 2003). The incidence of giardiasis is considerably more common in developing countries, and specifically under

circumstances with poor sanitary conditions, such as poor water supply, camps and day care centers (Geltman*et al.*, 2003).

Giardia lamblia has a worldwide distribution it is particularly common in the tropics and subtropics especially in areas where water supplies and the environment becomes contaminated with faecal matter. This parasite causes abdominal pain, severe diarrhoea, vomiting, weight loss and mal-absorption with lactose intolerance (Schunk *et al.,* 2001).

The domestic dog (*Canis familiaris*) is generally considered as the first domesticated mammal and has coexisted with man as a working partner and house pet in all eras and culture since the days of the cave dwellers (Brickner, 2002).They are among other canines known to be definitive host for most parasitic, bacterial and viral pathogens (Traub *et al.,* 2004). Transmission of zoonotic diseases by the dogs is very common. Domestic dogs living in urban environments can harbour zoonotic assemblages of *Giardia*, which also infect humans, more frequently than the dog-specific assemblage (Sprong *et al.,* 2009).

In United States, a 15.6% national prevalence of *Giardia* infection was recorded in dogs presented to clinics with gastrointestinal signs (Carlin *et al.,* 2006). Carmena *et al*. (2006) reported prevalence of *Giardia* cyst in surface water supplies from the province of A´lava, northern Spain, they recorded a prevalence of 92.3% of the cysts in river samples, 55.5% in reservoir samples, 26.9% and 45.2% in raw water samples from conventional and small water treatment facilities respectively, 19.2% of treated water from small treatment facilities, and 26.8% of tap water from municipalities with chlorination treatment only.

Giardiasis is associated with contaminated water supplies, poor personal hygiene, ignorance,poverty and the availability of mechanical vectors, such as houseflies (Oyerinde, 1976; Ogbe *et al.,* 2002), this disease causes diarrhoea with a record of over 3 million deaths mostly in children annually (WHO, 1990; Biu and Adam, 2004).

1.2 Statement of Research Problem

Giardia lamblia is one of the major causes of waterborne and foodborne diseases worldwide (CDC, 2010), and infection results in giardiasis which is characterized by malabsorption and severe diarrhoea. *Giardia*-induced intestinal infection is particularly severe in developing world, where giardiasis occurrence relates heavily to water source contamination. In developing countries such as Nigeria, the disease has important Veterinary and public health consequences (Godfroid, 2005; Franco, 2007).

Exposure to infected dogs is by means of some associated risk factors such as drinking water contaminated by the cyst, poor sanitary practice, ingestion of cyst in forage and animal feed, faeco-oral transmission, contact with animals that are infected (Neta *et al.,* 2010). The presence and extent of giardiasis in the developing world has been poorly investigated in the past. Presently, only few studies have revealed new data confirming the presence of *Giardia* in dogs, and moreover providing insight into the specific risk factors associated with this infection in dogs in different regions of the world (Sprong *et al.*, 2009).

In developing countries, the disease conditions for transmission to humans has not changed due to lack of adequate information on the disease, poverty, and reduced access to health care (WHO, 2009). Dog handlers like Veterinarians and dog breeders are constantly exposed to infection as a result of ignorance or lack of adherence to preventive measures in the course of

their professional occupations. Although the general proportion of giardiasis in our locality is not well documented, its potential impact on population groups especially the young ones are high and should not be underrated. The importation of foreign breed, cross breeding practices can contribute to development of resistant variants and re-emergence of giardiasis as an International concern for both indigenous and foreign breeds of dogs (Furness *et al.,* 2000).

Giardia cysts were identified in614 (8.5%)dogsin Romaniaof different communities with 7.2% in kennel dogs; 16.5% in shelter dogs; 4.3% in shepherd dogs; 4.8% in household dogs from urban areas; and 5.1% in household dogs from rural areas (Viorica *et al.,* 2012).

1.3 Justification

Information on the prevalence of *Giardiasis* in dogs and drinking water is scarce in Zaria. Control of *Giardia*, from a public health standpoint, should start with municipal drinking water. The prevalence of *Giardia* in humans within industrialized countries is 2-5% and within developing countries is 20-30% (Neta *et al.*, 2010). The organism has been found in as many as 80% of raw water supplies from lakes, streams, and ponds and in as many as 15% of filtered water samples (Robertson *et al.,* 2008). In children that attend day care centres, the prevalence of *Giardia* has been found to be as high as 35% (Adam, 2001).

Traub *et al.* (2004) reported significant association between the prevalence of *Giardia* cysts in humans and the presence of a *Giardia* positive dog in the same household. Dogs are long-term companion of man and therefore serve as a source of infection to man as they roam the streets especially in developing countries where there is high level of poverty and unsanitary environment as they stray, hence may pick up infectious agents from these environment (Little *et al.,* 2009).

In Nigeria, in addition to the role of the dog as a companion animal, dogs serve to provide an important source of protein to man. Dog meat is a delicacy and highly sought for in many parts of the country. However, dogs like many canines have been reported to harbor a variety of intestinal parasites, some of which can also infect livestock, wildlife and humans (Sowemimo and Asaolu 2008). The clinical signs of parasitic infections in dogsare varied and occasionally some infected animals may present no symptoms (Ramirez-Barrios *et al.,* 2004). Thesefactors, coupled with inadequate information by dog keepers on the risks of disease transmission, control of zoonoses transmitted by domestic animals, control of stray dogs and poor level of hygiene has resulted in an increased risk of exposure to zoonoses transmitted by these animals (Sowemimo and Asaolu 2008).

Determining the prevalence of *Giardia* in dogs in order to highlight its public health significance will go a long way in controlling this disease which is among the group of neglected diseases. Therefore, there is need to carry out research on the prevalence and public health significance of *Giardia* cyst in dogs and sources of drinking water in Zaria metropolis, Kaduna State. This research provides useful information on the prevalence of *Giardia* cysts in dogs and drinking water, which may likely help regulatory bodies and Government agencies in making policies in controlling Giardiasis in the study area.

1.4.0 Aim and objectives

1.4.1 Aim of the study

The aim of this study was to determine the prevalence of *Giardia* cysts in dog faeces and water sources in Zaria, Kaduna State, Nigeria.

1.4.2Objectives of the Study

The objectives were to determine:

1. the prevalence of *Giardia* cysts in dogs and water sources in Zaria
2. the associated risk factors that enhance spread of *Giardia* cysts in dogs and water sources in Zaria.
3. the association between age, sex, breed and location and *Giardia* cysts in dogs in Zaria.

1.5 Research Questions

1) What is the prevalence of *Giardia* cysts in dogs and water sources in Zaria?
2) What are the associated risk factors that enhance spread of *Giardia*cysts in dogs and water sources?
3) What is the association between age, sex, breed and location and *Giardia* cysts in dogs in Zaria?

CHAPTER TWO

LITERATURE REVIEW

2.1 History of *Giardia*

Giardia first description was attributed to the microscopist Antonie van Leeuwenhoek (1632 to 1723), Vilem Lambl (1824 to 1895), a Czech physician, was credited with the discovery in 1859 of the flagellate *Giardia*. The name *lamblia* was given to the species by Blanchard in 1888 (Meyer and Jarrol, 1980). Protozoan parasites within the genus *Giardia*have a long history within Veterinary Medicine.Most species that infect domestic animals were initially described as separate species in the1920s: *Giardia caprae* (Nieshulz, 1923) from sheep and goats; *Giardia bovis* (Fantham, 1921) from cattle; *Giardia equi* (Fantham, 1921) from horses; *Giardia canis* (Hegner, 1922) from dogs; and *Giardia felis* (Hegner, 1924) from cats (synonym, *Giardia cati* [Deschiens, 1925]).

During the first 50 years that these parasites were known to infect animals, it was difficult to assess their effects because of the many other gastrointestinal parasites co-inhabiting these hosts. As the prevalence of other enteric parasites' declines, the effects of *Giardia* infection alone are becoming better understood. Interest in this group of protozoa began only 20 years ago, when *Giardia* were isolated from mammal, bird, and amphibian hosts (Kulda and Nohynkova, 1978). Initially, assignment of a species name to *Giardia* was based on the animal host species from which the organism was isolated. Filice (1952) rejected this concept of host specificity and proposed to use the morphology of the trophozoite microtubular organelles known as the median body to classify species into three groups: (i) the amphibian group (*G. agilis*), which has a long teardrop-shaped median body; (ii) the rodent and bird group (*G. muris*), which has two small, rounded median bodies; and (iii) the human group (*G.*

Duodenalis= lamblia= intestinalis), in which the single or double median bodies resemble the claw of a claw hammer.

2.2 Morphology of *Giardia*

G. lamblia has two morphological stages: the trophozoite and the cyst. The trophozoite is pear shaped, with a broad anterior and much attenuated posterior. It is 10-12µm long and 5-7µm wide, bilaterally symmetrical, and has two nuclei. It is also relatively flattened, with a large sucking disk on the anterior ventral side, which serves as the parasite's method of attachment to the mucosa of the host. The trophozoite also has two median bodies and four pairs of flagella (anterior, caudal, posterior and ventral). The *G. lamblia* cyst is egg-shaped, and measures 8-14µm by 7-10µm. After encystation, each organelle duplicates, so each cyst contains four nuclei, four median bodies, eight pairs of flagella--although these organelles are not arraigned in any clear pattern. Upon excystation, each cyst produces two trophozoites.

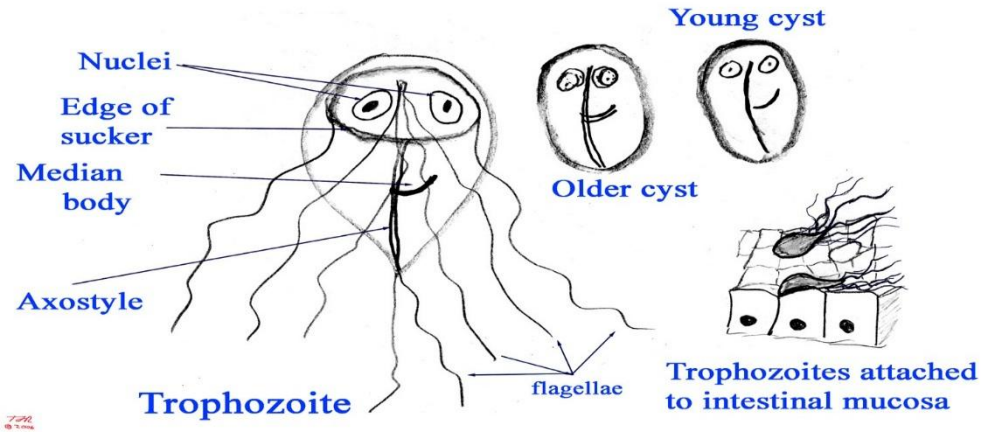


Figure 2.1: *Giardia* trophozoite and cysts. Source: CDC (2010)

2.3 Taxonomical Classificationof *Giardia*

Kingdom	Protista
Subkingdom	Protozoa
Phylum	Sarcomastigophora
Subphylum	Mastigophora
Class	Zoomastigophora
Order	Diplomonadida
Family	Hexamitidae
Genus	*Giardia*
Species	*lamblia*

2.4 Pathology and Immunity of *Giardia*

2.4.1 Pathology of *Giardia*

Pathology and clinical signs result from boththe direct action of the parasite and the body's response to it (Kirkpatrick, 1987). When signs occur, they are related to maldigestion and malabsorption. Studies of pathogenesis in animals are limited, and most of our assumptions are deduced from knowledge of human infections (Barr, 2006). Proposed mechanisms include epithelial cell apoptosis, barrier dysfunction. The histopathological changes occurring at the mucosal sites range from minimal to severe enough to cause enteropathy with enterocyte damage, villus atrophy, and crypt hyperplasia (Ferguson *et al.*, 1990.). The reasons for these variations are similar to those mentioned above as possible factors contributing to the variation of clinical manifestation. Shortly after the trophozoites leave the stomach of their new host in response to low pH, excystation will take place. Using their flagella and ventral disc, trophozoites released in the upper part of the small intestine move to the

microvillus-covered surface of the duodenum and jejunum, where they attach themselves (Inge *et al.,* 1986), and play a role in the onset of the pathology (Mohammed and Faubert, 1995). The suction force created by this mode of attachment may damage the microvilli and interfere with the process of food absorption (Magne *et al.,* 1991). Eventually, the rapid multiplication of the trophozoites by binary fission creates a physical barrier between the intestinal epithelial cells and the lumen of the intestine, interfering with the process of absorption of nutrients.

2.4.2 Host Immunityagainst *Giardia*

Immune response of dogs to *Giardia* are usually self-limiting, many researchers suggest an acquired immunological resistance to the parasite. Epidemiologic research suggests that previous contact with *Giardia* may serve to increase resistance to re-infection. Humoral immunity is considered to be important in the elimination of *Giardia*trophozoites from the host intestine. Immunologically naive and immunocompromised hosts have been found to be more vulnerable and also suffer more severe and chronic infections(Erlandsen *et al*., 1996). Research has shown, in experimentally infected humans and animals, that the immunocompetent host produces specific mucosal and serum antibodies against both cystosolic and surface *Giardia* antigens. The cellular immune system does not play a direct role in parasite clearance.Most persons infected with *Giardia* produce detectable levels of anti-parasite antibodies.

However, the role of specific antibody to *Giardia* in determining the host's clinical response to infection has not been delineated. Responses to a number of different *Giardia* antigens have been reported, but it is uncertain which, if any, of these responses predict a reduced risk of either infection or illness. A serological investigation of a waterborne outbreak in Vermont

suggests that elevated IgA antibody to *G. lamblia* may effectively determine exposure to cyst contaminated water and subsequent illness during waterborne outbreaks (Birkhead and Vogt, 1989).

Breast milk may protect some puppies from *Giardia* infection because of protective immunity of secretory antibodies in breast milk or because of breast milk enzymes that have been found *in vitro* to release substances which kill *Giardia* trophozoites. The use of breast milk also results in fewer exposure opportunities for the puppies. Development of protective immunity to *Giardia* is considered a relative lengthy process and does notnecessarily develop following a single infection. Only partial protective immunity to illness from *Giardia*infection is likely to develop. In a community that experienced two waterborne giardiasis outbreaks separated by a five year period, persons infected during the first outbreak were at significantly lower risk during the second outbreak (Isaac-Renton and Philion, 1992).

2.5 Lifecycle of *Giardia*

The *G. lamblia* life cycle consists of two stages: the cyst and trophozoites. The cyst is highly resistance against chlorination, ozonolysis, and can survive in cold water between 4~8 degrees Celsius (Ali and Hill, 2003). It is often found in contaminated water and faeces of infected individual. The trophozoite form is the vegetative form of *G. lamblia*, and is found in the small intestine of infected individuals. It may also be found in their faeces. The trophozoite is almost exclusively found in the human intestine, its primary niche.

2.5.1 Acquisition and excystationof *Giardia*

Acquisition of *Giardia* is primarily through the cyst form, in the fecal-oral route or, in unindustrialized regions, through contaminated water. The cyst is protected against the host's

gastric acid with its cyst wall. Studies have suggested that its passage through the stomach of the host, provided an acidic environment that contributes to initiation of excystation, transformation from the cyst form to trophozoite. (Elmendorf *et al*., 2003 and Adam, 2001) Excystation is also facilitated by pancreatic protease, and cysteine protease CP2. In addition, evidence have been gathered to show that excystation may be inhibited by antibody to the cyst wall, calmodulin antagonists TFP and W7 (Bernal *et al*., 1998), and by wheat germ agglutinin (Meng *et al*., 1996).

2.5.2 Attachment and reproduction of *Giardia*

The trophozoite adheres to the wall of the small intestine using its ventral disc, and replicates within the lumen. Attachment was thought be accomplished by the hydrodynamic force generated under the disc using the ventral flagella (Holberton and Marshall, 1995) Another proposed mechanisms for attachment involve a surface lectin, found on the ventral disc of the trophozoites, that binds to mannose. (Farthing, 1994).

Reproduction and encystations (formation of cyst) are carried out in the host mid-mid-jejunum (small intestine). The metabolic activity of the trophozoite may cause diarrhoea, malabsorption and weight loss- a condition known as Giardiasis. In some patients, no symptom may develop. The reason of this is unknown, but it is believed that the parasite strain and host factors may play a role (Thompson, 2001).

2.5.3 Encystationof *Giardia*

Encystation is observable under the microscope, and detailed mechanisms have been characterized by biochemical methods. Encystation occurs at mild alkalotic pH of 7.8 with the presence of fatty acid conjugated with bile salts (Gillin *et al*., 1989). In vitro studies have

shown that encystations is induced by cholesterol and exposure of bile salts and fatty acids (Kane *et al*., 1991).

There are two phases of encystation. In the early phase, cell wall proteins are synthesized and transported to the periphery. Increased cell wall protein synthesis renders a Golgi-like structure readily visible with electron microscopy (Reiner *et al.*, 1990). The proteins, containing a leucine-rich signature, are redirected to Encystation-specific transport vesicles (ESV), visible under light microscopy (Hehl *et al*., 2000).

The late phase involves the assembly of the cyst wall and morphological change. The assembly begins with cyst wall filaments, then the filamentous layer of the cell wall (Adam, 2001). During the course of late-phase encystations, the trophozoite loses motility. Eventually a non-adhering cyst enclosing two physicallyjoined trophozoites with four nuclei results.

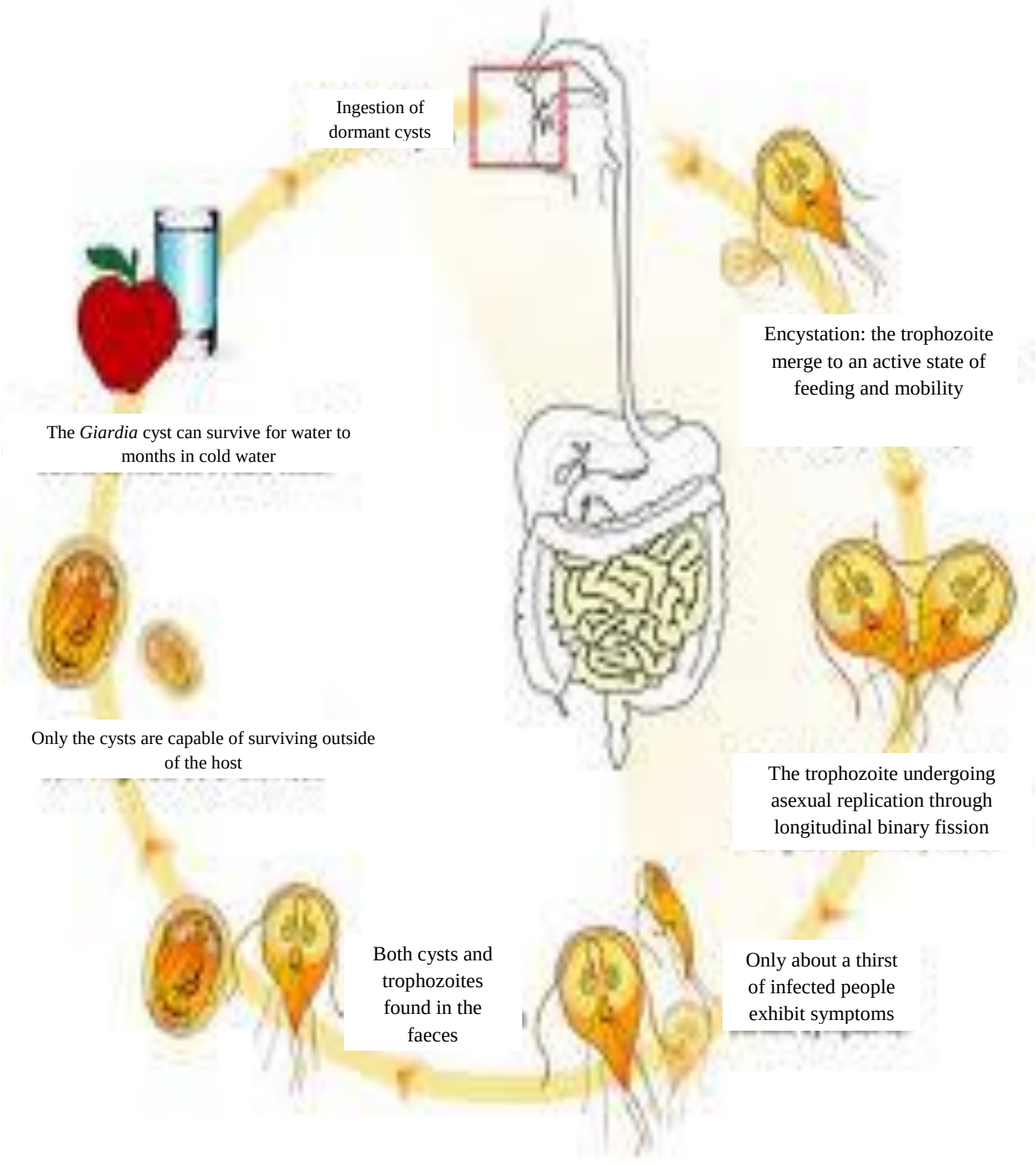


Figure 2.2: Lifecycle of *Giardia.*

Source: modified from CDC (2010)

2.6 Risk Assessment for Giardiasis in Water Sources.

Rose *et al*. (1991) used an exponential model to evaluate risks of *Giardia* infection from estimated exposures to *Giardia* in drinking water in the United States. Drinking water exposures were obtained from survey data describing the occurrence of *Giardia* in polluted and pristine water sources and considering averageremovals and inactivation of cysts with various types of water treatment. The same approach was used in thedevelopment of the SWTR where performance-based standards for the control of *Giardia* were used to meet the EPA's recommended public health goal of no more than one *Giardia* infection per 10,000 persons from drinking water exposures (U.S. EPA, 1989). The EPA felt that this goal could be maintained by achieving 99.9% reductions of *Giardia* cysts through filtration and disinfection in all water systems. Several small foodborne outbreaks of giardiasis have been associated with the contamination of ice and foods by infected food service workers, restaurant-associated transmission of *Giardia* appear to be a significant public health problem for children (Quick *et al.,* 1992).

2.7Global giardiasis and geographical distribution

Giardia lamblia is one of the major cause of waterborne diseases worldwide (CDC, 2010),Giardiasis is a disease of public Health importance. In some developing countries, infection among young children can be quite high.

2.7.1Distributionof giardiasis in Africa and the Middle East.

Giardia prevalence for countries in Africa and the Middle East. Enekwechi and Azubike (1994) conducted a survey of the prevalence of intestinal parasites in primary school children in Nimo, Nigeria. Of the 1,536 stool samples collected from eight primary schools, only 0.1% were positive for *G. lamblia* examined by light microscopy after formalin ether

centrifugation. Ejiofor *et al.* (2011) reported a prevalence rate of 10.1% in Children Presenting with Diarrhoea at Secondary Health Facility in Awka, South-East Nigeria. A survey in Pikine (Senegal) of five groups of children from ecologically representative sections of the town confirmed the high prevalence of *Giardia* (43.7%) in urban areas of Africa (Salem *et al.*, 1994). Okojukwo and Inabo (2012) reported a prevalence of *Giardia lamblia* in stool samples of children in day-care centres, nursery and primary schools in two Local Government Areas, Sabon-Gari and Zaria, in Kaduna State, Nigeria. Of 374 samples examined, 150 (41.45%) were positive for *Giardia lamblia*. The prevalence of giardiasis was higher in males (50.3%) than females (49.7%).The highest prevalence for *Giardia*(56.8%) was found in children living on the outskirts of the town.Also, Idowu and Rowland, (2006) studied oral fecal parasites and personal hygiene of food handlers in Abeokuta, Nigeriaand reported a prevalence of 13% with school children vendors. The prevalence of *G. lamblia*was 9.8% as reported by Mason and Patterson (1987) in Harare, Zimbabwe. The overall prevalence of *Giardia* infection was 19.4% with more urban children (21.1%) passing cysts than rural children (16.7%).

A survey of 770 households in Behera, Egypt, selected by a random cluster sampling technique (Curtale *et al.*, 1998), found *G. intestinalis*in 24.7% of children, aged 6 months to 12 years; faecal analyses from direct smear and the Kato-Katz examination techniques were available from 1844 and 1783 children respectively. A two-year study of the etiologic agents associated with episodes of diarrhoea in a family cohort population was conducted in eight villages of rural north-eastern Egypt; 3,243 stool specimens from 3,513 episodes of diarrhoea were analyzed for enteropathogens (Zaki*et al.*, 1986). The most commonly identified agent in persons withdiarrhoea was *G. lamblia*(44%); 60% of *Giardia*-positive stool specimens occurred in children 6 to 24 months of age. The isolation of *G. lamblia*from stool specimens

was similar for persons with diarrhoea and those without, and no discernible seasonal pattern was found for infection. Stazzone*et al*. (1996) found *Giardia* in 10.7% and 19.7% of 271 children who attended a clinic in Alexandria, Egypt, between December 1991 and July 1992 using conventional trichrome staining and immunofluorescent methods, respectively. Ahmed (1991) surveyed 1426 apparently healthy Saudi children, finding *G. lamblia*to be the most common pathogenic parasite (3.6%).

2.7.2. Distributionof giardiasis in Asia.

*Giardia*prevalence for countries in Asia.Ngan*et al.* (1992) found stool specimens positive for *G. lamblia*in 4% of 83 children under three years of age who were treated for persistent diarrhoea in the gastroenterology unit of the Institute for the Protection of Children's Health in Hanoi. Kang *et al.* (1998) determined the prevalence of intestinal protozoal infection in 78 members of 15 families from a rural village in India. Stool specimens from all subjects were examined on alternate days for one month; the overall prevalence of parasitic infections was 97.4%, with only 2 of 78 subjects not excreting parasites in any of fifteen specimens. Eighteen (23.1%) persons had only one type of parasite, while 58 (74.3%) excreted multiple parasites. *Giardia* was the most common protozoan infection, affecting 42 (53.8%) persons. In Punjab, India, Walia*et al*. (1986) found 35.1% of preschool children infected with *G. lamblia*16.5% of those infected had diarrhoea.

2.7.3 Distributionof giardiasis in Europe.

Gray and Rouse (1992) found that 23.7% of index cases of giardiasis in Bristol, England, were in preschool children; theremeander in travellers abroad and persons aged 10 years or more engaged in water recreation. Olszok and Kucharz (1996) found about 10% of adults and 20% of children in Poland infected with *G. lamblia*only a small percentage of infected

persons were symptomatic. Skorochodzki*et al.* (1998) studied a sample of 112 children hospitalized with chronic abdominal pain from 1992 to 1993 in north-eastern Poland; based on the results of the duodenal fluid examination, *G. lambli*ainfection was diagnosed in 77 (68%) children. Nikolic*et al*. (1998) surveyed intestinal parasitism among 5981 schoolchildren in central Serbia during the period 1984-1993. The study included 2887 females and 3094 males, 7-11 years old representing 10% of the total age-matched population in the region. *G. lambli*awas detected in 6.8% of the children.

To study the prevalence of intestinal parasites in school-age children of Centro de Salud de MotadelCuervo, Cuenca, Spain, Jarabo*et al*. (1995) analyzedfaecal samples from healthy children, 5-14 years old, randomly selected by stratified sampling. The study included 297 children of whom 133 (44.8%) were found infected with parasites. *G. lambli*awas the parasite most frequently detected (36.4%). There was no difference in prevalence between boys and girls. During 1994 to 1996, Perez Armengol *et al.*, (1997) found the overall prevalence of intestinal parasites (27.1%) in 1,917 children without symptoms, 6 to 10 years of age, living in 20 villages in the Guadalquivir valley of Spain to be similar to that found in other regions of Spain; *G. lamblia*(5.1%) was the second most commonly identified parasite in these children. Garcia *et al*. (1989) studied diarrhoea and the prevalence of enteropathogens for a one-year period in a group of 144 children in Spain, the prevalence rate of *G. lambli*ainfection was 4%. Buchriese*et al*. (1988)identified *G. lambli*ain 28.7% of stool specimens collected on the Cape Verde Islands; 90% of the samples came from children aged between 6 and 14 years.

2.7.4 Distributionof giardiasis in Latin America.

*Giardia*prevalence for Latin America countries is reported in. In a prospective study of 318 children, aged 3 to 14, without symptoms, attending school in eight villages in the eastern part of the province of Avila, Brazil, Pedraza *et al*. (1994) found a 4.4% prevalence of *G. lamblia*during 1992-93. No statistically significant differences in prevalence were found between girls and boys or between children over or under 10 years of age. Lindo*et al*. (1998) conducted a cross-sectional epidemiologic study of *G. lamblia*and *Cryptosporidum*infections in Jamaica. Three hundred twenty eight stool samples from patients less than one to 81 years of age were examined. In contrast to *Cryptosporidum*infections, which were most frequently diagnosed in children less than five years old and prevalence decreased with age, the prevalence of *Giardia* infection was highest among children aged 7-8 and infection increased as children became older.

2.7.5 Distributionof giardiasis in North America.

In the United States, *Giardia*is the most frequently identified parasite in stool specimens submitted for ova and parasites, and the overall prevalence for all age groups ranges from 4.0% to 12% depending on the year and state (Kappus*et al.,* 1994). In 39 states, *Giardia* was found to be the most frequently identified parasite every month of the survey periods; no information was reported specifically for prevalence in children. Harter *et al*. (1982) reviewed the results of randomly collected stool specimens in two counties of Washington State and found that 37 (7.1%) of 518 healthy 1- to 3-year-old children were positive for *Giardia* cysts. Caeiro*et al*. (1999) determined the etiology of acute, non-dysenteric diarrhoeaamong 147 children between 2 and 11 years of age from nine outpatient clinics in Texas, New York, Michigan, Florida, New Jersey, Utah, and Pennsylvania. A recognized etiologic agent was detected in the stools of 89(61%) of the children. *G. lamblia*was detected

in 22 (15%) children with a spring peak; most of the cases ofgiardiasis were identified in Houston, Texas, and Levittown, New York.

In an epidemiological study of endemic cases of giardiasis reported from 1983 to 1986 in Vermont, children aged one to four years had the highest incidence rate for symptomatic *Giardia* infection of any age group including adults (Birkhead and Vogt, 1989). Among children aged one to four years, the incidence of symptomatic giardiasis was almost four-fold higher than for infants less than one year of age and children 5-9 years of age. Among children aged one to four years, the incidence was 50% greater for boys (approximately1 200 cases/100,000/year) than girls (135/100,000/year). Among infants less than one year of age, symptomatic giardiasis rates were much lower, but the incidence was 40% greater for boys (55 cases/100,000/year) than girls (40/100,000/year). Incidence rates among girls and boys were similar after the age of 4 years: 40 cases/100,000/year for ages 5 to 9 years and 18 cases/100,000/year for ages 10-19. Isaac-Renton and Philion (1992) reviewed records from 2,186 *Giardia*-positive patients in British Columbia, Canada, and also found that the majority of *Giardia* infections were in the 1 to 5 year age group. Wright *et al.* (1977) reported the incidence of *G. lamblia*infection in Colorado among children age 0 to 15 years was 3.05 per 100,000 per year.

Giardiasis is often considered to be a disease of developing countries due to poor sanitation and lack of portable water supply (Olstein, 2001). The disease is worldwide in distribution, to the extent that even in developed nations where portable water could be contaminated with small amounts of sewage particularly if septic systems are built too close to water supply (Chalupka, 2005). The transmission of the cyst of *G. lamblia* could occur from person to person or by feco-oral route, but commonly it is by contaminated drinking water and food.

Infrequently transmission can occur by recreational activities involving contaminated water like during swimming (Thompson, 2000). Apart from that, children tend to commonly put their fingers or objects in their mouth and may even swallow pool water and mostly may not wash their hands well thereby increasing the chances of acquiring the infection (Stuart *et al.,* 2003).

2.8. Risk Factors of Giardiasis

Giardia has been recognized as a common causative parasite of diarrhoea (Marshall *et al.,* 1997) and nutritional disorders (Al-Mekhlafi *et al.,* 2005). In developed countries, giardiasis is considered a travel related disease. However, routine surveillance data from Germany indicate that >50% of infections were acquired indigenously (Werner *et al.,* 2010). Studies on risk factors for sporadic giardiasis have reported that in developed nations, giardiasis is significantly associated with drinking contaminated tap water, recreational exposure to fresh water and swim-ming pools, and travelling to developing countries (Hoque *et al.,* 2001).

In New Zealand, nappy changing was associated with a high risk of *Giardia* infection (Hoque *et al.,* 2003). However, in developing countries, socio-demographic factors play an important role in *Giardia* infections (Cifuentes *et al.,* 2004). In Malaysia, giardiasis is an endemic disease predominantly among children with prevalence ranging from 2.6% to 25% (Al-Mekhlafi *et al.,* 2005). Epidemiological studies have emphasized poverty, poor personal hygiene and lack of proper sanitation as factors playing major roles in the high prevalence of giardiasis. Although the Malaysian government has been very proactive in dealing with poverty, providing basic amenities and proper sanitation, infection rates have not reduced much since the 1970s.

Giardia is frequently spread directly from person to person, especially among young children attending day-care centers, nurseries, institutions, children living in areas with poor sanitation and hygiene, and children with siblings. In institutions, crowding, faecal incontinence, and poor personal hygiene may promote the transmission of infections among children (Hall, 1994). Children can also become infected from ingestion of contaminated drinking water and the accidental ingestion of water while swimming or other water recreation.

Infected infants and children, either symptomatic or asymptomatic, may transmit infection to other children or adults, especially family members or other care-givers. Higher incidence rates of symptomatic giardiasis (Birkhead and Vogt, 1989) and hospitalized cases of giardiasis (Lengerich *et al*., 1994) in women of child bearing age may be related to increased exposure to infected children. There is no evidence that *Giardia* is transmitted from mother to fetus (Hall, 1994), although infants can acquire infections at an early age suggesting that mothers can infect their children very soon after childbirth (Farthing, 1996).

2.8.1. *Giardia* in water.

*Giardia*cysts are distributed worldwide in surface waters, even those of excellent quality and have been found in surface waters from the Arctic to the tropics (U.S. EPA, 1998). Cysts occur in surface waters throughout all months of the year. Waterborne outbreaks have been reported, and some have resulted in a large number of cases of illness (U.S. EPA, 1998). In 26 waterborne outbreaks associated with drinking water in the United States, levels of *Giardia* cysts ranging from <1/100L to 580,000/100L were detected from either treated or source water (U.S. EPA, 1998). Children, as well as adults, have been affected by outbreaks associated with drinking water systems and recreational waters (U.S. EPA, 1998). Endemic

waterborne giardiasis in adults and children has also been associated with drinking unfiltered surface water or shallow wells and swimming (U.S. EPA, 1998).

Giardia has been the most commonly identified pathogen in waterborne outbreaks reported in the United States since 1971. During 1965 to 1996, 133 waterborne outbreaks and almost 28,000 cases of giardiasis were reported in the United States, primarily in unfiltered surface water systems (U.S. EPA, 1998). Ten (8%) of these outbreaks were associated with the use of individual drinking water systems or non-potable water sources, and 108 (81%) outbreaks were associated with public water systems; 14 (11%) outbreaks were associated with accidental ingestion of water during recreation. Unfiltered surface water systems were responsible for 56% of the reported waterborne giardiasis outbreaks in the United States. Communities with unfiltered surface water systems experienced a waterborne outbreak rate that was eight times greater than communities where surface water is both filtered and disinfected (U.S. EPA, 1998). Children were included among the reported cases in these outbreaks, but limited information is available on the number of cases or attack rates for children. In a waterborne outbreak in Berlin, New Hampshire, 38% of children under 10 years of age were infected; an infection rate of 60% was found in children 10-19 years (Lopez *et al.,* 2003). The infection rate among adults also ranged from 38 to 62%.

2.8.2. *Giardia* in pets.

Pets such as dogs, cats, snakes and other animals have been thought to present a risk for children, but there has been little epidemiological evidence that they pose a significant risk even though dogs and cats are often found infected. *Giardia* infection was found in 153 (77%) of 200 dogs and 9 (3%) of 300 cats tested in Minnesota (Bemrick, 1961). Similar prevalence were reported in Spain (Lopez-Brea, 1982) and Japan (Asano *et al.,* 1991).

Kirkpatrick and Green (1985) reported the prevalence of *Giardia* infection in cats to range from 1 to 11 percent in the United States. Franco and Cordeiro (1996) studied possible transmission of *Giardia* from pets in a study in Campinas, Brazil, but fecal examinations of the domestic animals were negative for *Giardia*. Chute *et al*. (1987) found no elevated risk of giardiasis associated with household cats or dogs in a study conducted in New Hampshire. De Sa Cardoso *et al*. (1995) found no association between *Giardia* infection in children under 5 years of age and domestic animals in a study in Aracaju, Brazil.

Giardia is the most frequently identified etiologic agent causing waterborne outbreaks in public water systems in the United States. Epidemiological studies of endemic giardiasis and reported waterborne outbreaks have identified higher risks among persons using unfiltered surface water. An estimated 155 million people in the United States continue to use unfiltered surface water from municipal water systems (U.S. EPA, 1998).

Public water systems that use surface water sources without filtration and that do not meet provisions of the SWTR (U.S. EPA, 1989) are considered at very high risk for waterborne transmission of giardiasis. Persons using shallow surface water are also at a higher risk of giardiasis. It is not known how many persons in the United States use shallow well water, and an estimate of children exposed to shallow surface water is not available. Outbreak investigations and epidemiological studies show that *Giardia* is also transmitted during swimming and other water recreational activities and the ingestion of contaminated water while attending picnics, camping, and hiking. Accidental ingestion of contaminated water while swimming and water play is also an important waterborne risk for young children. It is not known how many children may be exposed to potentially contaminated swimming pools, wading pool, lakes, and streams. Dog might get infected by contact with infected faeces from

another dog, Rolling and playing in contaminated soil, licking its body after contact with a contaminated surface (for example, a dirty litter box or dog cage or crate) and drinking water from a contaminated creek, pond, or other body of water.

2.8.3 Risk of travelling to giardiasis endemic areas

Children traveling to endemic areas are also at risk of infection. A suspected waterborne outbreak of giardiasis affected a 70% of 125 school children aged 10 to 12 years and 11 teachers from Walsall and Wolverhampton England who had gone on a cruise in the Western Mediterranean (Thompson *et al.,* 2008).Travel destinations were classified according to geographical regions and defined as high-risk (Central America, South America, Asia, Northern Africa and sub-Saharan Africa) or low-risk (Europe, Northern America, Australia and New Zealand) for contracting *Giardia*.

2.9 Clinical Signs of Giardiasis

The clinical diagnosis of giardiasis is difficult since symptoms are nonspecific and resemble those of a number of other gastrointestinal ailments. Common signs and symptoms of *Giardia* infection (in both humans and pets) are diarrhoea, gas, abdominal discomfort, nausea, and vomiting (Wolfe, 1990). However, it is possible to be infected and have no signs or symptoms of illness. Moreover, the symptoms observed vary with the life cycle stage of the parasite. The incubation period may last 12 to 19 days and is marked by the first detection of cysts in the faeces (Jopikii *et al.,* 1985).The clinical signs of parasitic infections in dogs are varied and occasionally some infected animals may present no symptoms (Ramirez-Barrios, 2004). These factors, coupled with inadequate information by dog keepers on the risks of disease transmission, control of zoonoses transmitted by domestic animals, control of stray dogs and poor of hygiene has resulted in an increased risk of exposure to zoonoses

transmitted by these animals (Sowemimo, 2008). Dog are infected from swallowing the *Giardia* cysts, usually in contaminated water. Water can be contaminated from faeces from infected dogs or other wild animals. *Giardia* is not transmitted from casual contact *Giardia* is more easily spread when the environment remains wet as dry environments do not allow the cysts to persist.

2.10 Transmission of *Giardia*

2.10.1 Cross-species transmission of *Giardia*

Giardia from some animals exhibit an apparent high degree of host specificity; other isolates may infectmore than one host. Recently conducted, carefully controlled studies indicate that cross-species transmission of *Giardia* can occur.Traditionally, species designations were assigned mainly based on the host species (Kirkpatrick, 1987).Classification was also based on morphologic characteristics (Sedinova *et al.*, 2003) (e.g., cell shape, morphometrics of cysts and trophozoites). Then, from the 1960s through the 1980s, a tendency arose to lump the different species of *Giardia* occurring in mammals (other than mice) as *G. duodenalis*, as redescribed by Filice(1952).

More recently, molecular methods have indicated that distinct groups of *Giardia* organisms (called assemblages) infect certain groups of hosts (Sedinova *et al*., 2003).The most commonly applied assemblage clusters place assemblages A/B in people, assemblages C/D in dogs, assemblage E in hoofed stock, assemblage F in cats, and assemblage G in rats; mice are host to their own recognized species, *Giardia muris*.The species-specific assemblages suggest that the potential zoonotic threat from these organisms is low. We now know that typically, people get *Giardia* A/B from other people, dogs get *Giardia* C/D from other dogs, cats get *Giardia*F from other cats, and cattle get *Giardia* E from other hoofed stock. Thus, for the

most part, people get human giardiasis, dogs get caninegiardiasis, and cats get feline giardiasis, and therisk of zoonotic infection is now thought to be much lower than when all species were lumped simply under the same name *G. duodenalis*.

2.10.2 Transmission of giardiasis between animals.

Studies using *Giardia*- free mice showed that *G. simoni, G. muris*and *G. peromysci* were host-specific while *G. microti* and *G. mesocricetus* were not. Mice were successfully infected with *Giardia* from hamsters, but *Giardia* cysts obtained from parakeet faeces and stored for 1-3 days were unable to infect mice or canaries. Erlandsen *et al.* (1987) found that beavers did not become infected when inoculated with cysts of *G. ondatrae* from muskrats or with *G. muris* from mice; however, five of eight (62%) muskrats became infected when administered *Giardia* cysts of beaver origin.

2.10.3 Transmission of giardiasis between animals and humans.

There have been cases under certain circumstances in which the human assemblage has been found in dogs (Traub *et al.*, 2004). *G. duodenalis* assemblage A has been recovered from humans and dogs living within the same locality (Traub *et al.,* 2004). In an urban setting inJapan, a mix of human- and dog-specific assemblages were recovered from dogs in breeding kennels and households (Hopkins *et al.*, 1997). In contrast, a study of an Australian aboriginal community found dogs to harbor purely dog-specific assemblages (Itagaki *et al.*, 2005).Questions clearly linger regarding the amount of crossover that actually occurs between these different assemblages and their hosts under conditions that allow transmission. In addition, the general public is aware of human giardiasis as a disease entity, and clients may refuse to accept an explanation of it being non-zoonotic. Thus, the simple response to the question of treatment is to treat the infected animals and thereby remove anypotential risk

for both humans and other animals.Erlandsen*et al*. (1990) showed that viable cysts, from symptomatic human donors, can cause infection in the beaver and muskrat and concluded that the beaver and muskrat were possible intermediate reservoirs for *Giardia* that infects humans. Cyst-bearing faeces of rats, mice, dogs, cats and deer may occasionally reach drinking water, these animals do not, as beavers and muskrats do, by nature defecate in water. The beaver has also been implicated as a source of contamination in waterborne outbreaks (Isaac-Renton and Philion, 1992).

2.11 Environmental occurrence of *Giardia*.

2.11.1 *Giardia* in surface water.

Cysts have been found all months of the year in surface waters from the Arctic to the tropics in even the most pristine of surface waters. Occasionally, seasonal variations are reported. Cyst levels are generally higher in rivers or streams influenced by agricultural (e.g., cattle or dairy farming) or residential (e.g., sewage discharges) activities. Cysts occur in surface waters throughout the year. In North America, levels are generally higher in the late summer to early winter. Generally, no relationship is seen between cyst levels and bacterial indicators of water contamination. In the United States, levels of *Giardia* in water are somewhat lower than *Cryptosporidium*; in Canada, surveys have found higher levels of *Giardia* than *Cryptosporidium*.

2.11.2 *Giardia* in waste water.

Examination of *Giardia* in raw sewage has been suggested as a way to assess the prevalence of *Giardia* infection and detecting possible outbreaks in communities. Only one study has examined the relationship between cysts in sewage and illness in the community; a correlation was found between raw sewage cyst levels and reported cases of giardiasis in 11

cities in the United States (Jakubowski *et al.*, 1991). All of the raw sewage samples were positive for *Giardia*, 48% of secondary effluent samples contained from 1 to 44 cysts/L, and 80% of the sludge samples contained from 70 to 30,000 cysts/L.

2.11.3 *Giardia* in ground waters.

Archer *et al*. (1995) did not detect *Giardia* in any of 17 samples from six wells in Wisconsin. Hibler (1988) found *Giardia* cysts in 19% of springs and 3% of wells sampled. Lee (1993) reported the contamination of two wells in Pennsylvania by surface streams less than 100 feet from the wells;*Giardia*was recovered from all samples collected from the wells. Hancock *et al.* (1997) collected 463 groundwater samples from 199 sites in 23 states in the United States; *Giardia* cysts were found in 14% of the springs, 1% of the vertical wells, 36% of the horizontal wells, and 25% of the infiltration galleries. The mean levels in positive water samples was 8 cysts/100 L (range = 0.1 to 120/100 L).

2.11.4 *Giardia* in contact surfaces.

Cody *et al*. (1994) evaluated a method for detecting *Giardia* cysts from environmental surfaces, and field tested the method in six commercial child day-care centers. The method was capable of recovering spiked cysts from Formica® surfaces when they were inoculated with 10 to 190 cysts on a surface area of 50 cm^2 or with 10 to 20 cysts/400 cm^2. Recoveries from stainless steel surfaces were lower and false negatives were higher. Cysts were not recovered from wood and fibreglass surfaces spiked with 190 cysts/400 cm^2. In two day-care centers; two fibreglass chairs (6%) and one Formica® table (2%) surface were found to be positive for *Giardia* cysts.

2.11.5 *Giardia* in soil.

The wide distribution of cysts in human and animal populations suggests that soil may be contaminated with *Giardia* through faecal deposition, irrigation and sewage treatment practices. However, no published data are available on cyst levels in soil, survival in soil, or transport through soil matrices. A progress report from the Cornell University Whole Farm Planning Scientific Support Group (1993) discusseddevelopment and evaluation of a soil sampling protocol and detection method to evaluate the prevalence andtransport of *Cryptosporidium* oocysts and *Giardia* cysts on dairy farms within the New York City watershed.

2.11.6 *Giardia* in air.

Data found indicates that *Giardia* cysts were released into the air and are transported via airborne route.

2.11.7 *Giardia* in food.

There are a lack of quantitative data on the occurrence of *Giardia* cysts in foods, and improvements are needed in both sampling and analysis. Although foodborne giardiasis outbreaks in the United States have involved fish, sandwiches, vegetables, fruit and noodle salad, no information was available for *Giardia* levels in these foods. Barnard and Jackson (1984) described four techniques that were originally developed for clinical specimens and had been adapted to foods. One of the techniques (sedimentation/zinc sulphate flotation) was used by Italian investigators to isolate *Giardia* cysts from lettuce in 1968; 75% of 64 heads of lettuce collected at random from four markets in Rome, Italy, were found positive for cysts.

2.12 Treatment of *Giardia*.

As with all diarrhoeas, fluid replacement is an important aspect of treatment. Anti-giardial drugs are also important in the management of individual cases of giardiasis, but they may not prevent frequent reinfection of children who attend day-care centers or live in communities where *Giardia* exposures are routine.

Chemotherapeutic agents used for treatment of giardiasis include metronidazole, tinidazole, quinacrine, furazolidone, albendazole, and ornidazole (Benenson, 1995; Farthing, 1996; Adam, 1991; Ortega and Adam, 1997; Rabbani and Islam, 1994). Various doses and treatment periods are recommended for each drug. These agents have different effectiveness in their ability to clear *Giardia,* and side-effects should be considered. Drug resistance or re-infection may occur. Paromomycin is recommended for pregnant women, but the cure rate may be low.

2.13 Health Effects of *Giardia* in Animals

Organisms in the genus *Giardia* have been reported as intestinal inhabitants within a variety of mammals, birds, reptiles, amphibians, and fishes. *Giardia* infection in animals is also spread via the fecal-oral route. Infection occurs worldwide, in most animal species; is more often than not asymptomatic; and is much more likely to spread within a host species than from one host species to another (Erlandsen *et al.,* 1987). In animal species (e.g., calves, cats, dogs) whose *Giardia* infections have been studied in detail, the resultant effects resemble those seen in humans. *Giardia* infection is more likely to be symptomatic in young animals. Mortality appears to be significant in some animals, e.g., chinchillas and budgerigars.

The parasites interfere with normal metabolism by forming a physical barrier between the lumen of the intestine and the absorptive cells. Excess mucus results from malabsorption of fats while excess water results in the diarrhoea. The intestinal lining is not usually injured so stools should not contain blood. The parasites feed on partially digested food in the lumen of the intestine. They do not compete directly with the host for food. Their metabolism is primarily anaerobic, meaning that they do not utilize oxygen in their respiration. They lack cellular organelles concerned with aerobic respiration such as mitochondria.

2.14 Dog Epidemiology in Zaria

The domestic dog (*Canis lupus familiaris*) is generally considered as the first domesticated mammal and has coexisted with man as a working partner and house pet in all eras and culture since the days of the cave dwellers (Brickner, 2002).In Nigeria, in addition to the role of the dog as a companion animal, dogs serve to provide an important source of protein to man. Dog meat is a delicacy and highly sought for in many parts of the country. Giardiasis in animals has received increasedattention in recent years, partly because *Giardia*infections do cause disease in people, and numerous human giardiasis outbreaks have been associated with drinking and recreationalwater (Hlavsa *et al.,* 2005).

However, dogs like many canines have been reported to harbour a variety of intestinal parasites, some of which can also infect livestock, wildlife and humans (Salb *et al.,* 2008). In addition, dogs are reported to act as transport host of many roundworms of man when they ingest infected human faeces (Hayward, 2004). Several epidemiological studies were conducted to assess the situation of intestinal parasitic infections in canines in Nigeria and other parts of the world (Anosike, 2004), information on the prevalence of intestinal helminths in dogs in Kaduna State is scanty.

2.15 *Giardia* as Water Safety Threat

The infectious cysts of *Giardia* are found in the faeces of infected animals (Hunter & Thompson, 2005). *Giardia* are organisms that pose a health threat in developed, as well as developing, countries. The World Health Organization placed these parasites on its list of neglected diseases due to the need for further preventative and treatment method research (Chakrabarti and Chakrabarti, 2009).The main public health threat currently posed by these organisms is a waterborne outbreak. *Giardia* concerns arise because: they are easily spread through ingestion of contaminated drinking water, recreational water, and food; easily spread by fecal-oral routes involving animals and soil; and is highly resistant to disinfection by chlorination at levels that are not toxic to people (Kosek*et al.*, 2001).

In 1998 the main water supply in Sydney, Australia was contaminated with *Giardia,* affecting over three million residents (Stein, 2000). In Florida there have been over 1,000 cases of *Giardia* is reported annually for more than a decade. In 2006 a neighbourhood water fountain became contaminated resulting in an outbreak with 38 cases of Giardiasis, 9 cases of cryptosporidiosis, and 2 cases of co-infection. According to the US EPA almost all of the *Giardia* outbreaks in the US after 1985 occurred as a result of a fault in treatment and/or filtration of water (US EPA, 2001). It is apparent that giardiasis is a disease of major concern due to their health and economic impacts. Enhanced water purification protocols were put into place in an effort to stem the spread and occurrence of *Giardia* from getting into any potable water source. As this disease is generally spread in a fecal-oral route, the highest degree of action was taken in the treatment of source water and wastewater that are open to the environment. Current requirements apply to public water systems that use ground or

surface water that is under the direct influence of surface water, the types of water that are most susceptible to protozoan contamination.

In 1974 the U. S. Congress enacted the Safe Drinking Water Act as a public health measure to assure the safety of the nation's drinking water supply. The regulations enacted examine chemical, microbiological, physical, and radiological contamination in water. This act was later amended and in 1989, *Giardia* was added as a contaminant for regulation. The long Term 1 Enhanced Surface Water Treatment Rule was enacted in 2002 and lead to the current Long Term 2 (LT2) Enhanced Surface Water Treatment Rule developed in 2006. The goal of these rules is to control microbial pathogens in water while minimizing the public health risks of disinfectants, disinfection by products, and chemical contaminants.

The Safe Drinking Water Act Amendments of 1996 require the US EPA to evaluate public health risks posed by drinking water contaminants including *Giardia*. The US EPA is responsible for assessing the parasite occurrence in raw surface waters used as source water for drinking water treatment plants. EPA Method 1623 was designed as the detection method for *Giardia* in water from the treatment plants. The results were submitted to the US EPA for the purpose of monitoring the source of water and to determine if additional treatment is required. This is essential to monitor increases in microbial risk that may occur when systems implement the Stage 2 Disinfectants and Disinfection By-products Rule (Stage 2, DBPR).

2.16 Public Health Action of *Giardia*

This study provides data to educate public health practitioners and health-care providers about the scope and magnitude of giardiasis in the Zaria. These data can be used to establish research priorities and to plan future prevention efforts.Despite the public health importance

of giardiasis, reliable data on prevalence and public health significance of *Giardia* infection in dogs and drinking water in the Zaria are not available. Estimates have been extrapolated from published data collected by United States with active giardiasis surveillance, laboratory surveys, and waterborne-disease outbreak reports. Giardiasis is the most frequently reported diarrheal disease in northern New England (Dennis *et al.*, 1993), and from 1983 through 1986, it was the most common reportable disease in Vermont (Birkhead and Vogt, 1989). *Giardia* also was the most prevalent protozoan parasite in Arkansas during 1997 (Daly *et al.*,1997) as well as the most commonly reported enteric pathogen in Wisconsin during the years 1983--1986 (Addis *et al.*, 1992).

2.17 Prevention of Giardiasis.

Prevention (CDC) report on giardiasis in the United States described data for 1998 to 2002, with 19,708 to 24,226 cases reported per yearduring that time period.15 Reported cases weregreatest among young people, in more northern states, and during the summer months. The actual number of cases was believed to be much higher, anywhere from 424,120 to 2,120,600 cases in 2002, equating to a possible annual incidence of 0.15% to 0.73%.

It is very difficult to prevent the entry of an infection that isknown to be carried by a percentage of normal dogs into a kennel. However, an initial period of isolation for all new entrants into kennels, for perhaps ten days, would reduce the risk of an infected dog spreading a large number of cysts around the main kennel area. All dogs could be observed and any infection present, which in the case of *Giardia* might be exacerbated by the stress of entry in kennels, could be identified and treated before entry into the main kennels.

Dogs should be prevented from access to foul water that may contain large numbers of cysts (e.g.: river-flooded paddocks). Small numbers of cysts may occasionally be present in the

potable water supply but the risk of this being a major source of infection is small. It is best to use chlorinated water for your dog's drinking water as much as possible. If you are using non-chlorinated water from a well, lake, or stream, you need to chlorinate the water yourself. To chlorinate drinking water: Use only liquid bleach that contains 5.25% sodium hypochlorite as its only active ingredient - no soap. Use a scant 4 drops of Clorox bleach per quart of water or 2 teaspoons per 10 gallons. As an alternate method of purification, you can also boil all of your dog's drinking water. To make sure the water is completely free from living bacteria and protozoans, you need to bring the water to a rapid boil for a minimum of five (5) minutes.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area

This study was carried out in Zaria metropolis which consists of two Local Government areas namely, Zaria and Sabon-Gari, Kaduna State, Northern Nigeria located on a plateau at a height of 2, 200 feet above the sea level (Mortimore, 1970). From each of these two Local Government Areas, three major districts were randomly selected for this study. The districts used were Samaru, Kwangila and Sabo all in Sabon-gari Local Government Area. In Zaria Local Government area, Tudunwada, Dan-magaji and Zaria city. Zaria town is situated between latitude $11^{0}07^{1}51^{11}$N and longitude $7^{0}43^{1}43^{11}$E (MED, 1996). It has a population of 408, 198 people according to 2006 Census (KDSG, 2008). There are two major seasons; wet (May to October) with a mean annual rainfall of 1092.8mm, and the dry season which spans between November to April. The monthly temperature shows a maximum of 39.7^{o}C in June and 13.8^{o}C in December (KDSG, 2008).

3.2 Study Design andSampling Procedure

A cross sectional study was used in this study. The sampling sites constitutes Zaria (Dan-magaji, Zaria city and Tudun-wada) and Sabon-gari (Kwangila, Samaru and Sabo) Local Government Areas (Figure: 3.1). A total of 402 faecal samples were collected within the six (6) locations in Zaria. A total of 201 samples each were collected from three (3) locations (Dan-magaji, Zaria city and Tudun-wada) in Zaria and Sabon-gari (Kwangila, Samaru and Sabo) Local Government Areas. Within each of the six (6) locations 67 samples were collected and households owning dogs were conveniently selected based on owner's compliance. A total of 120 water source samples were collected. Twenty (20) water samples were collected from each location. Within each location, 5 samples each of well water, tap water, streams and borehole water were collected. Sampling locations were visited four times a week (Monday to Thursday). Five (5) water samples each sourced from wells, taps, streams and boreholes in each district were collected making a total of 120 samples.

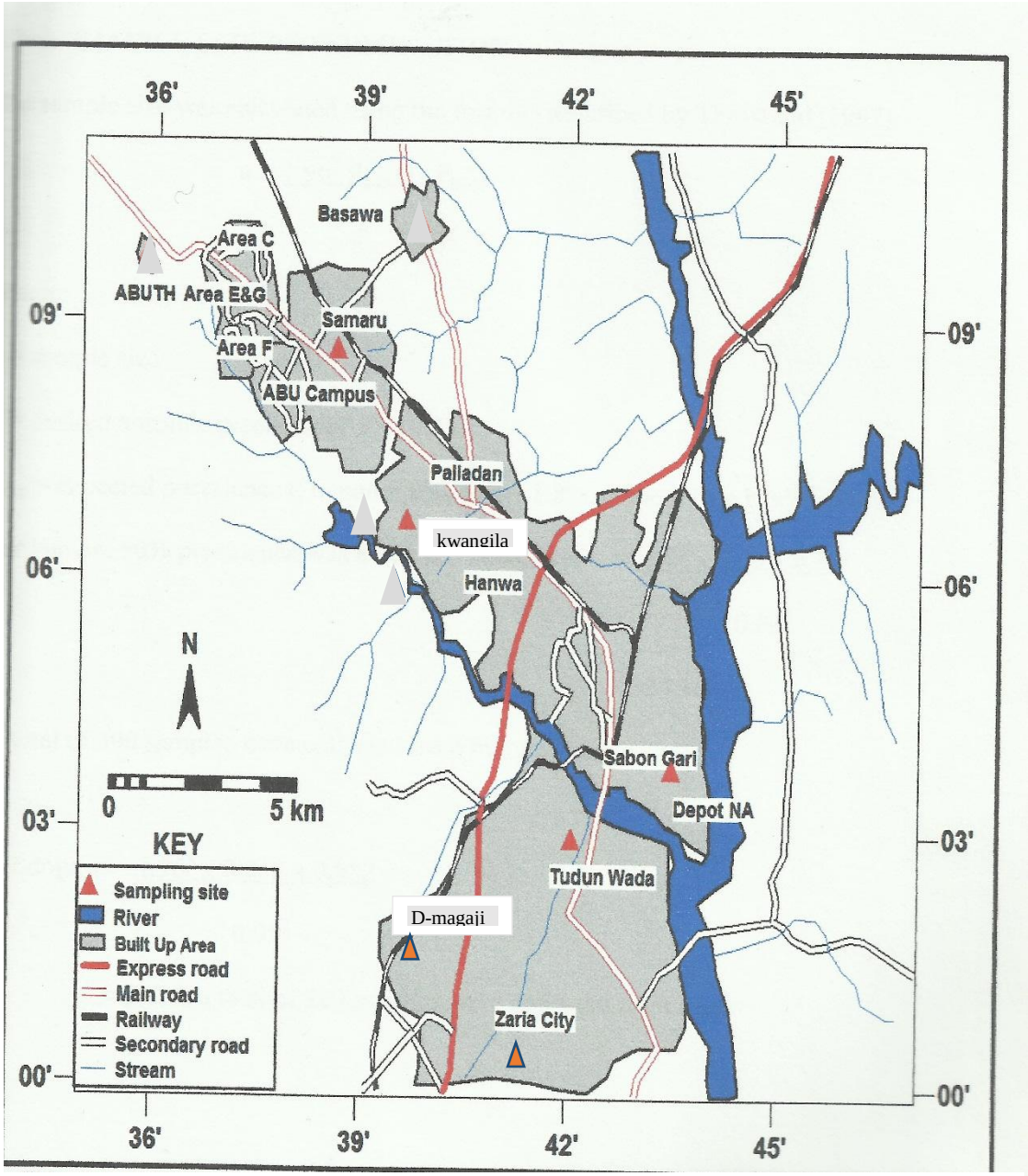


Figure 3.1: Study area showing sampling sites
Source: Modified from Google Earth, (2011)

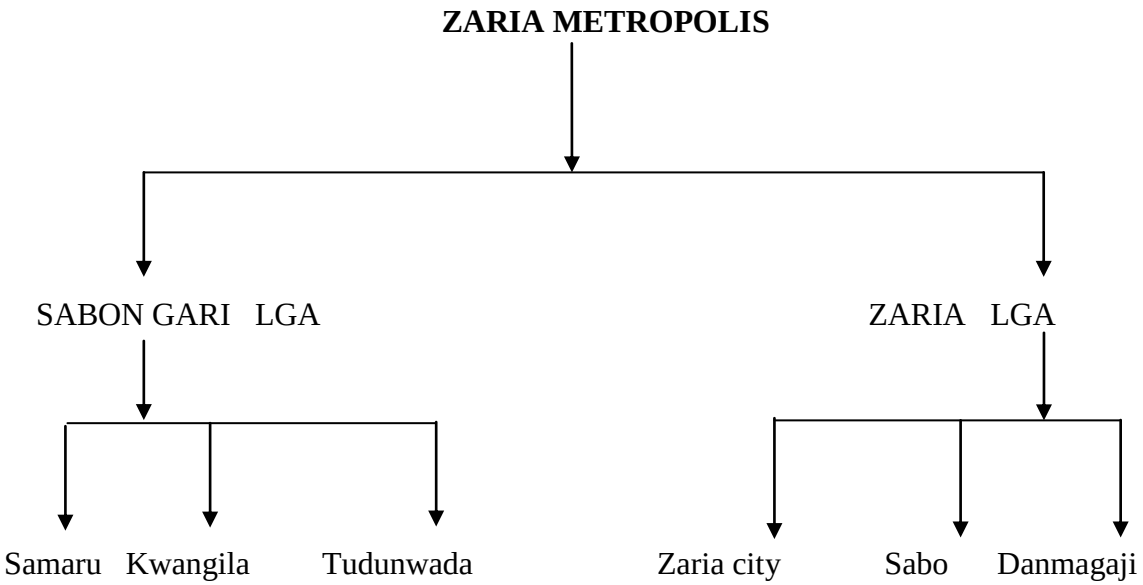


Figure 3.2: Flow Chart Showing the Major Districts Covered Zaria Metropolis.

3.3 Sample Size

The sample size was calculated using the formula by Mahajan (1997).

$$N = Z^2pq/d^2$$

Where;

$q = 1 - p$

d = desired absolute precision 0.05

z = appropriate value for the standard normal deviate set at 95% confidence interval (1.96).

a) Drinking water, at P_1 = (3.52%, Inabo *et al.*, 2011).

Therefore,

$$n_1 = \frac{1.96^2 \times 0.0352 \times 0.9648}{0.05^2} = 51$$

60 water source samples were collected in one liter clean bottles from each Local Government area (LGA) making a total (n_1) of 120 for the two Local Government Areas.

b) Dogs, at P_2 = (15.6%, Carlin *et al.,* 2006)

$$n_2 = \frac{1.96^2 \times 0.156 \times 0.844}{0.05^2} = 201$$

201dog faecal samples were collected from each Local Government Area making a total of 402 for the two Local Government Areas.

3.4 Structured Questionnaire

A structured questionnaire was administered inform of interview for collection of data. The questions asked included personal details, source of water, presence of diarrhoea, frequency of diarrhoea, sources of water for personal use and for dogs (Appendix 1).

3.5 Sample Collection

3.5.1 Dogs

Convenience random sampling technique was used to select dog owning houses in each location. Samples were collected between July and September 2013.Dogs were restrained by their owners and single faecal sample were taken from the rectum of each dog by means of a disposable polythene bag inverted over the index finger and emptied into a wide-mouthed disposable plastic container (Kosuwin*et al.,* 2010). Faecal samples collected were stored in packs and transported to Parasitic Zoonosis Laboratory, Department of Veterinary Public Health and Preventive Medicine, Ahmadu Bello University, Zaria.

3.5.2 Water source sampling

The water samples were sourced from wells, boreholes, taps and streams. The samples were collected in a litre of sterile plastic bottles. The bottles were filled with the water samples,

covered and transported to Parasitic Zoonosis Laboratory, Department of Veterinary Public health and Preventive Medicine, Ahmadu Bello University, Zaria.

3.6 Laboratory Analysis of Samples

3.6.1Dog faecal examination

Three (3.0)grams of each faecal sample was emulsified in water and then sievedinto a centrifuge test tube. This was topped with Zinc sulphate media and filled to brim covered with cover slip asdescribed by Urquhart *et al.* (1996). Theemulsion was centrifuged at 2000 rpm for 2minutes. Thereafter, the cover-slip was gently removed, placed on clean glass slides andexamined under the microscope. Positive faecal samples for cysts were identified as described by Adam *et al*. (1979) and Soulsby (1982).

3.6.2Preparation of drinking water samples

A total of 120 litres of water samples were examined for *Giardia* cyst. The water samples werebrought to the laboratory and allowed to stand opened for 12hours. It was later decanted into a sink. The sediments were filteredinto a centrifuge test tube and concentrated by repeated centrifugation at 1500*g*,rmp in 50 ml conical-bottomed centrifuge tubes before being brought down to 10 ml. The final concentrated sample was reduced to a final volume of 1—5 ml, depending on water turbidity. For each sample 5ml of sample concentrate was top up with the Zinc sulphate floatation media to the brim and covered with a cover slip to stand for 10 minutes. The cover slip was gently removed and placed onto a clean microscopic slide. Samples were stained with iodine. It was viewed under x10 objective lens and x40.

3.7DataAnalysis

Chi square was used to test for association between *Giardia* infection and factors such as age, sex, breed and location using Statistical Package for Social Science (SPSS) version 20.0. P values < 0.05 was considered significant. Percentage based prevalence was calculated using the formula:

$$\text{Prevalence (\%)} = \frac{\text{number of positive samples}}{\text{Total sample collected}} \times 100$$

CHAPTER FOUR

RESULTS

4.1 Prevalence of *Giardia*Cysts amongDogs in Zaria

Of the 402 dog faecal samples examined, 70 (17.4%) were positive for*Giardia* cysts (plate I). The cyst is oval shaped, and measures 8-14µm by 7-10µm, with distinct nuclei and median bodies seen as described by Adam *et al*. (1979). The highest prevalence of*Giardia* cysts was15 (22.4%) in Tudun-wada, followed by Kwangila 14(21.0%), Samaru 13(19.4%), Zaria city 11(16.4%), Dan-magaji 10 (14.9%) and Sabo 7(10.4%). There was no statistical association (P=0.480) between*Giardia*cysts in dogs and districts sampled (Table 4.1).

There wereother parasite eggs and oocysts seen among the 402 dog faeces examined. These were eggs of *Taenia*28(7.0%), *Ancylostoma*20(5.0%), *Toxocara*20(5.0%), *Dipylidium*7(1.7%), *Capillaria*6(1.5%) and*Isospora* oocyst 13(3.2%) (Plate II-VIII). The district-based prevalence for the parasite eggs and oocystswere Samaru 20(5.0%), Kwangila 21(5.2%), Sabo 21(5.2%), Tudun-wada 18(4.5%), Dan-magaji 6(1.5%) and Zaria city 7(1.7%) (Table 4.2).

Table 4.3 shows the difference inprevalence in*Giardia* cysts from both diarrhoeic and non diarrhoeic dogs. Of the total 364 dogs that had diarrhoea,64(17.6%) were positive for *Giardia* cysts. There was no significant association (P=0.782) between the prevalence of *Giardia* cysts and dogs with diarrhoea.

Table 4.1: District-Based Prevalence of *Giardia*Cysts in Dog Faeces in Zaria, Kaduna State.

District	Number Examined	Number positive (%)	x^2	df	P
Samaru	67	13(19.4)	4.4497	5	0.480
Kwangila	67	14(20.9)			
Sabo	67	7(10.4)			
Danmagaji	67	10(14.9)			
Tudun wada	67	15(22.4)			
Zaria city	67	11(16.4)			
Total	402	70(17.4)			



Plate I: *Giardia* cyst. Magnification: X40

Table 4.2: Districts-Based Prevalence of Eggs/Oocysts Parasites in Dogs in Zaria, Kaduna State.

Location	Numberexamined	Number positive (%)	Parasite eggs and oocysts					
			Taenia	*Dipylidium*	*Capillaria*	*Toxocara*	*Isospora*	*Ancylostoma*
Samaru	67	20(5.0)	9	0	1	1	2	7
Kwangila	67	21(5.2)	5	2	0	4	7	3
Sabo	67	22(5.5)	7	2	0	10	1	2
Tudunwada	67	18(4.5)	4	1	3	3	1	6
Danmagaji	67	6(1.5)	2	0	1	1	1	1
Zaria city	67	7(1.7)	1	2	1	1	1	1
Total	402	94(23.4)	28(7.0)	7(1.7)	6(1.5)	20(5.0)	13(3.2)	20(5.0)

Table 4.3 Prevalence of *Giardia*Cysts in Dogs with diarrhoea in Zaria, Kaduna State

Diarrhoea	Number examined	Number positive (%)	x^2	df	P
present	364	64(17.6)	0.077	1	0.782
absent	38	6(15.8)			
Total	402	70(17.4)			

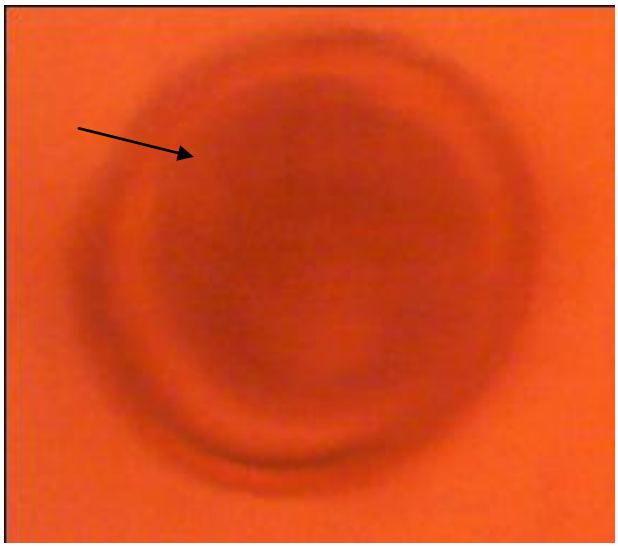


Plate II: *Toxocara* egg. Magnification: X40



Plate III: *Capillaria*egg. Magnification: X40

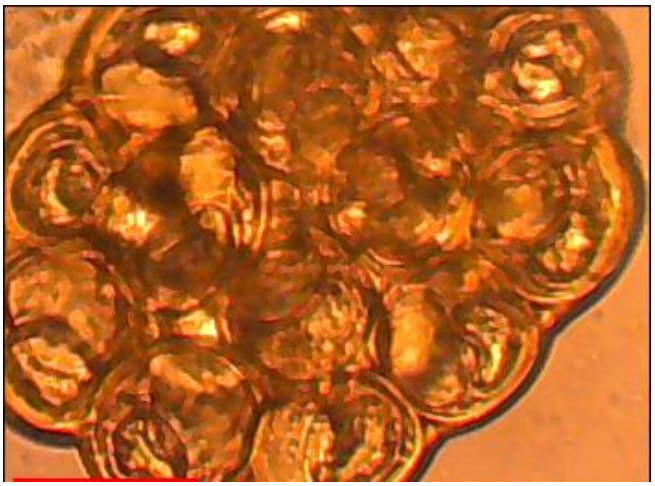


Plate IV: *Dipylidium*egg. Magnification: X40

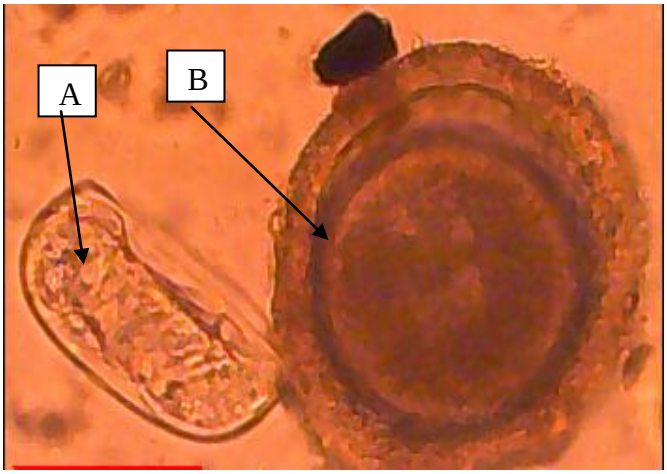


Plate V: *Ancylostoma* egg (A) and *Toxocara* egg(B). Magnification: X40



Plate VI: *Taenia* egg. Magnification: X40



Plate VII: *Ancylostoma*eggs. Magnification: X40



Plate VIII: *Isospora*oocyst. Magnification: X40

Giardia cystswere higher in male dogs 42 (18.9%)than in females 28(15.6%). There was no significant association (P=0.377) between*Giardia*cysts and sex (Table 4.4).Likewise other parasite eggs and oocysts seen were higher 56 (25.2%) in males than in females 38 (21.1%) (Table 4.5).

Higherprevalence of *Giardia*cysts was observed in puppies (<6months) 37(18.1%) than adults (>6months) 33(16.7%) (Table4.6). There was no significant association (P=0.697) between*Giardia*cysts and theage-group of dogs sampled. Other parasite eggs and oocysts seen was higher 54(26.5%) in puppies (<6months) thanin adults (>6 months) 40(20.2%) (Table 4.7).

Table 4.4 Sex-based prevalence of *Giardia* cysts in dogs in Zaria, Kaduna State.

Sex of dog	Number Examined	Number positive (%)	x^2	df	P
			0.782	1	0.377
Male	222	42(18.9)			
Female	180	28(15.6)			
Total	402	70(17.4)			

Table 4.5 Sex-based prevalence of eggs/oocysts of parasites in dogs in Zaria, Kaduna State.

Sex of dog	Number examined	Number positive (%)	Parasite eggs and oocysts					
			Taenia	*Dipylidium*	*Capillaria*	*Isospora*	*Toxocara*	*Ancylostoma*
Male	222	56(25.2)	16	5	3	14	7	11
Female	180	38(21.1)	12	2	3	6	6	9
Total	402	94(23.4)	28(7.0)	7(1.7)	6(1.5)	20(5.0)	13(3.2)	20(5.0)

Table 4.6 Age-based prevalence of *Giardia* cysts in dogs in Zaria, Kaduna State.

Age of dog	Number examined	Number positive (%)	x^2	df	P
			0.151	1	0.697
Puppies(<6months)	204	37(18.1)			
Adults (>6months)	198	33(16.7)			
Total	402	70(17.4)			

Table 4.7: Age group-based prevalence of eggs/oocysts parasites in dogs in Zaria, Kaduna State.

Age	Number examined	Number positive (%)	Parasite eggs and oocysts					
			Taenia	*Dipylidium*	*Capillaria*	*Toxocara*	*Isospora*	*Ancylostoma*
Puppies (<6months)	204	54(26.5)	15	2	5	12	7	13
Adults (>6months)	198	40(20.2)	13	5	1	8	6	7
Total	402	94(23.4)	28	7	6	20	13	20

Higherprevalence of *Giardia*cysts was observed in cross/exotic breeds 19(20.9%) as compared to local breeds 51(16.4%). There was no statistical association (0.322) between *Giardia*cysts and breed of dog (Table 4.8). The breed-based prevalence of eggs and oocysts of other parasites as shown in the study are as follows; local 73(24.5%) and cross/exotic breed 21(23.1%) (Table 4.9).

Thirty six (17.9%) out of the 201 dogs sampled in Sabon-gari Local Government Area were positive for *Giardia* cysts, while in Zaria local Government Area, it was 34(16.9%) out of the 201 dogs sampled that were positive (Table 4.10). For other categories of parasites eggs and oocysts,other than *Giardia* cysts, the prevalence was higher in Zaria Local Government Area 63(31.3%) than Sabon-gari Local Government Area 31(15.4%) (Table 4.11).

Table 4.12 shows higher 63(15.7%) prevalence in strayed dogs than in confined dogs 7(14.6%). There was statistically significant association (P=0.01) between *Giardia* cysts and straying of dogs.

4.2 Prevalence of *Giardia* Cysts in Water Sources in Zaria town, Kaduna State.

Two (1.7%) out of the 120 water source samples examined were positive for *Giardia* cysts. The positive samples werefrom Samaru, 1(5.0%) andSabo, 1 (5.0%). No *Giardia* cysts were identified inwater sourcesamples collected from Kwangila, Tudunwada, Danmagaji and Zaria city (Table: 4.13). All the positive samples were from streamwater 2(6.7%). There was no *Giardia* cyst in samples collected from tap, well and borehole (Table: 4.14).

Table 4.8 Breed-based prevalence of *Giardia* cysts in dogs in Zaria, Kaduna State.

Breed	Number examined	Number positive (%)	x^2	df	P
Local	311	51(16.4)	0.322	1	0.983
Cross/Exotic	91	19(20.9)			
Total	402	70(17.4)			

Table 4.9 Breed-based prevalence of eggs/oocysts parasites in dogs in Zaria, Kaduna State.

Breed	Number examined	Number positive (%)	Parasite eggs and oocysts					
			Taenia	*Dipylidium*	*Capillaria*	*Toxocara*	*Isospora*	*Ancylostoma*
Cross/Exotic	91	21(23.1)	6	1	1	5	2	6
Local	311	73(24.5)	22	6	5	15	11	14
Total	402	94(23.4)	28	7	6	20	13	20

Table 4.10 Prevalence of *Giardia*Cysts between two Local Government Areas in Zaria

LGA	Number examined	Number positive(%)	x^2	df	P
Zaria	201	34(16.9)	4.4497	5	0.480
Sabon-gari	201	36(17.9)			
Total	402	70(17.4)			

Table 4.11 Prevalence of Eggs/Oocysts Parasites between two Local Government Areas in Zaria.

LGA	Number examined	Number positive (%)	Parasite eggs and oocysts					
			Taenia	*Dipylidium*	*Capillaria*	*Toxocara*	*Isospora*	*Ancylostoma*
Zaria	201	63(31.3)	21	4	1	15	10	12
Sabon-gari	201	31(15.4)	7	3	5	5	3	8
Total	402	94(23.4)	28	7	6	20	13	20

Table 4.12 Prevalence of *Giardia* cysts in stray and confined dogs in Zaria, Kaduna State.

Dog	Number examined	Number positive(%)	Odds ratio (OR)	95% confidence interval on OR
Stray	354	63(17.8)	1.27	0.54-2.96
Confine$^{(ref)}$	48	7(14.6)	1.00	-
Total	402	70(17.4)		

Ref: Reference category

($\square^2$ = 0.973; df = 1; p = 0.01)

Table 4.13: Prevalence of *Giardia* cyst in water sources in different wards of Zaria.

Ward sampled	Number examined	Number positive (%)
Samara	20(16.7)	1(5.0)
Kwangila	20(16.7)	0(0.0)
Sabon gari	20(16.7)	1(5.0)
Danmagaji	20(16.7)	0(0.0)
Tudun wada	20(16.7)	0(0.0)
Zaria city	20(16.7)	0(0.0)
Total	120(100.0)	2(1.7)

Table 4.14 Source-based prevalence of *Giardia* cysts in water sources in Zaria, Kaduna State.

Water source	Number examined	Number positive (%)
Tap	30	0(0.0)
Stream	30	2(6.7)
Well	30	0(0.0)
Borehole	30	0(0.0)
Total	120	2(1.7)

Table 4.15 shows an overall prevalence of parasite eggs and oocysts in water to be 7(5.8%)with *Ancylostoma*eggs having the highest prevalence 5(4.2%), followed by *Isospora*oocysts 2(1.7%). Samaru had highest overall prevalence of 3(15.0%) followed by Kwangila 2(1.7%) while Danmagaji and Tudunwada had 1(5.0%) each, Sabo and Zaria city had none. Specific parasite prevalence in the districts were as follows:*Ancylostoma* eggs were highest 3(15.0%) in Samaru, while 1(5.0%) each in Kwangila and Tudunwada, and none in Sabo, Danmagaji and Zaria city,*Isospora* eggs were1(5.0%) each in Kwangila and Danmagaji while Samaru, Tudunwada and Zaria city had none (0%).

Table 4.16 shows distribution of parasite eggs and oocysts in drinking water samples as follows: tap 1(5.0%), borehole 2(1.7%), well 3(15.0%) and stream 1(5.0%). Parasite specific prevalence for*Isospora* oocyst was1(5.0%) each in borehole and well while tap and stream had none (0%), while for*Ancylostoma*egg it was 1(5.0%) each in tap, borehole and stream and 2(6.7%) in well.

Table 4.17 shows the association between the risk factors of *Giardia* cysts in dogs. The total number of respondents who were the dog owners was 402. Type of feed given to dogs were normal family food 80(19.9%), commercially prepared feed 185(46.0%), home-made 123(30.6%) and other feeds 14(3.5%) out of which dogs fed on the different types of feed had 12(15.0%), 28(15.1%), 29(23.7%) and 1(7.1%) *Giardia* cysts respectively. The prevalence of *Giardia* cysts was highest 2(20.0%) among those respondents that had greater than 3 dogs in households as compared to 65 (18.7%) and 3(6.7%) among 1 and 2 dogs per household respectively. Of the 68(16.9%) pet dogs,148(36.8%) security, 139(34.6%) for food and 47(11.7%) for hunting, the prevalence of*Giardia* cysts were 9(13.2%), 23(15.5%), 24(17.3%) and 14(29.8%) respectively. Thirty five (17.5%) out of the 200(49.8%) dogs that received veterinary care were positive for *Giardia* cysts.Pet (OR: 0.36; 95% C I on OR< 0.14 < 0.92)

and security (OR: 0.43; 95% C I on OR < 0.20 < 0.93) use of the dogs were the identified risk factors while type of feed, number of dogs per household and veterinary care were not risk factors (P>0.05).

Table 4.15 District-based prevalence of eggs/oocysts parasitesin water sources in Zaria, Kaduna State

District	Number examined	Parasitic eggs and oocysts Number positive (%)	
		Isospora	*Ancylostoma*
Samaru	20	0(0.0)	3(15.0)
Kwangila	20	1(5.0)	1(5.0)
Sabo	20	0(0.0)	0(0.0)
Danmagaji	20	1(5.0)	0(0.0)
Tuduunwada	20	0(0.0)	1(5.0)
Zaria city	20	0(0.0)	0(0.0)
Total	120	2(1.7)	5(4.2)

Table 4.16 Source-based prevalence ofeggs/oocysts parasites in drinking water in Zaria, Kaduna State

Source of water	Number examined	Parasite eggs and oocysts Number positive (%)	
		Isospora	*Ancylostoma*
Tap	30	0(0.0)	1(5.0)
Borehole	30	1(5.0)	1(5.0)
Well	30	1(5.0)	2(6.7)
Stream	30	0(0.0)	1(5.0)
Total	120	2(1.7)	5(4.2)

Table 4.17Risk factors associated with *Giardia* cysts in dogs sampled in Zaria.

Variable	Number of respondents (%)	Number of dogs positive for *Giardia* cysts (%)	OR (95% CI)
Type of feed			
Normal family food	80(19.9)	12(15.0)	2.29(0.27-19.20)
Commercially prepared	185(46.0)	28(15.1)	2.32(0.29-18.44)
Home-made	123(30.6)	29(23.6)	4.01(0.50-31.98)
others	14(3.5)	1(7.1)	1.00(-)
Number of dog in house			
1	347(86.3)	65(18.7)	0.92(0.19-4.44)
2	45(11.2)	3(6.7)	0.29(0.04-1.99)
>3(ref)	10(2.5)	2(20.0)	1.00(-)
Purpose of dog			
*Pet	68(16.9)	9(13.2)	0.36(0.14-0.92)
*Security	148(36.8)	23(15.5)	0.43(0.20-0.93)
Food	139(34.6)	24(17.3)	0.49(0.23-1.06)
Hunting(ref)	47(11.7)	14(29.8)	1.00(-)
Veterinary Care			
Yes	200(49.8)	35(17.5)	1.01(0.60-1.69)
No(ref)	202(50.2)	35(17.3)	1.00(-)

Ref: Reference category; *: significant association

CHAPTER FIVE

DISCUSSION

The overall prevalence rate of *Giardia* cysts in dogs obtained in this study was 17.4%. This prevalenceis higher than the 5.6 %(Hackett and Lappin, 2003),15.6 %(Carlin*et al.*, 2006) and 4% (Little *et al.*, 2009) reported in USA, Canada, 0.1% (Shukla *et al.*, 2006)and Brazil, 4.1% (Lorenzini *et al.*, 2007). However,the prevalence in this study is lower than that reported in Italy, 26.6% (Berrilli *et al.*, 2004), Europe, 24.8% (Epe *et al.*, 2010) Belgium, 18.1%(Claerebout *et al.*,2008), 22.7% (Claerebout *et al.*, 2009), and Romania, 71.2%(Viorica *et al.*,2012). The differences may be due to the fact that the dogs sampled varied in breed and system of management which might have contributed to the varying prevalence of*Giardia* cysts. This may also account for the differences seen in the recovery of other intestinal parasites. The presence of other stages of other intestinal parasites in the faeces suggest the extent of infection in the dogs sampled.

The higher prevalence of *Giardia* cysts in cross/exoticbreedscompared to the local breedsmay be attributed to the fact that cross/exotic breeds are less hardy in terms of disease resistance as the local breeds may be more resistant to *Giardia* infection due to their unrestricted movement within the environment making their immune system to be more resistant to *Giardia* infection than the cross/exotic breeds.In the findings of Viorica *et al.* (2011), a prevalence of 6.7% in pure breeds and 10.0%in cross breeds was reported.

The higher prevalence of *Giardia* cysts in puppies18.2% as compared to the adults16.7% may be because puppies are less immune to infection as immunity acquired during birth from the mother gradually wanes out making the puppies to be vulnerable to infections. This finding is similar to that of Adejinmi *et al.* (2001) and Viorica *et al.* (2012) who both reported a higher prevalence in puppies than adult dogs.

The prevalence of *Giardia* cysts was also higherin males than females probably because of the hormonal differences and most male dogs are more adventurous and go far in search of mating partners and food as compared to the females. Also, they engage in sniffing anal region of female dogs to get closer and may by so doing ingest *Giardia* cysts if their tongues are accidentally in contact with the anal region. Similar study by Eleni *et al.* (2011) also reported a higher prevalence in males than females.

This study shows prevalence of 1.7% *Giardia* cysts, 4.2% *Ancylostoma*eggsand 1.7% *Isospora*oocysts in drinking water. This is lower compared to the report by Gracene *et al.*,(2011)who noted *Giardia* cysts prevalence of 15.6% in stream. This may be due to indiscriminate defaecation and animal waste disposal from homes to our immediate water bodies.

Straying and use of dogs that have been identified as potential risk factors in *Giardia* infection of dogs in this study is justified by the fact that when these dogs are left loose within the environment, they can pick up infections such as *Giardia*. This is of public health significance.

CHAPTER SIX

CONCLUSIONAND RECOMMENDATION

6.1 Conclusion

The study shows that there is significant level of *Giardia* cysts (17.4%) in dogs than(1.7%) in drinking water in Zaria, Kaduna State Nigeria. It was observed that dogs and drinking water within the study area were loaded with parasiteoocysts, cysts and eggsof 17.4%*Giardia*, 3.2% *Isospora*(in dog),1.7% *Isospora*(in drinking water), 7.0%*Taenia*,1.7%*Dipylidium*, 5.0%*Ancylostoma*,1.5%*Capillaria*and 5.0% *Toxocara*.

This study has also shown that the overall prevalence of all the parasite eggs, cysts and oocysts were more in males (10.4%) than in females (7.0%). It was also observed that the cross/exotic breeds had higher prevalence (20.9%) than the local breeds (16.4%).Puppies had a higher prevalence (18.1%) than the adult ones (16.7%). The parasite eggs, cysts and oocysts in drinking water were few (10.0%) in this study.The risk factors were use and straying of dogs.

The findings from this research study has shown that *Giardia* cysts are present in water samples and dog faeces within the study area and this may have some zoonotic implications. Hence,detectionof *Giardia* cysts in the study area is of public health significance.

6.2 Recommendations

1. Owners of dogs should prevent their dogs from straying.
2. Water should be boiledbefore drinking.
3. There is need to carry out molecular characterization of *Garidia lamblia* to know if the genotypes prevalent in water and dog faeces in the study area are zoonotic.

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APPENDIX 1

DEPARTMENT OF VETERINARY PUBLIC HEALTH AND PREV. MEDICINE AHMADU BELLO UNIVERSITY, ZARIA

QUESTIONNAIRE

PREVALENCE AND PUBLIC HEALTH SIGNIFICANCE OF *GIARDIA* CYSTS IN DOGS AND DRINKING WATER IN ZARIA, KADUNA STATE, NIGERIA

INSTRUCTION: kindly tick [√] the following boxes below accordingly. The information obtained will be used strictly for academic purpose only and absolute confidentiality will be ensured.

SECTION A: DEMOGRAPHIC INFORMATION OF RESPONDENT

1. Location (town)_____
2. Age (years) a.<19[ ] b. 20-30[ ] c. 31-40[ ] d. >40[ ]
3. Marital status: a. single[ ] b. married [ ] c.divorced[ ] d.widowed[ ]
4. Sex: a.male[ ] b.female[ ]
5. Occupation: a.Unemployed[ ] b.civil servant[ ] c.Businessman/woman[ ] d.farmer[ ] e. others specify_____
6. Educational qualification: a.No formal education[ ]b.Primary[ ]c.Secondary[ ]d.Tertiary[ ]

SECTION B: DOG DATA

1. Do you own dog(s)?a.yes[ ] b.no[ ]
2. If yes, number of dogs owned: a.1[ ] b.2[ ] c.3[ ] d.4[ ] e.>4[ ]
3. Breed of dog_____
4. Age of dog?(years)a.<1[ ] b.1-3[ ]c.3-6[ ]d.>6[ ]
5. sex: a.male[ ] b.female[ ]
6. Have you noticed diarrhoea in your dog(s) before?a.yes[ ] b.no[ ]
7. If yes to the question above, what is the dog's frequency of diarrhoea in a year?a.1[ ]b.2[ ]c. 3[ ]d.4[ ]e.>4[ ]
8. Do you know about giardiasis?a.yes[ ] b.no[ ]

9. Do you think giardiasis is zoonotic/contagious?a.yes[ ] b.no[ ]
10. Obvious clinical signs in the dogs?a.yes[ ] b.no[ ]
11. If yes to question above, clinical signs observed? a. diarrhoea[ ] b.vomiting[ ] c. fever[ ] b. emaciation[ ]b. others specify[ ]
12. What function is the dog serving you?a.pet[ ] b.security[ ] c.food[ ]d.hunting d.others specify_____
13. Are there children in the house?a.yes[ ] b.no[ ]
14. If yes to question above, do the children play with your dog(s)?a. yes[ ] b. no[ ]
15. What type of dog feed do you give to the dog(s)? a. normal family food[ ] b. commercially prepared [ ] c. home-made [ ] b. others specify…….
16. Source of drinking water for routine personal use?a.well[ ] b.tap[ ]c.river[ ] d.others specify_____
17. Do you use well in the house?a.yes[ ] b.no[ ]
18. If yes to the question above, do you cover the well?a.yes[ ] b.no[ ]
19. Source of sample? a. Vet. clinics[ ] b. residential area[ ]
20. Do you allow your dog to stray?a. yes[ ] b. no[ ]
21. Do you confine your dog(s)?a. yes[ ] b. no[ ]
22. Do you take your dog(s) for routine veterinary care? a. yes[ ] b. no[ ]
23. If yes to question above, frequency to routine Vet. Care.a. monthly[ ] b.bimonthly[ ] c. quarterly[ ] d. every three months[ ]e. annually[ ]
24. Have you ever dewormed your dog(s) before?a. yes[ ] b. no[ ]
25. How often do you deworm your dog(s)?a .bimonthly[ ] b .every 3 months[ ] c. every 6months[ ] d.annually[ ]
26. Which water source do you give to the dog(s)? a. tap [ ] b. borehole[ ] c. well[ ] d. stream[ ]b. others specify_____
27. Is your dog(s) on any form of medication?a.yes[ ] b.no[ ]
28. If yes to the question above,what type of medication? a.dewormer[ ] b.antibiotics[ ] c. others specify_____