EVALUATION OF THE ROLE OF COCKROACHES AS CARRIERS OF MEDICALLY IMPORTANT PARASITES IN TWO DISTINCT COMMUNITIES IN ZARIA, NIGERIA

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MARCH, 2015.

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BY

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M.Sc/SCIE/8607/2011-2012

A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN BIOLOGY

DEPARTMENT OF BIOLOGICAL SCIENCES,
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MARCH, 2015.

DECLARATION

I hereby declare that the work in this thesis titled 'EVALUATION OF THE ROLE OF COCKROACHES AS CARRIERS OF MEDICALLY IMPORTANT PARASITES IN TWO DISTINCT COMMUNITIES IN ZARIA, NIGERIA' was performed by me in the Department of Biological Sciences under the supervision of Dr. E. Kogi and Dr. C. E. Mbah. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this work has been presented for another degree at any institution. I take exclusive responsibility for all errors and oversights in this project.

Clement Ameh YARO _____ _____

Signature Date

CERTIFICATION

This thesis titled 'EVALUATION OF THE ROLE OF COCKROACHES AS CARRIERS OF MEDICALLY IMPORTANT PARASITES IN TWO DISTINCT COMMUNITIES IN ZARIA, NIGERIA' by Clement Ameh YARO meets the regulations governing the award of the degree of Master of Science (M.Sc.) of the Ahmadu Bello University, Zaria and is approved for its' contribution to knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to my parents, Mr. Jacob Suleiman Yaro and Mrs. Martha Yaro.

ACKNOWLEDGEMENTS

The realization of this work could not have been possible without God Almighty. I thank Him for sustaining my life and keeping the entire members of my family in good health throughout the period of this study.

To the Chairman of my Supervisory Committee, Dr. E. Kogi and Dr. C. E. Mbah, I say thank you for always finding a way of sparing your time to listen to me, your useful corrections, advice and assistance added value to the standard required for this work.

I appreciate the contributions of the academic staff of the Department of Biological Sciences, Zaria.

My sincere gratitude to Mr. Kingsley Onazi of Parasitology and Entomology Laboratory, Department of Biological Sciences for his technical support and availability during the use of the Laboratory. I will not forget the immense contribution of my friends, some cleaners in Ahmadu Bello University and respondents from Samaru Village that helped in the collection of the samples, I am very grateful to you all.

To my beloved parents, thank you for your moral and financial support that made this programme a success and also for cherishing me with so much love.

My gratitude to my sister, Gloria Yaro for her supportive ideas and words of encouragement that kept me going throughout the period of the programme.

ABSTRACT

Cockroaches have been recognized as mechanical vectors of pathogens that cause diseases in human. This study was conducted to determine the role of cockroaches as potential carriers of parasites of medical importance in Ahmadu Bello University Main Campus and Samaru Village, Zaria, Kaduna State. Two species of cockroaches were collected from six sites areas in Ahmadu Bello University and four sites in Samaru Village respectively by handpicking and human parasites were recovered from the body surfaces of cockroaches using the sedimentation method. The prevalence of parasites in cockroach species was 96 (24.0%) in *Periplaneta americana* and 20 (8.70%) in *Blattella germanica.* On the sex of the cockroaches, male and female cockroaches had prevalence of 53 (17.79%) and 63 (18.98%) respectively, while based on the stage of development, adult cockroaches had a prevalence of 99 (19.08%) and nymph with a prevalence of 17 (15.32%). Three medically important parasites were recovered from the body surfaces. The prevalence of parasites recovered from external body surface are; *Strongyloides stercoralis,* 47 (7.5%), *Moniliformis dubius,* 27 (4.3%) and *Entamoeba histolytica,* 3 (0.5%) and from internal body surface; *Moniliformis dubius*, 40 (6.4%), *Strongyloides stercoralis,* 12 (1.9%) and *Entamoeba histolytica,* 5 (0.8%) were recovered. There was also no statistically significant difference ($p>0.05$) in the prevalence of parasites in sex, stage of development and point of collection of cockroaches. However, significant differences were observed between species ($P\leq0.01$).There was no significant difference ($P>0.05$) between protozoa and helminths parasites obtained from Ahmadu Bello University and Samaru Village. Cockroaches constitute an important reservoir for infectious pathogens. Control measures should be instituted by targeting both sexes; stage

of development. Also, improving sanitary conditions of our toilets, bathrooms, kitchens and environment could substantially minimize the spread of agents that cause diseases in the study area.

TABLE OF CONTENTS

Title **Page**

Title Page……...……...i

Declaration……...ii

Certification…….……...…iii

Dedication……..…….iv

Acknowledgment……..……...v

Abstract……...vi

Table of Contents……..viii

List of Figures…….…….…xii

List of Tables……...……...……xiii

List of Plates……..……...……....xiv

List of Appendices……..…….…….……xv

CHAPTER ONE

1.0 INTRODUCTION…….……..…1

1.1 General Introduction…….……...…1

1.2 Statement of Research Problem…….……..……3

1.3 Justification……...…….……4

1.4 Aim of the Study……...…..……4

1.5 Objectives of the Study……..5

1.6 Hypotheses……..……...….5

CHAPTER TWO

2.0 LITERATURE REVIEW……...…6

2.1 Cockroaches……..……..6

2.2 Cockroach Classification……...6

2.3 Description…….....…….6

2.3.1 German cockroach……..……7

2.3.2 American cockroach……..…….....9

2.4 Diet……...…….…….....11

2.5 Life Cycle of Cockroaches……..…….....12

2.5.1 Copulation…….……..…12

2.5.2 Ootheca formation……14

2.5.3 Metamorphosis.....……..…15

2.6 Habitat and Behaviour……...…….15

2.7 Dispersal……...…….....16

2.8 Public Health Importance……...17

2.9 Mechanical Transmission of Diseases……17

2.10 Control Measures…….…….....18

2.10.1 Environmental management…….…….19

2.11 Parasites Transmitted Mechanically by Cockroaches……...…….…….20

CHAPTER THREE

3.0 MATERIALS AND METHODS…….26

3.1 Study Area…….……..….26

3.2 Sample Size Determination……..……...26

3.3 Sample Collection…….……...….28

3.4 Isolation and Identification of Parasites from External Surfaces.....29

3.5 Isolation and Identification of Parasites from Internal Surfaces……...29

3.6 Dissection of Cockroaches for Internal Parasites…….....29

3.7 Isolating the Alimentary Canal……...30

3.8 Statistical Analyses……..……31

CHAPTER FOUR

4.0 RESULTS……..32

4.1 Distribution of Parasites Based on Sex of Cockroach Species……..…32

4.2 Distribution of Parasites Based on Sex of Cockroach Species…….....34

4.3 Distribution of Medically Important Parasites Based on the Sex of Cockroach……..36

4.4 Distribution of Medically Important Parasites Base on the Stage of Development of Cockroach Species…….38

4.5 Distribution of Parasites from Species of Cockroach……...40

4.6 Distribution of Parasites by Gender……...42

4.7 Occurrence of Parasites in Developmental Stages of Cockroaches……..…43

4.8 Distribution of Parasites On Body Surfaces of Cockroaches in Study Areas……....45

4.9 Distribution of Parasites from Body Surfaces of Cockroaches……....47

4.10 Occurrence of Parasites Base on Point of Collection……...….49

4.11 Distribution of *E. histolytica* from Body Surfaces of Cockroaches…….....53

4.12 Distribution of *M. dubius* from Body Surfaces of Cockroaches….....53

4.13 Distribution of *S. stercoralis* from Body Surfaces of Cockroaches…….....56

4.14 Load of Protozoa and Helminths Parasites from Body Surfaces of Cockroaches……58

4.15 Load of Protozoan and Helminths from districts……...……...…60

CHAPTER FIVE

5.0 DISCUSSION……...…66

5.1 Occurrence of Parasites……...66

CHAPTER SIX

6.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS……...71

6.1 Summary……...71

6.2 Conclusions……...……..……..71

6.3 Recommendations……..……...…...72

REFERENCES…….……74

APPENDIX……...80

LIST OF FIGURES

Figure Page

Figure 2.1 Side view of a cockroach (*Blattella germanica*)……8

Figure 2.2 Life cycle of cockroach……13

Figure 3.1 Map Showing Sampling Points from A.B.U. and S.V., Zaria. ……27

LIST OF TABLES

Table		Page
Table 4.1	Prevalence of Parasites Based on Sex of Cockroach Species from Locations	33
Table 4.2	Prevalence of Parasites Based on Developmental Stages of Cockroach Species from Locations	35
Table 4.3	Prevalence of Parasites Based on Sex of Cockroaches Species from Sampling Locations	37
Table 4.4	Prevalence of Parasites Based on Developmental Stage of Cockroaches Species from Sampling Locations	39
Table 4.5	Distribution of Medically Important Parasites by Species of Cockroaches in the Study Areas	41
Table 4.6	Distribution of Medically Important Parasites by Gender of Cockroach in the Study Areas	44
Table 4.7	Occurrence of Medically Important Parasites in the Different Developmental Stages of Cockroaches in the Study Areas	46
Table 4.8	Distribution of Medically Important Parasites by Body Surfaces of Cockroach Isolated from the Study Areas	48
Table 4.9	Distribution of Parasites from Body Surfaces of Cockroaches from the Study Areas	50
Table 4.10	Occurrence of Medically Important Parasites Based on Point of Collection of Cockroaches in the Study Areas	51
Table 4.11	Distribution of *Entamoeba histolytica* from External and Internal Body Surface of Cockroaches from the Study Areas	54
Table 4.12	Distribution of *Moniliformis dubius* from External and Internal Body Surface of Cockroaches from the Study Areas	55
Table 4.13	Distribution of *Strongyloides stercoralis* from External and Internal Body Surface of Cockroaches from the Study Areas	57
Table 4.14	Mean Load of Parasites per Cockroach from Body Surfaces of Cockroaches Collected from Study Area	59
Table 4.15	Mean Load of Parasites from Sampling Areas in the Two Districts	61

LIST OF PLATES

Plate		Page
Plate 1:	Dissected Cockroaches……..…….62	
Plate 2:	*Strongyloides stercoralis*……63	
Plate 3:	*Moniliformis dubius*…….…..64	
Plate 4:	*Entamoeba histolytica*……65	

LIST OF APPENDICES

Appendix Page

Appendix 1: Prevalence of Parasites Based on Sex of Cockroach Species from Locations……..80

Appendix 2: Prevalence of Parasites Based on Developmental Stages of Cockroach Species from Locations……...…81

Appendix 3: Prevalence of Parasites Based on Sex of Cockroaches Species from Sampling Locations……..…82

Appendix 4: Prevalence of Parasites Based on Developmental Stage of Cockroaches Species from Sampling Locations……...83

Appendix 5: Distribution of Medically Important Parasites by Species of Cockroaches in the Study Areas……...……..……...…84

Appendix 6: Distribution of Medically Important Parasites by Gender of Cockroach in the Study Areas……...…85

Appendix 7: Occurrence of Medically Important Parasites in the Different Developmental Stages of Cockroaches in the Study Areas……..86

Appendix 8: Distribution of Medically Important Parasites by Body Surfaces of Cockroach Isolated from the Study Areas…….….87

Appendix 9: Distribution of Parasites from Body Surfaces of Cockroaches from the Study Areas…….88

Appendix 10: Occurrence of Medically Important Parasites Based on Point of Collection of Cockroaches in the Study Areas……..…89

Appendix 11: Distribution of *Entamoeba histolytica* from External and Internal Body Surface of Cockroaches from the Study Areas……...90

Appendix 12: Distribution of *Moniliformis dubius* from External and Internal Body Surface of Cockroaches from the Study Areas……...91

Appendix 13: Distribution of *Strongyloides stercoralis* from External and Internal Body Surface of Cockroaches from the Study Areas……...92

Appendix 14: Mean Load of Parasites per Cockroach from Body Surfaces of Cockroaches Collected from Study Area……93

Appendix 15: Mean Load of Parasites from Sampling Areas in the Two Districts…….94

Appendix 16: Akenzua Hall, ABU……...…….……...…96

Appendix 17: Suleiman Hall, ABU……...…….……...…98

Appendix 18: Yar'adua Hall, ABU……..…….…..……100

Appendix 19: Danfodio Hall, ABU……..…….……102

Appendix 20: Queen Amina Hall, ABU……104

Appendix 21: Ribadu Hall, ABU……...……106

Appendix 22: Danraka, SV…….....108

Appendix 23: New layout, SV……...……110

Appendix 24: Hayin Dan Yaro, SV……...……..112

Appendix 25: Hayin Dogo, SV…….……..114

CHAPTER ONE

1.0 INTRODUCTION

1.1 General Introduction

Cockroaches are the world's most common insects and have been on earth for about 300 million years. They are considered one of the most successful groups of animals because of their adaptability (Steven, 2007). Thirty species of cockroaches are associated with human habitations and about 4,500 species can be found in every part of the world with *Periplaneta americana* (Linnaeus, 1758) and *Blattella germanica* (Linnaeus, 1767) being the most common species (Robinson, 2005; Uneke, 2007).

Cockroaches are the most abundant, notorious and obnoxious non-biting insect pest in residential buildings, hospitals, Halls and restaurants (Mba and Kelly, 2003). Increased infestations by cockroaches in buildings have become more serious with urbanization, complexity of building structures and the arrangement of furniture and fittings as well as the development of insecticide resistance which makes control difficult. Such difficulties in control of cockroaches depend on factors which help determine wandering activity, population growth and choice of harbourage (Ikuo and Mitugu, 1993).

Cockroaches are often found in unsanitary communities where garbage, dead animal carcasses, and piles of faeces are left scattered and unattended. They frequently feed on human faeces, and can disseminate helminths and protozoan parasites in the environment if such faeces are contaminated. Faeces are effective in enhancing the transmission of infectious agent by cockroaches which is much greater than of any other substrate or

medium, this is due to faecal viscosity which increases the ability of tarsi and bristles in tapering particles suspended in the faeces (Graczyk *et al.*, 1999). Increased risk of contact between cockroaches and pathogen-positive faecal matter is high when infected persons excrete in open areas.

Cockroaches have been recognized as mechanical vectors of human pathogens (Cochran, 1982). They contaminate food by their droppings containing parasites (Che Ghani *et al.*, 1993) and also transmit bacteria, fungi, and other pathogenic microorganisms in infested areas (Gore and Schal, 2007). They serve as carriers of bacterial diarrhea and nosocomial infections in hospitals (Fotedar *et al.*, 1991). Cockroaches act as vectors for pathogens by the transmission of pathogens in the following way: mechanical dislodgement from the exoskeleton used for adherence to vertical surfaces, faecal depositjujion and regurgitation of incompletely digested foods. Cockroaches disseminate these microorganisms in many ways, predominantly by depositing them along with their excrement on human food (Robinson, 2005; Uneke, 2007).

Size limitations regarding the transmission from the communicated sites occurs as bigger particles such as helminths eggs are transported by cockroaches on their external surface, i.e., exoskeletons, while small cystic stages of human infectious intestinal protozoans can be ingested as well as transported on the exoskeleton. When infected persons excrete in open areas, there is an increased risk of contact between cockroaches and pathogen-positive faecal matter.

Protozoans are single-celled animals which resemble a single cell of a higher organism. However, the protozoan cell is capable of carrying out vital functions such as

reproduction, feeding, and locomotion. Intestinal protozoans include species which can live in the lumen of the intestine and others which additionally live and reproduce in the cells of the intestinal walls.

Cockroaches are nocturnal and their feeding habits make them perfect carriers of a variety of pathogenic microorganisms such as oocysts of *Isospora belli, Cryptosporidium parvum, Cyclospora cayetanensis,* cysts of *Entamoeba histolytica, Balantidium coli,* and *Giardia lamblia* (Fotedar *et al.,* 1991; Graczyk *et al.,* 2005; Salehzadeh *et al.,* 2007; Uckay *et al.*, 2009).

A number of gastrointestinal infections can reach epidemic proportions. The protozoan pathogen *Cryptosporidium parvum* has been known to cause severe water-borne epidemics, even in first-world countries such as the United States and the United Kingdom. Other infections such as amoebiasis or enterobiasis can be more localized, infecting households or institutions.

Several studies have shown that eggs of *Ascaris lumbricoides, Trichuris trichiura,* hook worm, *Enterobius vermicularis, Hymenolepis nana, Toxocara canis, and Strongyloides stercoralis* larvae are carried by many species of cockroaches (Oteifa and Moustafa, 1997; El Gindy *et al*., 1999; Haridy *et al.,* 2000; Ismail and El Kady *et al.,* 2011).

1.2 Statement of Research Problem

There is an increase in cockroach population in areas with poor sanitary conditions all over the world particularly in Nigeria, the risk to human health arising from cockroach infestations have been reported as cockroaches are known mechanical vectors of human

pathogens as there are reports of the isolation of various pathogenic human helminth and protozoan parasites from them (Fotedar *et al.*, 1991).

The behaviour, feeding habits, body structure, and mobility of cockroaches make them well adapted for the mechanical transmission of oocysts, cysts and larvae of parasites that cause diseases whose epidemiology are still poorly understood in developing countries. This may be due to the presence of the parasites in stool, lack of documentation, under or over reporting of episodes due to inaccurate diagnosis, different levels of hygiene and sanitation as well as different socio-economic status of the people.

1.3 Justification

Some of the rare protozoan infections such as the microsporidia are only now being understood as they are appearing as concomitant infections in homes with cockroach infestation and are affecting people with depressed immune responsiveness, e.g. Acquired Immune Deficiency Syndrome (AIDS) (Michael *et al.*, 2011).

The result obtained will provide baseline information on the parasites that are transmitted mechanically by cockroaches.

1.4 Aim of The Study

To isolate and identify medically important cysts and ova of parasites from the external and internal surfaces of cockroaches found in Samaru Community (Samaru Village and Ahmadu Bello University Main Campus) Zaria.

1.5 Objectives of The Study

1. To isolate and identify cyst of protozoa, ova and larvae of helminths from cockroaches.
2. To determine and compare the prevalence of parasites among sex, stage of development and body surfaces of cockroach species (*Periplaneta americana* and *Blattella germanica*) from Ahmadu Bello University and Samaru Village, Zaria.

1.6 Hypotheses

1. Cysts of protozoa, ova and larvae of helminths are not carried by cockroaches.
2. There is no significant difference in the prevalence of parasites among sexes, stage of development and body surfaces of cockroach species (*Periplaneta americana* and *Blattella germanica*) from Ahmadu Bello University and Samaru Village, Zaria.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Cockroaches

Cockroaches are among the most common pests in many homes and other buildings. At night they search for food in kitchens, food storage places, rubbish bins, drains and sewers. They are pests and have filthy habits and bad smell. Cockroaches can play a role as carriers of parasites that cause intestinal diseases such as diarrhoea, dysentery, typhoid fever and cholera (Chan *et al.*, 2004).

2.2 Cockroach Classification

Cockroaches belong to Kingdom Animalia, Phylum Arthropoda, Subphylum Hexapoda, Class Insecta, Subclass Pterygota, Infraclass Neoptera, Superorder Dictyoptera, Order Blattodea and Families Blaberidae, Blattellidae, Blattidae, Cryptocercidae, Polyphagidae, Nocticolidae, Tryonicidae, Lamproblattidae. Species of cockroaches are housed in several genera such as *Blaptica, Blatta, Blattella, Blaberus, Eurycetis. Gromphadorhina, Periplaneta, Pyconoscelus* and *Supella* (Jordan and Verma, 2006).

2.3 Description

Cockroaches are insects, dorsoventrally flattened, usually with two pairs of wings folded flat over the back (fig. 2.1). Most species rarely fly but they walk very fast. The colour usually varies from light brown to black. The length of the species varies from 2– 3 mm to over 80 mm in length (Cornwell, 1968). Of over 3500 identified species only a few are of importance to people because they have adapted to living in buildings. The most

common species are the German cockroach (*Blatella germanica*) and the American cockroach (*Periplaneta americana*) (Richardson and Peter, 2003).

2.3.1 German cockroach, *Blattella germanica* (Linnaeus, 1767)

2.3.1.1 Distribution

The German cockroach is found throughout the world in association with humans. It was originally a native of Africa. They are unable to survive in locations away from humans or human activity (Cornwel, 1968; Omudu and Ejumah, 2008). The major factor limiting German cockroach survival appears to be cold temperatures. Studies have shown that German cockroaches were unable to colonize inactive ships during cool temperatures and could not survive in homes without central heating in northern climates (Jordan and Verma, 2006). The availability of water, food, and harborage also govern the ability of German cockroaches to establish populations, and limit growth (Steven, 2014).

2.3.1.2 Description

(a) **Egg:** The ootheca can be seen protruding from the posterior end (genital chamber) of the female. Nymphs will often hatch from the ootheca while the female is still carrying it. A typical egg case contains 30 to 40 eggs. The egg case is a tiny, brown, purse-shaped capsule. It is about 8 mm long, 3 mm high and 2 mm wide (Brenner *et al.*, 1987).

(b) **Nymph:** The nymphal stage begins with egg hatch and ends with the emergence of the adult. Nymphs of *B. germanica* are dark brown to black in color, with distinct dark parallel bands running the length of the pronotum and do not possess

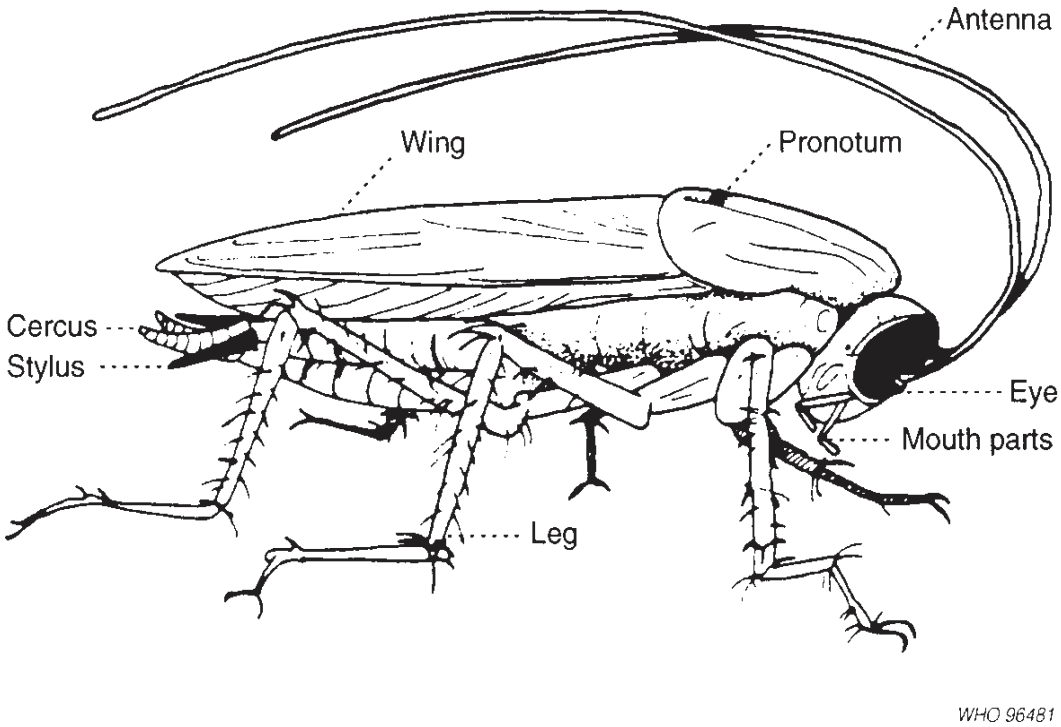


Fig. 2.1 Side view of a cockroach (*Blattella germanica)* (WHO, 2003).

wings (Jordan and Verma, 2006). The number of molts required to reach the adult stage varies, but the most frequently reported number of molts is six. The stage between molts is called an instar. At room temperature nymphs complete development in about 60 days. All developmental stages actively forage for food and water (Cornwell, 1968).

(c) **Adult:** The adult is 10 to 15 mm long, brown to dark brown in color with two distinct parallel bands running the length of the pronotum. The sexes can be distinguished by the following characteristics: male - body thin and slender, posterior abdomen is tapered, terminal segments of abdomen visible, not covered by tegmina (leathery outer wings) and female - body stout, posterior abdomen is round, entire abdomen just covered by tegmina (Jordan and Verma, 2006).

2.3.2 American cockroach, *Periplaneta americana* (Linnaeus, 1758)

2.3.2.1 Distribution

The American cockroach is distributed throughout the world by commerce. It is commonly known as the American or ship cockroach (Cornwell, 1968; Jordan and Verma, 2006). The cockroach is often found residing indoors as well as outdoors. It is found mainly in basements, sewers, steam tunnels, and drainage systems (Rust *et al.*, 1991). This cockroach is readily found in commercial and large buildings such as restaurants, grocery stores, bakeries, and where food is prepared and stored (Rust *et al.*, 1991).

American cockroaches are found in moist shady areas outdoors, in yards, hollow trees, wood piles, and mulch. They are occasionally found under roof shingles and in attics. The cockroaches dwell outside but will wander indoors for food and water during

extremes in weather conditions. In areas such as trees, woodpiles, garbage facilities, and accumulations of organic debris around homes provide adequate food, water, and harborages for peridomestic cockroaches such as the American cockroach (Hagenbuch *et al.*, 1988). Mass migrations of the American cockroaches are common (Ebeling, 1975). They migrate by crawling or flying into structures often entering houses and apartments from sewers via the plumbing, by trees and shrubs located alongside buildings or trees with branches overhanging roofs facilitate the entry of cockroaches into the home. During the day the American cockroach, which responds negatively to light, rests in harborages close to water pipes, sinks, baths, and toilets, for example, where the microclimate is suitable for survival (Bell and Adiyodi, 1981).

2.3.2.2 Description

(a) **Egg:** Females of the American cockroach lay their eggs in a hardened, purse shaped egg case called an ootheca. About one week after mating the female produce an ootheca and at the peak of her reproductive period, she may form about two ootheca per week (Bell and Adiyodi, 1981). The female deposits the ootheca near a source of food by either simply dropping it or gluing it to a surface with a secretion from her mouth. The deposited ootheca contains water sufficient for the eggs to develop without receiving additional water from the substrate (Bell and Adiyodi, 1981). The egg case is brown when deposited and turns black in a day or two. A typical egg case contains about 14 to 16 eggs. It is about 8 mm long and 5 mm high.

(b) **Nymph:** The nymphal stage begins when the egg hatches and ends with the emergence of the adult. The number of times an American cockroach molts varies from 6 to 14 (Bell and Adiyodi, 1981). The first instar American cockroach is white immediately after hatching which becomes greyish brown with time. After molting, instars of the cockroach nymphs are white and then become a uniformly reddish-brown with the posterior margins of the thoracic and abdominal segments being a darker color. Wings are not present in the nymphal stages and wing pads become noticeable in the third or fourth instar. Complete development from egg to adult is about 600 days. The nymphs as well as the adults actively forage for food and water (Jordan and Verma, 2006).

(c) **Adult:** The adult American cockroach is reddish brown in appearance with a pale-brown or yellow band around the edge of the pronotum. The males are longer than the females because their wings extend 4 to 8 mm beyond the tip of the abdomen. Males and females have a pair of slender, jointed cerci at the tip of the abdomen. The male cockroaches have cerci with 18 to 19 segments while the female has 13 to 14 segments. The male American cockroaches have a pair of styli between the cerci while the females do not (Jordan and Verma, 2006).

2.4 Diet

The American cockroach is an omnivorous and opportunistic feeder. It consumes decaying organic matter but since the cockroach is a scavenger it will eat anything. It prefers sweets and has been observed eating paper, boots, hair, bread, fruit, book

bindings, fish, peanuts, old rice, putrid sake, the soft part on the inside of animal hides, cloth and dead insects (Bell and Adiyodi, 1981).

2.5 Life Cycle of Cockroaches

Cockroaches are primitive, having only three stages in their life cycle: egg, nymph and adult (Fig. 2.2).

2.5.1 Copulation:

The active breeding season of cockroach starts from March and last up to September. Copulation occurs at night. During copulation, the male cockroach finds a suitable mate and the two partners come together by thin posterior ends. The male opens the gynovalvular plates of the female by its titillator and inserts its phallomere into the genital chamber of the female (Cornwell, 1968; Jordan and Verma, 2006). The pseudopennis of the male is then inserted into the gonosphore of the female and rotated transversely to hold in position. The anterior gonaphyses of the oviposition are held by the right phallomere. The ventral phallomere move to the right thus, opening the gonomere of the ejaculatory duct, then the spermatosphore is expelled and deposited directly on the spermathecal papilla to which it is fixed in about an hour (Jordan and Verma, 2006). The phallic gland now pairs it secretion on the spermatosphore to form its outmost covering which hardens in about two hours. Copulation last for about an hour and quarter after which the two cockroaches separates. The sperm pass from the spermatosphore into the spermathecae slowly in the course of the next 20 hours after which empty spermatosphore is discarded (Jordan and Verma, 2006).

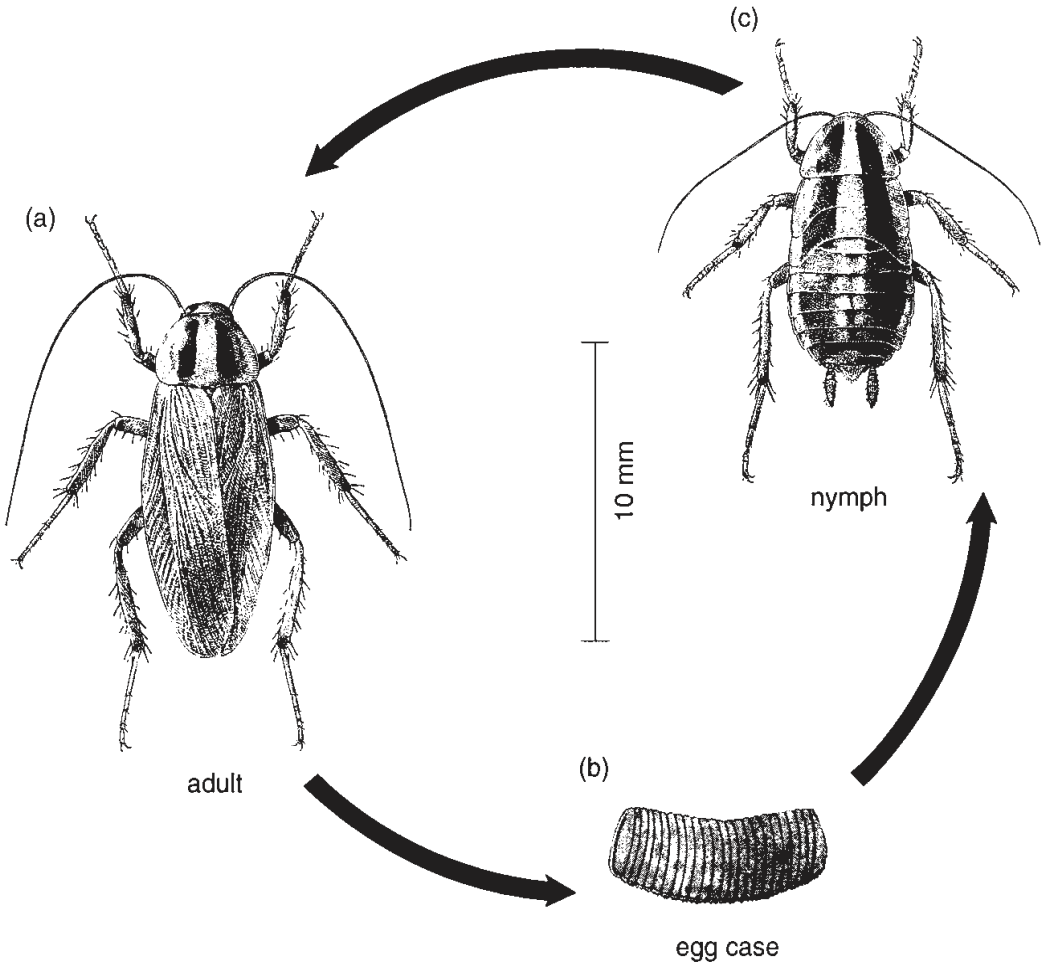


Fig. 2.2 Life cycle of cockroach (*Blattella germanica*) (Source: The Natural History Museum, London, 2003).

2.5.2 Ootheca formation

The eggs come alternatively from two ovaries into the common oviduct and passes through the female gonosphore into the genital chamber where they are fertilized by sperm coming from the spermathecae (Brenner *et al.*, 1987). The two collaterial glands pour different secretion on the fertilized eggs, these secretion combines to form a scleroprotein which harden to form dark brown oothecae around the eggs. The oothecae is shaped and moulded by the ovipositor and the walls of the oothecal chamber.

The oothecae is 12 mm in length, on one side it has straight crest with a separate margins, it contains 16 fertilized eggs standing vertically in two rows, the position of eggs can be seen on the outer surface of ootheca. The ootheca is completed in about a day and it protrudes the oothecal chamber being held in place by the 10^{th} tergum and gynovalvular plates (Brenner *et al.*, 1987; Steven, 2014). The female cockroach carries the ootheca for several days and finally drops it in some dark, dry place. Every female cockroach produces nearly 15 to 40 ootheca in its life span of about one to two years (Jordan and Verma, 2006).

The eggs of cockroach, like other insect are called centrolecithal because of ooplasm is placed in the form of a thin film outside a central mass yolk. The embryonic development occurs in the ootheca, which takes nearly 5 to 13 weeks (Cornwell, 1968).

After the embryonic development is complete, the ootheca rupture and the young ones hatch out. The young cockroaches resemble their parents in early respect except that they are smaller in size and without wings (Cornwell, 1968; Jordan and Verma, 2006).

2.5.3 Metamorphosis

The nymph of cockroach which resembles its adult in structure and feeding habit is paler in colour, smaller in size, devoid of wings and the gonads are immature. As it feed it grows, its outer skeleton is cast off, and this process of shading the exoskeleton is known as moulting or ecdysis which is controlled by the hormonal activity (Jordan and Verma, 2006).

During ecdysis, the hypodermis of the integument secretes an enzyme under the lower surface of the old cuticle, thus separating the cuticle from the hypodermis then the hypodermis secretes epicuticle which is impervious to the enzyme. Finally, the hypodermis secretes a new procuticle, the epicuticle form a new cuticle. The old is ruptured and is shed by the animal. Thus the nymph form a new exoskeleton by its hypodermis before the old one is east off and growth can take place only before the new covering has hardened, because the tough exoskeleton does not allow increase in size. The cockroach nymph undergoes ten to twelve ecdyses to become an adult in about a year (Cornwell, 1968; Jordan and Verma, 2006; Omudu and Ejumah, 2008). During this period the nymph grows wings formed from the integument and gonad becomes mature. The ecdysis is, thus closely associated with the growth also. After the last ecdysis, no further increase in size. This gradual assumption of adult characters with hardly any change is called paurometabolic metamorphis (Jordan and Verma, 2006).

2.6 Habitat and Behaviour

Pest cockroaches live in close association with people (Roth and Willis, 1960; Cornwell, 1968). They are tropical in origin but in the temperate zones most species live in parts of

houses and other buildings where warmth, moisture and food are adequate (Richardson and Peter, 2003). Cockroaches usually live in groups. They are mostly active at night; in the daytime they hide in cracks and crevices in walls, door frames and furniture, and in secure places in bathrooms, cupboards, steam tunnels, animal houses, basements, televisions, and radios and other electric devices, drains and sewer systems. If the lights are turned on in an infested kitchen at night the cockroaches will run from dishes, utensils, working surfaces and the floor towards shelter (Robinson, 2005; Jordan and Verma, 2006).

Cockroaches eat a great variety of food, including all food used for human consumption. They prefer starchy and sugary materials. They sip milk and nibble at cheese, meats, pastry, grain products, sugar and sweet chocolate. They also feed on cardboard, book bindings, ceiling boards containing starch, the sized inner lining of shoe soles, their own cast-off skins, dead and crippled cockroaches, fresh and dried blood, excrement, sputum, and the fingernails and toenails of babies and sleeping or sick persons (Robinson, 2005).

2.7 Dispersal

Mass migrations have been reported for some species, apparently resulting from overcrowding. The migrants move into new areas by crawling or flying. They commonly enter houses in boxes of bottled drinks and bags of potatoes, onions or other foodstuffs that have become infested in poorly maintained food stores. Long-distance transportation of the pests can occur on aircraft, ships or other vehicles (Jordan and Verma, 2006).

2.8 Public Health Importance

Cockroaches are important pests because they spread filth and ruin food, fabrics and book-bindings. They disgorge portions of their partially digested food at intervals and drop faeces. They also discharge a nauseous secretion both from their mouths and from glands opening on the body which give a long-lasting, offensive cockroach smell to areas or food visited by them (Robinson, 2005).

2.9 Mechanical Transmission of Diseases

Transmission of human parasites by cockroaches is mechanical. In adult cockroaches, it occurs via mechanical dislodgement from the exoskeleton, feacal deposition and regurgitation, i.e. vomit (Greenberg, 1993). Cockroach carries human pathogens on their mouth parts, on body, under wings and leg hairs (i.e. setae) or on the sticky pads of the feet. The effectiveness of feces in enhancing the transmission of infection agents by cockroach is much more than that of any other substrate or medium, this is as result of fecal viscosity which enhances the efficiency of tarsi and bristles in trapping particles suspended in feces (Graczyk *et al.,* 1997). Frequently, meal on contaminated substrates together with alternating regurgitation and ingestion cause progressive accumulation of human pathogens in cockroach alimentary system. Human pathogens can also be transmitted as air particles for short distance (Greenberg, 1993; Graczk *et al.*, 2005).

Cockroaches move freely from one building to the other or from drains, gardens, sewers and latrines to human habitations because they feed on human faeces as well as human food, they can spread germs that cause disease (Cornwell, 1968; Roth and Willis, 1957). Cockroaches are not usually the most important cause of a disease, but like houseflies can

spread disease by contaminating human food with germs they pick up in latrines, garbage dumps, etc. They may play a supplementary role in the spread of some diseases. They are proven or suspected carriers of the organisms causing: diarrhea – dysentery, cholera, leprosy, plague, typhoid fever and viral diseases such as poliomyelitis. In addition they carry the eggs of parasitic worms and may cause allergic reactions, including dermatitis, itching, swelling of the eyelids and more serious respiratory conditions (Stankus *et al.,* 1990).

2.10 Control Measures

The key to control is cleanliness, which may be difficult in houses where there are children and domestic animals. In isolated homes, control is easier to achieve than in apartments where cockroaches may have easy access from adjacent quarters. Re-infestation occurs from outdoors in warm areas, or along heating ducts and water pipes in apartments, or luggage brought from cockroach infested areas (Robinson, 2005). Cockroaches may even sometimes be found in very clean houses, but are unlikely to establish colonies.

The presence of several sizes of nymphs and oothecae is an indication of a well-established colony. Infestations can be detected by searching behind skirting boards, boxes, furniture and other common hiding places. At night, cockroaches are easily detected using light.

Heavy infestations of cockroaches can be dealt with by chemical control measures, followed by environmental management to deprive the insects of food and shelter. Low numbers can be effectively controlled by baits or traps (Robinson, 2005).

2.10.1 Environmental management

(a) Cleanliness and Hygiene: Food should be stored in tightly covered containers in screened cabinets or refrigerators. All areas have to be kept clean so that no fragments of food or organic matter remain. Rubbish bins should be securely covered and emptied frequently, preferably daily. Basements and areas underneath buildings should be kept dry and free of accessible food and water.

(b) Reduction of Accessibility: Laundry, dirty clothing, egg crates and furniture should be checked before being taken into a building. In some instances, accessibility to buildings can be reduced by closing gaps in floors and door frames. Openings for drain water and sewer pipes, drinking-water and electricity cables should also be closed.

(c) Chemical Control: Cockroaches are difficult to control with insecticides for several reasons, one of which is that they may become resistant to commonly used compounds. Moreover, many insecticides are repellent to them and are therefore avoided (Wooster and Ross, 1989). Chemical control gives only temporary relief and, wherever possible, it should be accompanied by environmental sanitation and house improvement (Schal, 1988). Insecticides are applied to the resting and hiding places as residual sprays and insecticidal dusts. Such applications are effective for periods ranging from several days to months, depending on the insecticide and the substrate on which it is deposited. Insecticides can also be combined with attractants as toxic baits.

(d) Resistance: The cockroach is resistant to several organochlorine, organophosphorus, carbamate and pyrethroid insecticides (Cochran, 1989). The Oriental cockroach, the American cockroach and the large brown cockroach (*Periplaneta brunnae*) have developed little resistance, mainly to DDT and chlordane. Recently, the American cockroach has been found to be resistant to trichlorfon in China and the large brown cockroach to diazinon in the USA.

Several essential oils, such as mint oil, spearmint oil and eucalyptus oil are known to repel cockroaches, but the best results are obtained with synthetic products that are easier to standardize. For example, packing materials or interior surfaces of storerooms can be treated with appropriate dilutions of deet (*N*,*N*-diethyl-3-toluamide) or DMP (dimethyl phthalate). A deposit of 0.5mg of deet per cm^2 repels more than 90% of *Blattella germanica* and more than 80% of *Periplaneta americana* from cardboard boxes for about a week, depending on temperature and humidity. More promising synthetic compounds, such as DEPA (*N*,*N*-diethylphenylacetamide) and DECA (diethylcyclohexylacetamide), are presently used in India (Prakash *et al.*, 1990).

Several hymenopteran natural enemies of the cockroach have been found (Suiter *et al*., 1998). These parasitic wasps deposit their eggs in the cockroach ootheca preventing the emergence of cockroach nymphs.

2.11 Parasites Transmitted by Cockroaches

Several studies on the parasites transmitted by cockroaches have been reported by many workers in different parts of the world. A study on the bacterial, fungal and parasitic contamination of cockroaches in public hospital of Hamadan, Iran by Salehzadeh *et al.*

(2007) revealed that 130 out of 133 (98%) *Blattella germanica* showed contamination with high bacterial load (more than 1×10^3) whereas only 2 out of 45 (4.45%) cockroaches of the control group were carrying medically important bacteria with high bacterial load. Bacteriological exQueen Aminations revealed that almost all test cockroaches had at least one of the following microorganisms either in their body surface or digestive tract. *Enterobacter* (22.6%), *Klebsiela* (21%), *Enterococcus* (17.3%), *Staphylococcus* (16.5%), *Esherichia coli* and *Streptococcus* (8.3%), *Pseudomonas* (3%), and also *Shigella*, *Haemophilus* and group A ß-hemolytic *Streptococcus* each less than 1%. In addition the results showed (74.4.%) of test cockroaches harboured fungi *Candida* (48.9%), *Mucor* (10.5%), *Aspergillus niger* (7.5%), *Rhizopus* (4.5) and also *Penicillium* and *Aspergillus fumigans* each 1.5%. Some parasitic worms of medical importance were also isolated from the test cockroaches, but carriage rates were low.

Pennapa *et al.* (2011) undertook a study on the mechanical transmission of parasitic organisms by cockroaches in Samutprakam province of Thailand. Their study revealed the role of cockroaches in the contamination with pathogenic organisms. 920 cockroaches were examined for parasites by them and the results show that 498 (54.1 %) of the cockroaches harbored parasitic organisms. Of these, 56.1 % were protozoa and the remaining 43.9 % were helminths (pathogenic helminths, 1.4 %, non-pathogenic helminths, 42.5 %). Of the pathogenic helminths, the species found included *Strongyloides stercoralis* (6 instances of the free-living adult male, 0.8 %), *Ascaris lumbricoides* (2 decorticated eggs, 0.3 %), *Trichuris trichiura* (2, 0.3 %), and *Taenia* spp. (1 egg, 0.1 %). The protozoa types that were identified included *Cyclospora* spp. (10 oocysts, 1.3 %), *Endolimax nana* (10 cysts, 1.3 %), *B. hominis* (9 instances of the

vacuolated form, 1.2 %), *Isospora belli* (75 oocysts, 9.6 %), *Entamoeba histolytica/E. dispar* (36 cysts, 4.6 %), *Cryptosporidium* spp. (220 oocysts, 28.1 %), *Chilomastix mesnilli* (2 cysts, 0.3 %), *Entamoeba coli* (31 cysts, 4.0 %), *Balantidium coli* (45 trophozoites, 5.8 %), and *Iodamoeba butschlii* (1 cyst, 0.1 %). These results show that cockroaches isolated from these markets are carriers of several parasitic organisms that cause commonly found symptoms of illness such as diarrhea or bowel disorder.

Cockroaches have become the most common pests in a majority of households in Africa. In a study carried out in Gaborone, the capital city of Botswana. The bacterial, total spore forming, *Bacillus cereus*, coliforms and *E. coli* counts from the surfaces of cockroaches were estimated using bacteriological media. Aerobic and facultatively anaerobic bacteria from the fecal pellets were isolated and characterized. Specialized media were used for culturing pathogens. 67 %, 22.2 % and 28.6 % of the cockroaches trapped in the kitchen from Central/Broadhurst, Old Naledi and Tlokweng, respectively, had aerobic plate counts of $>10^6$ CFU/cockroach. The cockroaches trapped from the toilets had higher counts than kitchens. Spore formers were present in most samples though in lower numbers. However, *Bacillus cereus* was only found in some of the cockroaches at much lower numbers. As much as 70–98.3% of the cockroaches had coliforms; but, *E. coli* was only found in 5–6.5% of the cockroaches at $> 10^3$ CFU/cockroach. 70 species of bacteria representing 37 genera were isolated from the surface and fecal pellets. Even though the majority of the bacteria that were isolated from the surfaces were Gram negative those from the pellets were mostly Gram positive. The most common and abundant species belonged to *Pseudomonas* and *Serratia*, with members of the Enterobacteriaceae following. In the pellets, species of Bacillus were predominant, but, there were some

members of Enterobacteriaceae. Pathogens like *Salmonella, Shigella* and *B. cereus* were isolated. Opportunistic pathogens like species of *Pseudomonas, Klebsiella* and *Vibrio* and food spoilage bacteria such as species of *Enterobacter, Citrobacter, Escherichia, Erwinia,* and *Pseudomonas* were also found. Proper care in disposal of food remnants and overall cleanliness at the households prevents cockroaches from foraging in the kitchen and toilet.

Bouamama *et al.* (2007) in their studies on the 'Bacteriological analysis of *Periplaneta americana* and *Musca domestica* in ten districts of Tangier, Morocco' showed that eleven species of bacteria were isolated from isolated from *M. domestica* and *P. americana*. In this study, more bacterial species were recovered from *P. americana* than those from *M. domestica*. In similar studies carried out in France, 56 species of bacteria were isolated from cockroaches and 14 species were found to be pathogenic or potentially pathogenic for man and animal, with *E. coli* and *K. pneumoniae* being the most important (Rivault *et al.,* 1993; Vythilingam *et al.,*1997).

In Nigeria, a study was conducted to determine the role of cockroaches in Arkilla, Sokoto, Nigeria (Bala and Sule, 2012). From this study, a total of 218 cockroaches comprising of two species were examined for parasites. The dominant cockroach species was *Periplaneta americana* 145 (66.51%) followed by *Blatta orientalis* 73 (33.49%) and six medically important parasites were encountered, *Entamoeba histolytica* (40.83%), *Ascaris lumbricoides* (28.40%), *Enterobius vermicularis* (15.98%), *Schistosoma mansoni* (9.48%), *S. haematobium* (2.95%) and *Trichuris trichura* (2.36%).

Cockroaches have being involved in transmission of variety of parasites ranging from protozoan parasites, helminths parasites, bacteria and viruses.

Amoebiasis is worldwide in distribution and is the third most common cause of death due to parasitic infection after malaria and schistosomiasis. An estimated 40,000 to 100,000 deaths from amoebiasis occurs worldwide annually (WHO, 2012). The estimate as at 1986 is that *E. histolytica* causes between 34 million and 50 million symptomatic infections, that is, amoebic colitis or liver abscess each year (Walsh, 1986). The occurrence of amoebic liver abscess is 5-50 times less common than that of diarrhoea (Walsh, 1986). Reports from all the geographical regions of the country showed that amoebiasis is endemic in Nigeria. In Ahmadu Bello University Teaching Hospital Zaria, Kaduna state, report shows 23% *E. histolytica* as an etiology of chronic diarrhoea among children (Yakubu and Sathiakumar, 1985), another study reports 8.51% in five rural villages in Kaduna and Zaria (Inabo *et al*., 2000), in Maiduguri, 5.7% was reported (Mbaya and Nwosui, 2005), while in Ilesa, 80.5% was also reported (Ogunlesi *et al.*, 2005). Epidemiological studies have shown that low socioeconomic status and bad sanitary conditions are significant independent risk factors for infection. In addition, people living in developing countries have a higher risk and earlier age of infection than those in developed regions (Fuchis *et al.*, 1988).

In Nigeria, more unsanitary disposal of human faeces determined the level of parasite to be found in an area and this accelerates the development of soil – transmitted helminths (Youseffa, 2003). According to the study carried out by Adamu *et al.* (2010), indiscriminate defaecation contributed to the prevalence of *Strongyloides stercoralis* in observed in four local government of Kano State whereby Nassarawa (28.85%) and Ungoggo (26.92%) have the highest rate of infection than Dala (21.15%) and Fagge

(23.08%), because more open–space defaecation and faecal disposal is observed in the former two Local Governments.

Moniliformis dubius has been reported in Iraq, Italy, Sudan, Honduras, and Palestine (Al-Rawas *et al.,* 1977) in association with cockroaches. *Moniliformis* species has been reported in rodents in Khuzestan, Iran (Sadjjadi and Massoud, 1999).The first report of *Macracanthorhyncus hirudinaceus* in man was reported by LAMBL in 1859 in a child in Prague. The first case of human infection with *Moniliformis* species in Iran was reported in 1970 in an 18 month-old child from a village in the southeast of the country, near Zabol. The child suffered from anorexia and vomiting accompanied by foamy diarrhoea (Sahba *et al.,* 1970). The second case was a 4 month old Iranian boy, who exhibited characteristics of irritability, cough, diarrhoea, sweating, and pallor. A total of 9 worms were detected in the patient during 5 months of follow up (Moayedi *et al.*, 1971). Data on the epidemiology of *Moniliformis dubius* is rare as there is inadequate information on the distribution of the parasite.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

Samaru Community lies on latitude 11°10□N and 7°38□E in DMS (Degrees Minutes Seconds). It is located in Sabon Gari Local Government Area of Kaduna State after Kaduna town north ward along Kaduna-Kano highway (fig. 3.1).

The area is a village opposite Ahmadu Bello University, Main Campus along Zaria-Sokoto road and Zaria – Kaura/Namoda railway line. It is also one of the major settlements that make up the urban Zaria. The establishment of the Ahmadu Bello University resulted in the establishment of the Samaru settlement opposite the institution.

3.2 Sample Size Determination

The total sample size from each location was estimated using the standard formula of Handerson and Sundaresan; $N=Z^2PQ/D^2$ (UNDP/World Bank/WHO, 2001). Where N is the number of samples that were collected; Z is the normal deviate (1.96 for an alpha of 0.05) corresponding to a confidence interval of 95%; P is the number infected; Q=1-P. D^2 is the precision of the estimates.

The value of P in the calculation was set at 77.52% (Bala and Sule, 2012). The value of D was set at 5%. Therefore, N is equal to 268 cockroaches approximately, which is the minimum number of cockroaches that were to be collected.

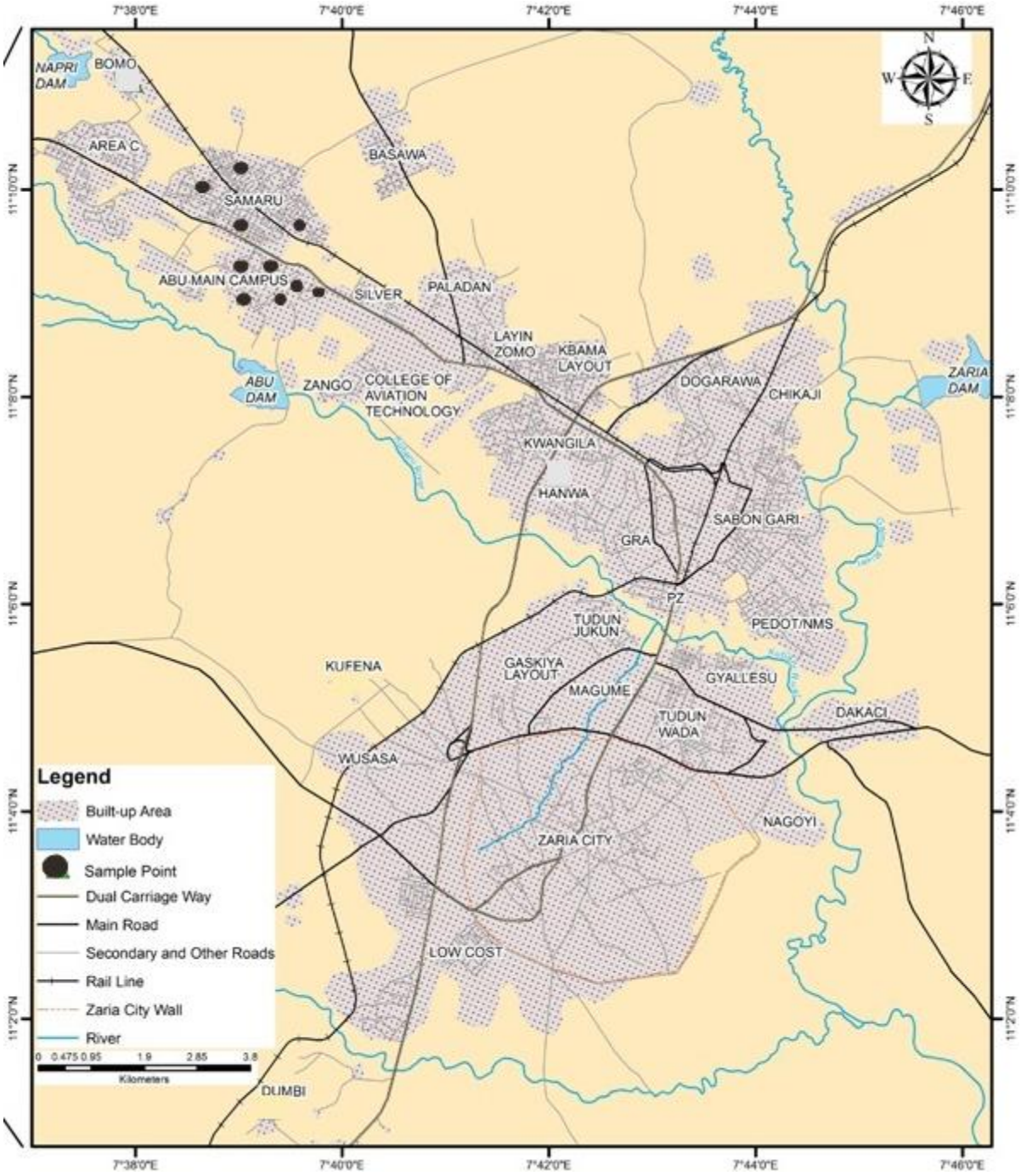


Figure 3.1 Map Showing Sampling Points from Ahmadu Bello University Main Campus and Samaru Village, Zaria (Source: Department of Geography, A.B.U. Zaria).

3.3 Sample Collection

Cockroaches were collected from different parts of Ahmadu Bello University Main Campus and Samaru Village, Zaria, Kaduna State. The following are the sampling areas for collection of cockroaches;

(a) Ahmadu Bello University Main Campus

- (i) Akenzua Hall
- (ii) Suleiman Hall
- (iii) Danfodio Hall
- (iv) Yar'adua Hall
- (v) Queen Amina Hall
- (vi) Ribadu Hall

(b) Samaru Community

- (i) Danraka Area
- (ii) Samaru New Layout School Area
- (iii) Hayin Dogo Area
- (iv) Hanyin Dan Yaro Area

Samples were collected daily between the hours of 10:00 pm and 4:00 am. During the period, cockroaches were collected from kitchens, basements or bathrooms of residential area, Halls, and toilets. Each cockroach was collected using gloved hands and placed in a sterile test tube containing 5 ml of sterile normal saline (0.9%) (Adeleke *et al.*, 2012); samples were transported to the laboratory and immobilized by freezing at 0^{o}C for 5 min. The cockroaches were identified morphologically using standard taxonomic keys

(Tawatsin *et al.,* 2001). Only cockroaches captured whole and live was utilized for the study.

3.4 Isolation and Identification of Parasite Cyst and Ova/Larvae From External Surfaces:

After identification, the cockroaches were thoroughly shaken in the 5 ml of 0.9% normal saline for 2 minutes. The washings was decanted into centrifuge tubes and centrifuged at 2000 rpm for 2 minutes. The sediment was transferred to a clean glass slides, and a drop of 1% Lugols Iodine was added for clarity. The slide was then covered with a cover slip and examined under a light microscope at x10, x40 and x100. The cyst, ova and larvae of parasites were identified and counted (Chandler and Read, 1962; Chatterjee, 1976; Cheesbrough, 2009,).

3.5 Isolation and Identification of Parasite Cyst and Ova/Larvae From Internal Surfaces

After external washings, cockroaches were placed in flasks rinsed with 70% alcohol for 5 min (to decontaminate external surfaces as 70% alcohol is bactericidal), transferred to sterilized flasks, and allowed to dry at room temperature for 5 minutes. Cockroaches were then washed with sterile normal saline for 2–3 min to remove traces of alcohol.

3.6 Dissection of Cockroaches for Internal Parasites

The head and legs were severed out, with the help of fine pointed entomological forceps and scissors. The body was then pinned to a small dissection tray with thin but rigid pins (the best are the kind used by entomologists to pin their specimens, but you can use the thinnest and longest steel hand sewing needles).

With the scissors, the ligaments was cut on the right hand side of the abdominal sternites, beginning at the rear end, and the ventral plate so released is hinged towards the left side, clearing its adhesions to the internal organs with sharp needles or with a microscalpel, and was discarded or pinned down.

3.7 Isolating The Alimentary Canal

With thin and sharp teasing needles and or very fine pointed forceps, the fat that surrounds the abdominal organs was removed. The alimentary canal was isolated and was then set free from its ties, it was then separated more or less completely, the gizzard was moved with the tweezers until the esophagus was seen and then it was cut distally. The rest of the digestive tract was then liberated with the needles, and cut at the other end, at the level of the anus (or cloaca).

The intestinal cecae was identified. With the help of the forceps and the scissors, two cuts were made in the intestine: one below the cecae, and another one at the level of the cloaca. The separated intestine was then transferred to a capsule with clean physiological solution. With the two rigid teasing needles, fine and sharpened, the intestine was open alongside, releasing its content.

After dissection, the intestines of the cockroach were macerated aseptically in a sterile pestle and mortar in 5 ml of sterile normal saline. The resulting macerated intestine was then processed in a similar way as described previously and the results were recorded (Garcia and Bruckner, 1997, Cheesbrough, 2006).

3.8 Statistical Analyses

Descriptive statistics was used to analyze the prevalence and Analysis of Variance (ANOVA) was used to show level of significance between the locations, species, sex and stage of developments. Comparison of data obtained from the external and internal body of cockroaches collected from Samaru Village and Ahmadu Bello University Main Campus, Zaria was subjected to independent and paired t-test. Statistical Package for Social Sciences (SPSS) version 21.0 was used for the Analyses.

CHAPTER FOUR

4.0 RESULTS

4.1 Distribution of Parasites Based On Sex of Cockroach Species

A total of 630 cockroaches were collected. They were made up of 400 (63.49%) *Periplaneta americana* and 230 (36.51%) *Blattella germanica*. Out of the total number, 116 (18.41%) cockroaches were positive for parasites i.e. 96 (24.0%) of *Periplaneta americana* and 20 (8.70%) of *Blattella germanica* (Table 4.1).

The distribution of parasites according to gender of cockroaches in different locations in ABU community shows that prevalence of male *P. americana* cockroaches was highest in Queen Amina Hall with 12 (30.00%) followed by those recovered in Ribadu Hall, 11 (27.50%) while in male *B. germanica*, Queen Amina Hall had the highest prevalence of 6 (26.09%). In females *P. americana*, Danfodio Hall had the highest prevalence of 9 (22.50%) followed by Suleiman Hall with 8 (20.00%) and in female *B. germanica*, Ribadu Hall had the highest prevalence of 2 (8.70%).

In Samaru Village, male *P. americana* cockroaches collected from Hayin Dan Yaro harboured more parasites with prevalence of 3 (7.50%) while in male *B.* germanica, Hayin Dogo and Hayin Dan Yaro had the same prevalence of 1 (4.35%). In female *P. americana*, Hayin Dogo had the highest prevalence of 6 (15.00%) and in female *B. germanica*, Hayin Dan Yaro and New Layout had a prevalence of 2 (8.70%) both.

On a general note, the female had the highest prevalence of 53 (13.25%) and 11 (4.78%) among *Periplaneta americana* and *Blattella germanica* respectively. Significant difference ($P \leq 0.05$) was noted in the prevalence of parasites between *P. americana* and *B. germanica* in ABU and also among *Blatella germanica* cockroaches in SV (Appendix 1).

Table 4.1: Prevalence of Parasites Based On Sex of Cockroach Species from Locations

Locations	Areas	*Periplaneta americana*				*Blattella germanica*				Grand Total (%)
		Total Captured	Number of Male (%)	Number of Female (%)	Total Number (%)	Total Number Captured	Number of Male (%)	Number of Female (%)	Total Number (%)	
ABU	Akenzua Hall	40	0 (0.00)	5 (12.50)	5 (12.50)	23	0 (0.00)	0 (0.00)	0 (0.00)	**5 (7.94)**
	Suleiman Hall	40	6 (15.00))	8 (20.00)	14 (35.00)	23	0 (0.00)	1 (4.35)	1 (4.35)	**15 (23.81)**
	Yar'adua Hall	40	4 (10.00)	6 (15.00)	10 (25.00)	23	1 (4.35)	1 (4.35)	2 (8.70)	**12 (19.05)**
	Danfodio Hall	40	5 (12.50)	9 (22.50)	14 (35.00)	23	0 (0.00)	1 (4.35)	1 (4.35)	**15 (23.81)**
	Queen Amina Hall	40	12 (30.00)	6 (15.00)	18 (45.00)	23	6 (26.09)	1 (4.35)	7 (30.43)	**25 (39.68)**
	Ribadu Hall	40	11 (27.50)	6 (15.00)	17 (42.50)	23	0 (0.00)	2 (8.70)	2 (8.70)	**19 (30.16)**
		240	**38 (15.83)**	**40 (16.67)**	**78 (32.50)**	**138**	**7 (5.07)**	**6 (4.35)**	**13 (9.42)**	**91 (24.07)**
SV	Danraka	40	0 (0.00)	0 (0.00)	0 (0.00)	23	0 (0.00)	0 (0.00)	0 (0.00)	**0 (0.00)**
	New Layout	40	0 (0.00)	2 (5.00)	2 (5.00)	23	0 (0.00)	1 (4.35)	1 (4.35)	**3 (4.76)**
	Hayin Dan Yaro	40	3 (7.50)	5 (12.50)	8 (20.00)	23	1 (4.35)	2 (8.70)	3 (13.04)	**11 (17.46)**
	Hayin Dogo	40	2 (5.00)	6 (15.00)	8 (20.00)	23	1 (4.35)	2 (8.70)	3 (13.04)	**11 (17.46)**
		160	**5 (4.13)**	**13 (8.13)**	**18 (11.25)**	**92**	**2 (2.17)**	**5 (5.43)**	**7 (7.61)**	**25 (9.92)**
Total		**400**	**43 (10.75)**	**53 (13.25)**	**96 (24.00)**	**230**	**9 (3.91)**	**11 (4.78)**	**20 (8.70)**	**116 (18.41)**

4.2 Distribution of Parasites Based On Developmental Stages of Cockroach Species from Locations

In ABU community, the prevalence of adult *P. americana* cockroaches was highest in Ribadu Hall with 15 (37.50%) followed by those recovered in Amina Hall, 14 (35.00%) while in Adult *B. germanica,* Queen Amina Hall had the highest prevalence of 6 (26.09%) followed by Yar'adua and Ribadu Halls with prevalence of 2 (8.70%) both. In nymph of *P. americana* and nymph of *B. germanica,* Queen Amina Hall had the highest prevalence of 4 (10.00%) and 1 (4.35%) respectively (Table 4.2).

In Samaru Village, adult *P. americana* cockroaches collected from Hayin Dan Yaro harboured more parasites with prevalence of 7 (17.50%) followed by Hayin Dogo with 6 (15.00%) while in adult *B.* germanica, Hayin Dogo had the highest prevalence of 3 (13.04%) followed by Hayin Dan Yaro with a prevalence of 2 (8.70%). In nymph of *P. americana,* Hayin Dogo had the highest prevalence of 2 (5.00%) and in nymph of *B. germanica,* Hayin Dan Yaro and New Layout had a prevalence of 1 (4.35%) both.

On the developmental stages of the cockroaches, the highest prevalence was observed in adult *P. americana* with 82 (20.50%) which was significant ($P \leq 0.05$) from adult *B. germanica* with 17 (7.39%). Between locations, ABU had a prevalence of 91 (24.07%) which was significant ($P \leq 0.05$) from SV with 25 (9.92%) (Table 4.2). Also, the adult had the highest prevalence of 17 (7.39%) in *B. germanica*. Significant difference in prevalence ($P \leq 0.05$) was noted between location and species of cockroach, species and stage of development and also between the location and stage of development at $P \leq 0.05$ (Appendix 2).

Table 4.2: Prevalence of Parasites Based On Developmental Stages of Cockroach Species from Locations

Locations	Areas	*Periplaneta americana*				*Blattella germanica*				Grand Total (%)
		Total Captured	Number of Adult (%)	Number of Nymph (%)	Total Number (%)	Total Number Captured	Number of Adult (%)	Number of Nymph (%)	Total Number (%)	
ABU	Akenzua Hall	40	5 (12.50)	0 (0.00)	5 (12.50)	23	0 (0.00)	0 (0.00)	0 (0.00)	**5 (7.94)**
	Suleiman Hall	40	12 (30.00)	2 (5.00)	14 (35.00)	23	1 (4.35)	0 (0.00)	1 (4.35)	**15 (23.81)**
	Yar'adua Hall	40	9 (22.50)	1 (2.50)	10 (25.00)	23	2 (8.70)	0 (0.00)	2 (8.70)	**12 (19.05)**
	Danfodio Hall	40	12 (30.00)	2 (5.00)	14 (35.00)	23	1 (4.35)	0 (0.00)	1 (4.35)	**15 (23.81)**
	Queen Amina Hall	40	14 (35.00)	4 (10.00)	18 (45.00)	23	6 (26.09)	1 (4.35)	7 (30.43)	**25 (39.68)**
	Ribadu Hall	40	15 (37.50)	2 (5.00)	17 (42.50)	23	2 (8.70)	0 (0.00)	2 (8.70)	**19 (30.16)**
		240	**67 (27.91)**	**11 (4.58)**	**78 (32.50)**	**138**	**12 (8.70)**	**1 (0.72)**	**13 (9.42)**	**91 (24.07)**
SV	Danraka	40	0 (0.00)	0 (0.00)	0 (0.00)	23	0 (0.00)	0 (0.00)	0 (0.00)	**0 (0.00)**
	New Layout	40	2 (5.00)	0 (0.00)	2 (5.00)	23	0 (0.00)	1 (4.35)	1 (4.35)	**3 (4.76)**
	Hayin Dan Yaro	40	7 (17.50)	1 (2.50)	8 (20.00)	23	2 (8.70)	1 (4.35)	3 (13.04)	**11 (17.46)**
	Hayin Dogo	40	6 (15.00)	2 (5.00)	8 (20.00)	23	3 (13.04)	0 (0.00)	3 (13.04)	**11 (17.46)**
		160	**15 (9.38)**	**3 (1.88)**	**18 (11.25)**	**92**	**5 (5.43)**	**2 (2.08)**	**7 (7.61)**	**25 (9.92)**
Total		**400**	**82 (20.50)**	**14 (3.50)**	**96 (24.00)**	**230**	**17 (7.39)**	**3 (1.30)**	**20 (8.70)**	**116 (18.41)**

4.3 Distribution of Medically Important Parasites Based On The Sex of Cockroach Species

In ABU community, prevalence of male *P. americana* cockroaches with *Moniliformis dubius* and *Strongyloides stercoralis* was highest in Queen Amina Hall with 9 (14.2%) and Ribadu Hall with 5 (7.94%) respectively. In male *B. germanica*, Queen Amina Hall had the highest prevalence of 3 (4.76%) for both *Strongyloides stercoralis* and *Entamoeba histolytica* with no *Moniliformis dubius* found. In females *P. americana*, Suleiman Hall and Ribadu Hall had the highest prevalence of 8 (12.70%) for *Moniliformis dubius* and 6 (9.52%) for *Strongyloides stercoralis* respectively. *Entamoeba histolytica* was not found at all in male and female *P. americana* cockroaches from ABU while in female *B. germanica* in ABU, *S. stercoralis* and *E. histolytica* had a prevalence of 1 (1.59%) in all the Halls where it was found, *Moniliformis dubius* (Table 4.3).

In Samaru Village, male *P. americana* harboured only *Strongyloides stercoralis* and *Entamoeba histolytica* with the highest prevalence of 2 (3.18%) and 1 (1.59%) in Hayin Dan Yaro and Hayin Dogo respectively. Male *B. germanica* cockroaches collected from Hayin Dan Yaro and Hayin Dogo were the only ones to harboured *Entamoeba histolytica* with prevalence of 1 (1.59%) both. *Strongyloides stercoralis* and *Moniliformis dubius* was not found here. In female *P. americana, S. stercoralis* had the highest prevalence in Hayin Dogo with 6 (9.52%) and *Entamoeba histolytica* was only encountered in Hayin Dan Yaro with prevalence of 1 (1.59%). In female *B. germanica*, Hayin Dan Yaro and Hayin Dogo had the highest prevalence of 2 (3.18%) for both *S. Stercoralis* and *E. histolytica*.

Table 4.3: Prevalence of Parasites Based On Sex of Cockroaches Species from Sampling Locations

Locations	Sampling Areas	No. Sampled	*Periplaneta americana*						*Blattella germanica*					
			Male			Female			Male			Female		
			MD (%)	SS (%)	EH (%)	MD (%)	SS (%)	EH (%)	MD (%)	SS (%)	EH (%)	MD (%)	SS (%)	EH (%)
ABU	Akenzua Hall	63	0 (0.0)	0 (0.0)	0 (0.0)	5 (7.94)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	Suleiman Hall	63	6 (9.52)	0 (0.0)	0 (0.0)	8 (12.70)	1 (1.59)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.59)	0 (0.0)
	Yar'adua Hall	63	3 (4.76)	1 (1.59)	0 (0.0)	3 (4.76)	3 (4.76)	0 (0.0)	0 (0.0)	1 (1.59)	0 (0.0)	0 (0.0)	1 (1.59)	0 (0.0)
	Danfodio Hall	63	4 (6.35)	2 (3.18)	0 (0.0)	9 (14.2)	2 (3.18)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.59)	0 (0.0)
	Queen Amina Hall	63	9 (14.2)	5 (7.94)	0 (0.0)	3 (4.76)	3 (4.76)	0 (0.0)	0 (0.0)	3 (4.76)	3 (4.76)	0 (0.0)	0 (0.0)	0 (0.0)
	Ribadu Hall	63	7 (11.11)	5 (7.94)	0 (0.0)	2 (3.18)	6 (9.52)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.59)
		378	**29 (7.67)**	**13 (3.44)**	**0 (0.00)**	**30 (7.94)**	**15 (3.97)**	**0 (0.00)**	**0 (0.00)**	**4 (1.06)**	**3 (0.79)**	**0 (0.00)**	**3 (0.79)**	**1 (0.26)**
SV	Danraka	63	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	New Layout	63	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (3.18)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	Hayin Dan Yaro	63	0 (0.0)	2 (3.18)	0 (0.0)	0 (0.0)	3 (4.76)	1 (1.59)	0 (0.0)	1 (1.59)	0 (0.0)	0 (0.0)	2 (3.18)	0 (0.0)
	Hayin Dogo	63	0 (0.0)	1 (1.59)	1 (1.59)	0 (0.0)	6 (9.52)	0 (0.0)	0 (0.0)	1 (1.59)	0 (0.0)	0 (0.0)	1 (1.59)	2 (3.18)
		252	**0 (0.00)**	**3 (1.19)**	**1 (0.40)**	**0 (0.00)**	**11 (4.37)**	**1 (0.40)**	**0 (0.00)**	**2 (0.79)**	**0 (0.00)**	**0 (0.00)**	**3 (1.19)**	**2 (0.79)**
Total		**630**	**29 (4.60)**	**16 (2.54)**	**1 (0.16)**	**30 (4.76)**	**26 (4.13)**	**1 (0.16)**	**0 (0.00)**	**6 (0.95)**	**3 (0.48)**	**0 (0.00)**	**6 (0.95)**	**3 (0.48)**

On a general note, males of *P. americana* had the highest *Moniliformis dubius* carriage which is the highest prevalence based on parasite species and the sex of cockroaches. This parasite was not encountered at all in SV and also among *B. germanica*. *Strongyloides stercoralis* and *Entamoeba histolytica* were not significant among the location and also in sex of cockroaches. Although, *Strongyloides stercoralis* was significant between the species of cockroaches with *P. americana* having the prevalence of 16 (2.54%) in males and 26 (4.13%) in females compared to that in *B. germanica* with 6 (0.95%) in both males and females (Appendix 3).

4.4 Distribution of Medically Important Parasites Based On The Stage of Development of Cockroach Species

In ABU community shows that prevalence of adult *P. americana* cockroaches with *Moniliformis dubius* and *Strongyloides stercoralis* was highest in Suleiman Hall with 12 (19.04%%) and Ribadu Hall with 9 (14.2%) respectively. In adult *B. germanica*, Yar'adua Hall and Queen Amina Hall had the highest prevalence of 3 (3.18%) and 3 (4.76%) for both *Strongyloides stercoralis* and *Entamoeba histolytica* respectively. No *Moniliformis dubius* was found. In the nymph of *P. americana*, *Moniliformis dubius* harboured more parasites in Queen Amina Hall with prevalence of 4 (6.35%) and *Entamoeba histolytica* in Ribadu Hall with prevalence of 2 (3.18%). In the nymph of *B. germanica*, only *Entamoeba histolytica* was found only in Queen Amina Hall with a prevalence of 1 (1.59%) (Table 4.4).

Table 4.4: Prevalence of Parasites Based on Developmental Stage of Cockroaches Species from Sampling Locations

Locations	Sampling Areas	No. Sampled	*Periplaneta americana*						*Blattella germanica*					
			Adult			Nymph			Adult			Nymph		
			MD (%)	SS (%)	EH (%)	MD (%)	SS (%)	EH (%)	MD (%)	SS (%)	EH (%)	MD (%)	SS (%)	EH (%)
ABU	Akenzua Hall	63	5 (7.94)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	Suleiman Hall	63	12 (19.04)	1 (1.59)	0 (0.0)	2 (3.18)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.59)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	Yar'adua Hall	63	5 (7.94)	4 (6.35)	0 (0.0)	1 (1.59)	0 (0.0)	0 (0.0)	0 (0.0)	2 (3.18)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	Danfodio Hall	63	11 (17.46)	4 (6.35)	0 (0.0)	2 (3.18)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.59)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	Queen Amina Hall	63	8 (12.70)	8 (12.70)	0 (0.0)	4 (6.35)	0 (0.0)	0 (0.0)	0 (0.0)	2 (3.18)	3 (4.76)	0 (0.0)	1 (1.59)	0 (0.0)
	Ribadu Hall	63	9 (14.2)	9 (14.2)	0 (0.0)	0 (0.0)	2 (3.18)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.59)	0 (0.0)	0 (0.0)	0 (0.0)
		378	**50 (13.22)**	**26 (6.88)**	**0 (0.00)**	**9 (2.38)**	**2 (0.53)**	**0 (0.00)**	**0 (0.00)**	**6 (1.59)**	**4 (1.06)**	**0 (0.00)**	**1 (0.26)**	**0 (0.00)**
SV	Danraka	63	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	New Layout	63	0 (0.0)	2 (3.18)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	Hayin Dan Yaro	63	0 (0.0)	5 (7.94)	1 (1.59)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (3.18)	0 (0.0)	0 (0.0)	1 (1.59)	0 (0.0)
	Hayin Dogo	63	0 (0.0)	6 (9.52)	0 (0.0)	0 (0.0)	1 (1.59)	1 (1.59)	0 (0.0)	2 (3.18)	2 (3.18)	0 (0.0)	0 (0.0)	0 (0.0)
		252	**0 (0.00)**	**13 (5.16)**	**1 (0.40)**	**0 (0.00)**	**1 (0.40)**	**1 (0.40)**	**0 (0.00)**	**4 (1.59)**	**2 (0.79)**	**0 (0.00)**	**1 (0.40)**	**0 (0.00)**
Total		**630**	**50 (7.94)**	**39 (6.19)**	**1 (0.16)**	**9 (1.43)**	**3 (0.48)**	**1 (0.16)**	**0 (0.00)**	**10 (1.59)**	**6 (0.95)**	**0 (0.00)**	**2 (0.32)**	**0 (0.00)**

In Samaru Village, adult *P. americana* harboured only *Strongyloides stercoralis* and *Entamoeba histolytica* with the highest prevalence of 6 (9.52%) and 1 (1.59%) in Hayin Dogo and Hayin Dan Yaro respectively. Adult *B. germanica* cockroaches collected from Hayin Dan Yaro and Hayin Dogo were the only ones to harboured *Entamoeba histolytica* and *Strongyloides stercoralis* with a prevalence of 1 (3.18%), *Moniliformis dubius* was not found. In nymph *P. americana*, *S. stercoralis* and *E. histolytica* only in Hayin Dogo with a prevalence of 1 (1.59%). In nymph *B. germanica*, *Entamoeba histolytica* was the only parasite encountered and in Hayin Dan Yaro with a prevalence of 1 (1.59%).

Distribution of medically important parasites based on the stage of development of the cockroaches revealed no significant difference (P>0.05) in *Entamoeba histolytica* recovered among the stage of development but significant difference in *Moniliformis dubius* and *Strongyloides stercoralis* among adult and nymph of cockroaches as well as between the species of cockroaches (Appendix 4). *Moniliformis dubius* was carried more than the other parasites with a prevalence of 50 (13.22%) in ABU main campus and was not found at all in all the cockroaches from SV and in *Blatella germanica* cockroaches.

4.5 Distribution of Parasites from Species of Cockroach

In ABU community, *P. americana* collected from Amina hostel harboured highest the number of parasites, 18 (45.0%) followed by those recovered in Ribadu Hall, 17 (42.50%). The least prevalence was recorded in Akenzua hall, 5 (12.5%). On the other hand, out of the 23 *B. germanica* captured from each hall, the ones captured from Amina Hall were found to harbour more parasites, 7 (30.43%) followed by Ribadu hall and Yar'adua had 2 (8.7%) prevalence each (Table 4.5).

Table 4.5: Distribution of Medically Important Parasites by Species of Cockroaches in the Study Areas.

Locations	Sampling Areas	*Periplaneta americana*		*Blattella germanica*	
		Total Captured	**Number Positive (%)**	**Total Captured**	**Number Positive (%)**
ABU	Akenzua Hall	40	5 (12.50)	23	0 (0.00)
	Suleiman Hall	40	14 (35.00)	23	1 (4.35)
	Yar'adua Hall	40	10 (25.00)	23	2 (8.70)
	Danfodio Hall	40	14 (35.00)	23	1 (4.35)
	Queen Amina Hall	40	18 (45.00)	23	7 (30.43)
	Ribadu Hall	40	17 (42.50)	23	2 (8.70)
		240	**78 (32.50)**	**138**	**13 (9.42)**
SV	Danraka	40	0 (0.00)	23	0 (0.00)
	New Layout	40	2 (5.00)	23	1 (4.35)
	Hayin Dan Yaro	40	8 (20.00)	23	3 (13.04)
	Hayin Dogo	40	8 (20.00)	23	3 (13.04)
		160	**20 (12.50)**	**92**	**7 (7.61)**
Total		**400**	**96 (24.00)**	**230**	**20 (8.70)**

The least prevalence was in Suleiman Hall and Danfodio Hall where only 1 cockroaches each representing 4.35% of the study population in the Hall harboured parasites. No parasite was recovered from *B. germanica* species captured from Akenzua hall.

In Samaru Village, *P. americana* species collected from Hayin Dogo and Hayin Dan Yaro harboured the highest parasites each, 8 (20.0%) while New Layout had the least prevalence, 2 (5.0%). No parasite was recovered from cockroaches captured from Danraka estate. The same trend was recorded in *B. germanica* captured from Samaru Village whereby species captured in Hayin Dan Yaro and Hayin Dogo harboured more parasites, 3 (13.04%) followed by those captured in New Layout, 1(4.35%). No single parasite was recovered from *B. germanica* species captured in Danraka Estate (table 4.5).

There was statistically significant difference ($P \leq 0.01$) in prevalence between *P. americana* and *B. germanica*, and between *P. americana* and *B. germanica*. Also, there was statistically significant difference ($P \leq 0.05$) between *P. americana* in ABU and SV. In *Blatella germanica*, the study revealed that there was no statistically significant difference ($P > 0.05$) in prevalence of parasites recovered from *B. germanica* captured in ABU and Samaru Village (Appendix 5). On a general note, Amina hall in ABU both had the highest prevalence of parasites in species of cockroaches that were captured while in Samaru Village, the least prevalence was recorded in New Layout.

4.6 Distribution of Parasites by Gender

In ABU community, Male collected from Amina hostel harboured highest number of parasites, 18 (54.55%) followed by those recovered in Ribadu Hall, 11 (35.48%). The least prevalence was recorded in Yar'adua Hall with a prevalence of 5 (15.63%) while all

the male cockroaches from Akenzua Hall had no parasites. On the other hand, female captured from each hall revealed that cockroaches captured from Danfodio Hall were found to harbour more parasites with 10 (29.41%) prevalence followed by Suleiman hall with 9 (26.47%) prevalence. The least prevalence was in Akenzua Hall with 5 (14.7%) prevalence (Table 4.6).

In Samaru Village, male cockroaches collected from Hayin Dan Yaro harboured more parasites with prevalence of 4 (12.90%) followed by Hayin Dogo, 3 (9.09%) while New Layout had the least prevalence of 1 (4.17%). No parasite recovered from cockroaches captured from Danraka Area. In females cockroaches from Samaru Village, females captured from Hayin Dogo harboured more parasites, 8 (26.67%) followed by those captured in Hayin Dan Yaro, 7 (21.88%). No single parasite was recovered from female cockroaches captured in Danraka Area (Table 4.6).

There was no statistically significant difference ($P>0.05$) in prevalence between male and female in ABU, male and female in SV, Male from ABU and SV, female from ABU and SV, and male and female (Appendix 6). On a general note, Amina hall in ABU had the highest prevalence of parasites of 18 (54.55%) in male cockroaches and Danfodio Hall in ABU had the highest prevalence of 10 (29.41%) in female cockroaches while New Layout in SV had the least prevalence in males, 1 (4.17%) and females, 2 (5.13%). No parasites recovered in Danraka Area and males captured in ABU.

4.7 Distribution of Parasites by Developmental Stages of Cockroaches

In ABU community, adult cockroaches collected from Queen Amina hall harboured highest number of parasites, 20 (40.82%) followed by those recovered in Ribadu Hall,

Table 4.6: Distribution of Medically Important Parasites by Gender of Cockroach in the Study Areas.

Locations	Sampling Areas	Male		Female	
		Total Captured	**Number Positive (%)**	**Total Captured**	**Number Positive (%)**
ABU	Akenzua Hall	29	0 (0.00)	34	5 (14.71)
	Suleiman Hall	29	6 (20.69)	34	9 (26.47)
	Yar'adua Hall	32	5 (15.63)	31	7 (22.58)
	Danfodio Hall	29	5 (17.24)	34	10 (29.41)
	Queen Amina Hall	33	18 (54.55)	30	7 (23.33)
	Ribadu Hall	31	11 (35.48)	32	8 (25.00)
		183	**45 (24.59)**	**195**	**46 (23.59)**
SV	Danraka	27	0 (0.00)	36	0 (0.00)
	New Layout	24	1 (4.17)	39	2 (5.13)
	Hayin Dan Yaro	31	4 (12.90)	32	7 (21.88)
	Hayin Dogo	33	3 (9.09)	30	8 (26.67)
		115	**8 (6.96)**	**137**	**17 (12.41)**
Total		**298**	**53 (17.79)**	**332**	**63 (18.98)**

17 (32.69%) while the least prevalence was recorded in Akenzua Hall with a prevalence of 5 (10.20%). On the other hand, nymph of cockroaches captured from each hall revealed that cockroaches captured from Amina Hall were found to harbour more parasites with 10 (29.41%) prevalence followed by Danfodio Hall, 9 (26.47%). The least prevalence was in Yar'adua Hall, 1 (10.00%). No parasite was recovered from nymph from Akenzua Hall in ABU (Table 4.7).

In Samaru Village, adult cockroaches collected from Hayin Dan Yaro and Hayin Dogo harboured more parasites with prevalence of 9 (16.98%) each while New Layout Area had the least prevalence of 2 (3.77%). In nymph cockroaches from Samaru Village, nymphs captured from Hayin Dan Yaro and Hayin Dogo still harboured more parasites with prevalence of 2 (20.00%) each while New layout had the least prevalence of 1 (10.00%). No parasite was recovered from adult and nymph of cockroaches from Danraka Area in SV (table 4.7).

There was no statistically significant difference ($P>0.05$) in prevalence between adult and nymph of cockroaches. Significant difference was noted between adult cockroaches from ABU and SV ($P\leq0.05$) and between adult and nymph ($P\leq0.01$) cockroaches from ABU.
On a general note, Amina hall in ABU had the highest prevalence of 20 (40.82%) while New Layout in SV had the least prevalence of 1 (10.00%) (Appendix7). No parasites recovered in adult and nymph cockroaches captured from Danraka Area, Samaru Village.

4.8 Distribution of Parasites On Body Surfaces of Cockroaches in Study Areas

In ABU community, highest prevalence of parasite recovered from the external body surface was in Ribadu Hall, 16 (25.40%) followed by Queen Amina Hall, 14 (22.22%)

Table 4.7: Distribution of Medically Important Parasites in the Different Developmental Stages of Cockroaches in the Study Areas.

Locations	Sampling Areas	Adult		Nymph	
		Total Captured	**Number Positive (%)**	**Total Captured**	**Number Positive (%)**
ABU	Akenzua Hall	49	5 (10.20)	14	0 (0.00)
	Suleiman Hall	50	13 (26.00)	13	2 (15.38)
	Yar'adua Hall	53	11 (20.75)	10	1 (10.00)
	Danfodio Hall	54	13 (24.07)	9	2 (22.22)
	Queen Amina Hall	49	20 (40.82)	14	5 (35.71)
	Ribadu Hall	52	17 (32.69)	11	2 (18.18)
		307	**79 (25.73)**	**71**	**12 (3.91)**
SV	Danraka	53	0 (0.00)	10	0 (0.00)
	New Layout	53	2 (3.77)	10	1 (10.00)
	Hayin Dan Yaro	53	9 (16.98)	10	2 (20.00)
	Hayin Dogo	53	9 (16.98)	10	2 (20.00)
		212	**20 (9.43)**	**40**	**5 (2.36)**
Total		**519**	**99 (19.08)**	**111**	**17 (15.32)**

while the least prevalence was recorded in Akenzua Hall, 3 (4.76%). On the other hand, the highest prevalence from internal body surface was in Queen Amina Hall, 21 (33.33%) followed by Ribadu Hall, 16 (25.40%) while the least prevalence was in Akenzua Hall, 2 (3.17%) (Table 4.8).

In Samaru Village, cockroaches collected from Hayin Dogo harboured more parasites with prevalence of 10 (15.87%) followed by Hayin Dan Yaro, 8 (12.70%) and New Layout had the least prevalence of 1 (1.59%) while on the internal body surface, Hayin Dan Yaro had the highest prevalence of 5 (7.94%) followed by Hayin Dogo, 3 (4.76%) with the least in New Layout, 2 (3.17%). No parasite was recovered from external and internal body surfaces of cockroaches from Danraka Area in SV (table 4.8).

There was significant difference ($P \leq 0.05$) in prevalence of parasites recovered from internal body surfaces of cockroaches from ABU and SV. There was no statistically significant difference ($P > 0.05$) in prevalence of parasites recovered from external and internal body surfaces, external body surfaces of cockroaches from ABU and SV, external and internal body surfaces of cockroaches from ABU, external and internal body surfaces of cockroaches from SV (Appendix 8). On a general note, Ribadu Hall in ABU had the highest prevalence of 16 (25.40%) while New Layout in SV had the least prevalence of 1 (1.59%). No parasites recovered from cockroaches captured from Danraka Area, Samaru Village.

4.9 Distribution of Parasites from Body Surfaces of Cockroaches

Strongyloides stercoralis was the most encountered parasite externally with a prevalence of 47 (7.5%) and *Moniliformis dubius* was the most encountered parasite internally with

Table 4.8: Distribution of Medically Important Parasites by Body Surfaces of Cockroach Isolated in the Study Areas.

Locations	Sampling Areas	Total Captured (Number Positive, %)	External	Internal
			Number Positive (%)	Number Positive (%)
ABU	Akenzua Hall	63 (5,7.94)	3 (4.76)	2 (3.17)
	Suleiman Hall	63 (15, 23.81)	11 (17.46)	12 (19.05)
	Yar'adua Hall	63 (12, 19.05)	10 (15.87)	4 (6.35)
	Danfodio Hall	63 (15, 23.81)	7 (11.11)	13 (20.63)
	Queen Amina Hall	63 (25, 39.68)	14 (22.22)	21 (33.33)
	Ribadu Hall	63 (19, 30.16)	16 (25.40)	16 (25.40)
		378 (91, 24.07)	**61 (16.14)**	**68 (17.99)**
SV	Danraka	63 (0, 0.00)	0 (0.00)	0 (0.00)
	New Layout	63 (3, 4.76)	1 (1.59)	2 (3.17)
	Hayin Dan Yaro	63 (11, 17.46)	8 (12.70)	5 (7.94)
	Hayin Dogo	63 (11, 17.46)	10 (15.87)	3 (4.76)
		252 (25, 9.92)	**19 (7.54)**	**10 (3.97)**
	Total	**630 (116, 18.41)**	**80 (12.70)**	**78 (12.38)**

prevalence of 40 (6.4%) while the least encountered was *Entamoeba histolytica* from external (3, 0.5%) and internal (5, 0.8%) body surfaces (Table 4.9). No significant difference (P>0.05) between the parasites from external and internal body surfaces and also between the helminths and protozoa parasites from both locations.

4.10 Distribution of Parasites Based On Point of Collection

The prevalence of parasites from cockroaches based on point of collection revealed that cockroaches captured from toilets had the highest prevalence. In ABU, prevalence was highest in Queen Amina Hall, 11 (64.71%) followed by Ribadu Hall 11 (55.00%) and Danfodio Hall 8 (53.33%) while the least was in Yar'adua Hall, 9 (29.03%). In Samaru Village, Hayin Dan Yaro had the highest prevalence in toilet with 5 (27.78%) followed by New Layout with 3 (11.54%) while the least was in Hayin Dogo, 3 (11.11%). No parasites recovered from cockroaches collected from Toilet in Akenzua Hall, ABU and Danraka Area, SV (Table 4.10).

In bathroom, Ribadu Hall had the prevalence of parasites with 5 (35.71%) followed by Queen Amina Hall, 5 (33.33%) while the least was in Yar'adua Hall with 1 (14.29%). In Samaru Village, Hayin Dogo had the highest prevalence of 3 (27.27%) while the least was in Hayin Dan Yaro with 2 (20.00%) with no parasites recovered in Danraka and New Layout Areas.

In kitchen, no parasites was recovered in all the Halls in ABU except in Queen Amina Hall where a prevalence of 1 (14.29%) was obtained. In Samaru Village, no parasite was found at all in all the cockroaches caught from kitchen.

Table 4.9: Distribution of Parasites from Body Surfaces of Cockroaches from the Study Areas.

Parasites	Total Examined	External Number Positive (%)	Internal Number Positive (%)
Entamoeba histolytica	630	3 (0.5)	5 (0.8)
Moniliformis dubius	630	27 (4.3)	40 (6.4)
Strongyloides stercoralis	630	47 (7.5)	12 (1.9)
Total		**77 (4.1)**	**57 (9.1)**

Table 4.10: Distribution of Medically Important Parasites Based on Point of Collection of Cockroaches in the Study Areas (n=63 per sampling area).

Locations	Sampling Areas	Toilet		Bathroom		Kitchen		Room		Outside	
		Number captured	Number Positive (%)	Number captured	Number Positive (%)	Number captured	Number Positive (%)	Number captured	Number Positive (%)	Number captured	Number Positive (%)
ABU	Akenzua Hall	14	0 (0.00)	20	5 (25.00)	6	0 (0.00)	17	0 (0.00)	8	0 (0.00)
	Suleiman Hall	23	10 (43.48)	15	3 (20.00)	8	0 (0.00)	6	1 (16.67)	9	1 (11.11)
	Yar'adua Hall	31	9 (29.03)	7	1 (14.29)	0	0 (0.00)	23	2 (8.70)	2	0 (0.00)
	Danfodio Hall	15	8 (53.33)	18	5 (27.78)	4	0 (0.00)	22	1 (4.55)	4	1 (25.00)
	Queen Amina Hall	17	11 (64.71)	15	5 (33.33)	7	1 (14.29)	16	6 (37.50)	8	2 (25.00)
	Ribadu Hall	20	11 (55.00)	14	5 (35.71)	12	0 (0.00)	11	2 (18.18)	6	1 (16.67)
		120	**49 (40.83)**	**89**	**24 (26.97)**	**37**	**1 (2.70)**	**95**	**12 (12.63)**	**37**	**5 (13.51)**
SV	Danraka	19	0 (0.00)	10	0 (0.00)	16	0 (0.00)	18	0 (0.00)	0	0 (0.00)
	New Layout	26	3 (11.54)	9	0 (0.00)	7	0 (0.00)	21	0 (0.00)	0	0 (0.00)
	Hayin Dan Yaro	18	5 (27.78)	10	2 (20.00)	9	0 (0.00)	26	4 (15.38)	0	0 (0.00)
	Hayin Dogo	27	3 (11.11)	11	3 (27.27)	1	0 (0.00)	24	5 (20.83)	0	0 (0.00)
		90	**11 (12.22)**	**40**	**5 (12.50)**	**33**	**0 (0.00)**	**89**	**9 (10.11)**	**0**	**0 (0.00)**
Total		**210**	**60 (28.57)**	**129**	**29 (22.48)**	**70**	**1 (1.43)**	**184**	**21 (11.41)**	**37**	**5 (13.51)**

The prevalence of parasites from cockroaches captured in rooms revealed that Queen Amina Hall had the highest prevalence of 6 (37.50%) followed by Ribadu Hall, 2 (18.18%) in ABU while the least was in Yar'adua Hall, 2 (8.70%). In Samaru Village, Hayin Dogo had the highest prevalence of 5 (20.83%) while Hayin Dan Yaro had the least prevalence of 4 (15.38%) with no parasites recovered in Danraka and New Layout Areas.

Cockroaches captured from outside was had the highest prevalence of parasites in Danfodio Hall and Queen Amina Hall in ABU with 1 (25.00%) and 2 (25.00%) respectively followed by Ribadu Hall, 1 (16.67%) while the least was in Suleiman Hall, 1 (11.11%). In Samaru Village, no parasite was recovered from all the cockroaches captured.

Distribution of parasites based on point of collection revealed no significant differences ($P>0.05$) between the two locations. Comparison of the parasites based on points of collection was non-significant ($P>0.05$) for all the points of collection, i.e. toilet, bathroom, outside, kitchen and rooms. On a general note, toilet had the highest prevalence of 60 (28.57%) followed by bathroom with 29 (22.48%) while the lowest prevalence was observed in the kitchen with 1 (1.43%) as shown in table 4.10 and appendix 10. Comparison of parasites between the two locations showed no significant difference ($P>0.05$) for all the points of collection. Queen Amina Hall, ABU had the highest prevalence of 64.71% (toilet), 14.29% (Kitchen), 37.50% (room) and 25.00% (outside) and Ribadu Hall, ABU had the highest for bathroom (35.71%). No parasites recovered from all the point of collections in Danraka Area, SV.

4.11 Distribution of *Entamoeba histolytica* From Body Surfaces of Cockroaches

In ABU, *E. histolytica* was not encountered on the external body surface in all the cockroaches captured from all the Halls while in Samaru Village, the parasite was recovered in Hayin Dogo and Hayin Dan Yaro with 2 (3.17%) and 1 (1.59%) respectively with none in Danraka and New Layout (Table 4.11).

From the internal body surface of cockroaches in ABU, the parasite was encountered only in Queen Amina Hall, 3 (4.76%) and Ribadu Hall, 1 (1.59%) while with no parasites found in Akenzua, Suleiman, Yar'adua and Danfodio Halls. In SV, the parasite was found only in Hayin Dogo, 1(1.59%) with no parasite found in Danraka, New Layout and Hayin Dan Yaro.

Comparison of external body surface (3, 0.48%) and internal body surface (5, 0.79%) revealed no significant difference ($P>0.05$). Also, no significant difference ($P>0.05$) was observed with external from ABU and SV and internal from ABU and SV. The highest prevalence of *Entamoeba histolytica* in this study was obtained from the internal body surface in Queen Amina, ABU (3, 4.76%) and external body surface in Hayin Dogo Area (2, 3.17%) (Table 4.11, Appendix 11).

4.12 Distribution of *Moniliformis dubius* From Body Surfaces of Cockroaches

The prevalence of parasites from external body surface in ABU revealed that Suleiman Hall had the highest prevalence of 9 (14.29%) followed by Queen Amina Hall and Ribadu Hall with a prevalence of 5 (7.94%) both while the least prevalence was in Akenzua and Yar'adua Halls with 4 (6.35%) both. The parasite was not found on the external body surface of cockroaches from Danfodio Hall (Table 4.12).

Table 4.11: Distribution of *Entamoeba histolytica* from External and Internal Body Surfaces of Cockroaches from the Study Areas.

Locations	Sampling Areas	Total Captured	External Number Positive (%)	Internal Number Positive (%)
ABU	Akenzua Hall	63	0 (0.00)	0 (0.00)
	Suleiman Hall	63	0 (0.00)	0 (0.00)
	Yar'adua Hall	63	0 (0.00)	0 (0.00)
	Danfodio Hall	63	0 (0.00)	0 (0.00)
	Queen Amina Hall	63	0 (0.00)	3 (4.76)
	Ribadu Hall	63	0 (0.00)	1 (1.59)
		378	**0 (0.00)**	**4 (1.06)**
SV	Danraka	63	0 (0.00)	0 (0.00)
	New Layout	63	0 (0.00)	0 (0.00)
	Hayin Dan Yaro	63	1 (1.59)	0 (0.00)
	Hayin Dogo	63	2 (3.17)	1 (1.59)
		252	**3 (0.79)**	**1 (0.26)**
Total		**630**	**3 (0.48)**	**5 (0.79)**

Table 4.12: Distribution of *Moniliformis dubius* from External and Internal Body Surfaces of Cockroaches from the Study Areas.

Locations	Sampling Areas	Total Captured	External	Internal
			Number Positive (%)	Number Positive (%)
ABU	Akenzua Hall	63	4 (6.35)	2 (3.17)
	Suleiman Hall	63	9 (14.29)	6 (9.52)
	Yar'adua Hall	63	4 (6.35)	2 (3.17)
	Danfodio Hall	63	0 (0.00)	13 (20.64)
	Queen Amina Hall	63	5 (7.94)	8 (12.70)
	Ribadu Hall	63	5 (7.94)	9 (14.29)
		378	**27 (7.14)**	**40 (10.58)**
SV	Danraka	63	0 (0.00)	0 (0.00)
	New Layout	63	0 (0.00)	0 (0.00)
	Hayin Dan Yaro	63	0 (0.00)	0 (0.00)
	Hayin Dogo	63	0 (0.00)	0 (0.00)
		252	**0 (0.00)**	**0 (0.00)**
Total		**630**	**27 (4.29)**	**40 (6.35)**

The prevalence of the parasite from the internal surface of cockroaches from ABU revealed that cockroaches collected from Danfodio Hall had the highest prevalence of 13 (20.64%) followed by Ribadu Hall, 9 (14.29%) while the least on the internal surface in ABU was in Akenzua and Yar'adua Hall with 2 (3.17%) both. This parasite was not encountered on the external and internal body surfaces of cockroaches captured from Samaru Village in the four Areas.

Prevalence of *Moniliformis dubius* was found to be non-significant (P>0.05) between the body surfaces as this parasite was not seen in SV throughout the period of the study with 27 (4.29%) and 40 (6.35%) was observed for external and internal body surfaces of cockroaches from ABU respectively as shown in table 4.12. Comparison of the prevalence between the external in ABU (27, 7.14%) and SV (0, 0.00%) and also internal in ABU (40, 10.58%) and SV (0, 0.00%) showed significant difference (P≤0.05). Meanwhile, Suleiman Hall, ABU (9, 14.29%) and Danfodio, ABU (13, 20.64 %.) had the highest for external surface and internal surface respectively (Appendix 12).

4.13 Distribution of *Strongyloides stercoralis* From Body Surfaces of Cockroaches

Prevalence of parasites on external body surface in ABU was in highest Ribadu Hall with prevalence of 10 (15.87%) followed by Queen Amina Hall, 7 (11.11%) while the least was in Suleiman Hall, 1 (1.59%). This parasite was not encountered in Akenzua Hall, ABU. In SV, Hayin Dogo had the highest prevalence of 9 (14.29%) followed by Hayin Dan Yaro, 8 (12.70%) while the least in New Layout, 1 (1.59%) (Table 4.13).

On the internal body surface of cockroaches in ABU, Queen Amina Hall had the highest prevalence of 5 (7.94%) followed by Ribadu Hall, 2 (3.17%) while Suleiman Hall had the

Table 4.13: Distribution of *Strongyloides stercoralis* from External and Internal Body Surfaces of Cockroaches from the Study Areas.

Locations	Sampling Areas	Total Captured	External	Internal
			Number Positive (%)	Number Positive (%)
ABU	Akenzua Hall	63	0 (0.00)	0 (0.00)
	Suleiman Hall	63	1 (1.59)	1 (1.59)
	Yar'adua Hall	63	6 (9.52)	0 (0.00)
	Danfodio Hall	63	5 (7.94)	0 (0.00)
	Queen Amina Hall	63	7 (11.11)	5 (7.94)
	Ribadu Hall	63	10 (15.87)	2 (3.17)
		378	**29 (7.67)**	**8 (2.12)**
SV	Danraka	63	0 (0.00)	0 (0.00)
	New Layout	63	1 (1.59)	2 (2.17)
	Hayin Dan Yaro	63	8 (12.70)	2 (2.17)
	Hayin Dogo	63	9 (14.29)	0 (0.00)
		252	**18 (7.14)**	**4 (1.59)**
Total		**630**	**47 (7.46)**	**12 (1.90)**

least prevalence of 1 (1.59%). *Strongyloides stercoralis* was not encountered in Akenzua, Yar'adua and Danfodio Halls in ABU. In SV, the parasite was found only in New Layout and Hayin Dan Yaro with prevalence of 2 (2.17%).

Strongyloides stercoralis was encountered more externally (47, 7.46%) than internally (12, 1.90%) which was significant ($P \leq 0.05$) as shown in table 4.13. Although, there was no significant difference ($P > 0.05$) between *S. stercoralis* from obtained externally from ABU (29, 7.67%) and SV (18, 7.14%) and also those obtained internally from ABU (8, 2.12%) and SV (4, 1.59%) (Appendix 13). Meanwhile, Ribadu, ABU (10, 15.87%) and Queen Amina, ABU (5, 7.94%) had the highest prevalence from external body surface and internal body surface respectively. Cockroaches from Akenzua Hall, ABU and Danraka, SV had no parasites on both the external and internal body surfaces.

4.14 Mean Load of Protozoan and Helminths Parasites From Body Surfaces of Cockroaches

The highest mean parasitic load was noted for *Strongyloides stercoralis* for both external (537 parasites,0.85) and internal (194 parasites, 0.31) body surfaces while the lowest mean parasitic load was observed with the protozoan parasite *Entamoeba histolytica* with external and internal mean load of 3 (0.0048) and 11 (0.018) respectively (Table 4.14). Comparison of the external and internal mean load, helminths and protozoa load revealed no significant difference at $P > 0.05$ (Appendix 14).

Table 4.14: Mean Load of Parasites per Cockroach from Body Surfaces of Cockroaches Collected from Study Area (n = 630 per parasite).

Parasite Type	Parasites	External		Internal	
		Load	mean load	Load	mean load
Helminths	*Moniliformis dubius*	184	0.29	169	0.27
	Strongyloides stercoralis	537	0.85	194	0.31
Protozoa	*Entamoeba histolytica*	3	0.00	11	0.02
	Total	**724**	**1.14**	**374**	**0.6**

4.15 Mean Protozoan and Helminths Load from Locations

The highest mean load of 128 (2.03) was found in Suleiman Hall with Moniliformis dubius in ABU, followed by Ribadu Hall with mean load of 86 (1.37). this parasite was not found in SV at all.

The mean load of *Strongyloides stercoralis* was highest in Queen Amina Hall with 230 (3.65) followed by Ribadu Hall with 176 (2.79) while the least was in Suleiman Hall with 8 (0.13). In SV, Hayin Dogo had the highest mean load of 75 (1.21) followed by Hayin Dan Yaro with 51 (0.81) while the least mean load in New Layout Area.

The mean load of Entamoeba histolytica was highest in Queen Amina Hall with 8 (0.13) while Ribadu Hall had the least mean load of 2 (0.03). In SV, Hayin Dan Yaro and Hayin Dogo had the mean load of 3 (0.05) and 1 (0.02) respectively.

Comparison of the mean load of parasites isolated from the sampling areas revealed significant difference ($P \leq 0.05$) in ABU (952 parasites, 2.52) and SV (145 parasites, 0.58). Also comparison of the three parasites was significant ($P \leq 0.05$) only in *Moniliformis dubius* with mean load of (353 parasites, 0.93) in ABU and 0 parasites (0.00) in SV (Table 4.15). Also, comparison of the helminths load, protozoan and Helminths load in ABU and SV was non-significant ($P > 0.05$) (Appendix 15). Meanwhile, Danfodio Hall (86 parasites, 1.37), Queen Amina Hall (230 parasites, 3.65) and Queen Amina Hall (8 parasites, 0.13) had the highest mean load for *Moniliformis dubius*, *Strongyloides stercoralis* and *Entamoeba histolytica* respectively.

Table 4.15: Mean Load of Parasites from Sampling Areas in the Two Communities

Locations	Sampling Areas	Number Sampled	Number of Parasites Found (Load)			
			Moniliformis dubius	***Strongyloides stercoralis***	***Entamoeba histolytica***	**Total (%)**
ABU	Akenzua Hall	63	8 (0.13)	0 (0.00)	0 (0.00)	8 (0.13)
	Suleiman Hall	63	128 (2.03)	8 (0.13)	0 (0.00)	136 (2.16)
	Yar'adua Hall	63	15 (0.24)	32 (0.51)	0 (0.00)	47 (0.75)
	Danfodio Hall	63	60 (0.95)	143 (2.27)	0 (0.00)	203 (3.22)
	Queen Amina Hall	63	56 (0.89)	230 (3.65)	8 (0.13)	294 (4.67)
	Ribadu Hall	63	86 (1.37)	176 (2.79)	2 (0.03)	264 (4.19)
		378	**353 (0.93)**	**589 (1.56)**	**10 (0.03)**	**952 (2.52)**
SV	Danraka	63	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
	New Layout	63	0 (0.00)	15 (0.24)	0 (0.00)	15 (0.24)
	Hayin Dan Yaro	63	0 (0.00)	51 (0.81)	1 (0.02)	52 (0.83)
	Hayin Dogo	63	0 (0.00)	75 (1.21)	3 (0.05)	78 (1.24)
		252	**0 (0.00)**	**141 (0.56)**	**4 (0.02)**	**145 (0.58)**
Total		**630**	**353 (0.56)**	**731 (1.16)**	**14 (0.22)**	**1097 (1.74)**

Plates



(a)



(b)



(c)

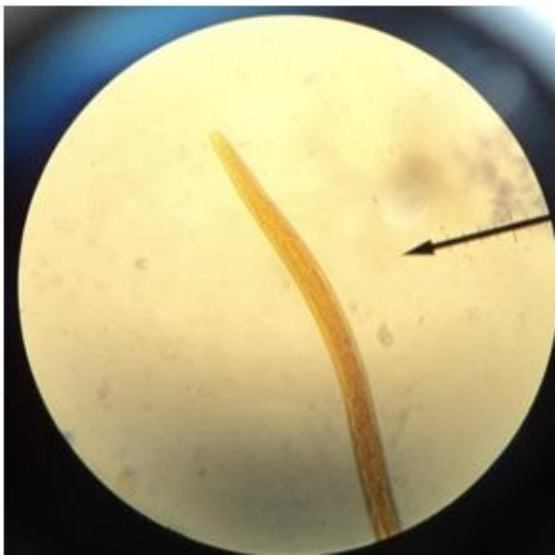


(d)

Plate I: Dissection of cockroaches (a) *Periplaneta americana* in sample test tubes after collection (b) *Periplaneta americana* after external washing spread to dry (c) dissected *Periplaneta americana* for internal parasites, (d) dissected *Blattella germanica*



(a)

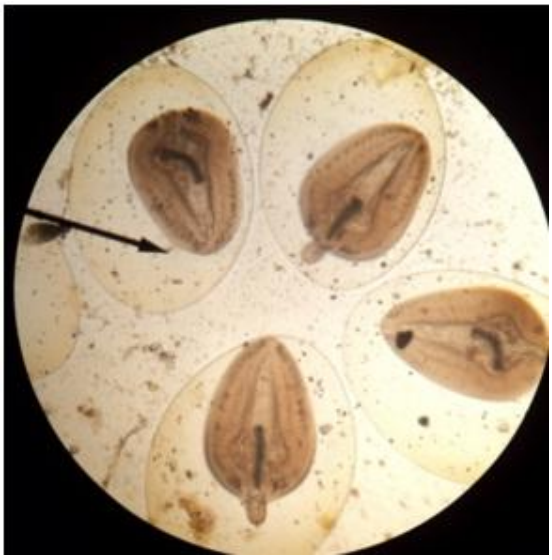


(b)

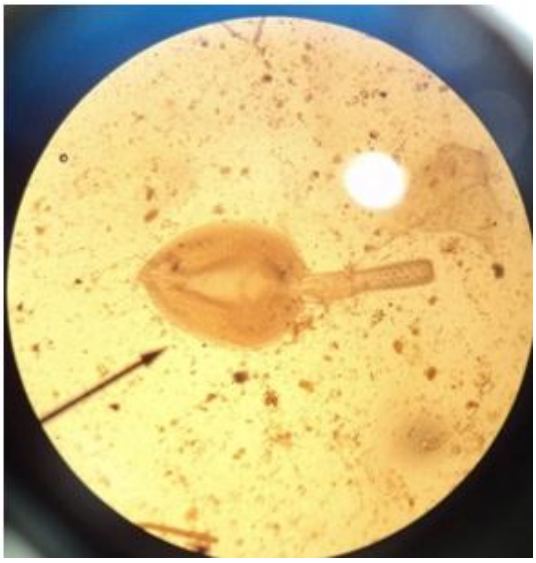


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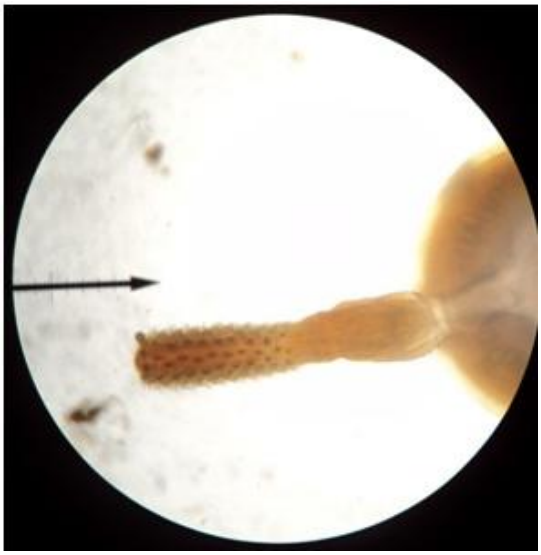
Plate II: *Strongyloides stercoralis* (magnification = X100) (a) larvae of *Strongyloides* (Magnification = X100 (b) anterior part of larvae (Magnification =X1000 (c) posterior part of larvae (Magnification = X1000).



(a)



(b)



(c)

Plate III: *Moniliformis dubis* (a) cystacanths within cyst (Magnification = X100) (b) cystacanth freed from cyst and proboscis evaginated (Magnification = X100) (c) proboscis showing rows of hooks use in attaching to host intestines (Magnification =X400).

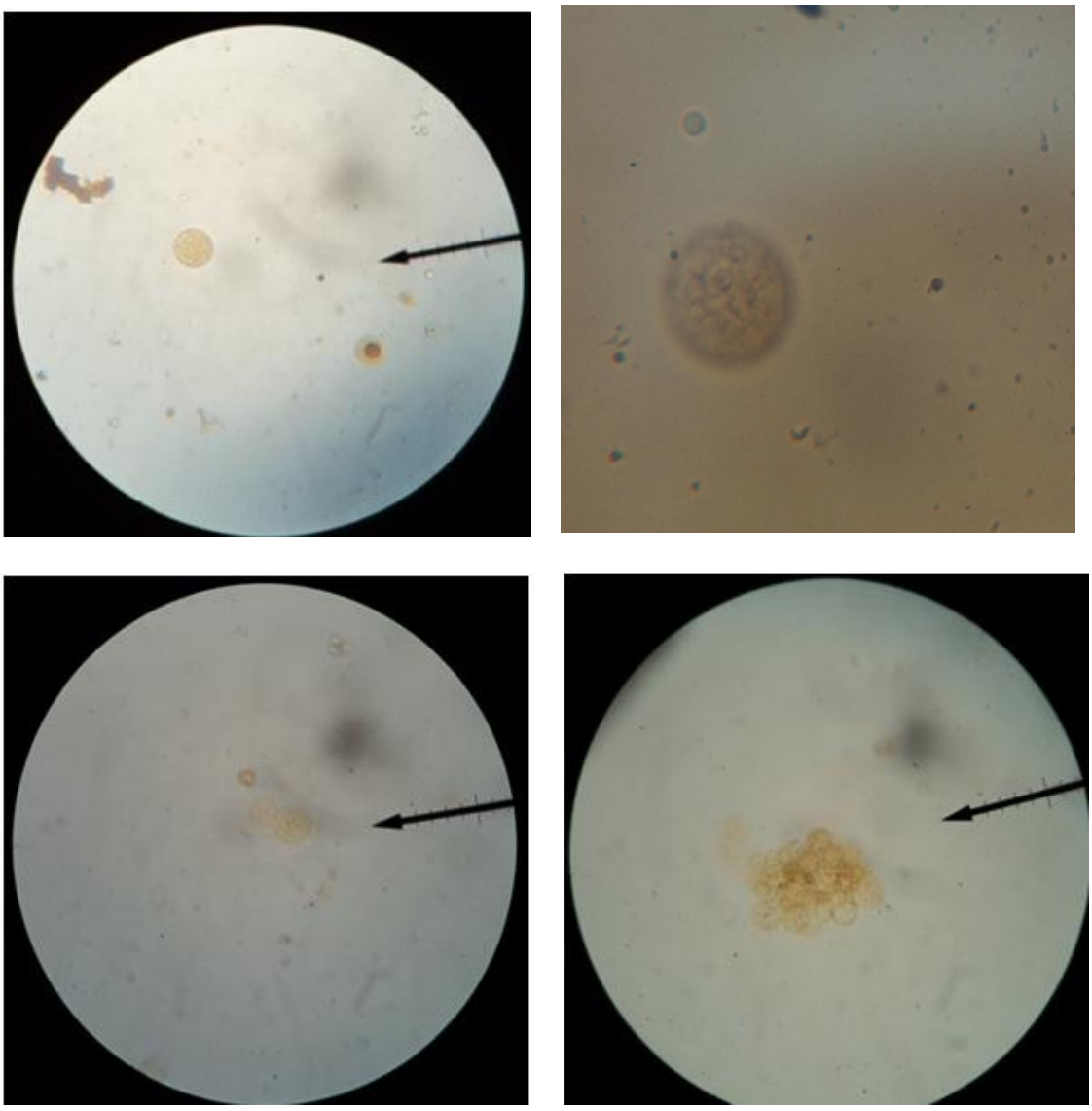


Plate IV: *Entamoeba histolytica* cyst (a) to (d) (Magnification =X1000).

CHAPTER FIVE

5.0 DISCUSSION

5.1 Occurrence of Parasites

The importance of cockroaches, as carriers of parasitic worms, cysts, or eggs, was based on some reports about the presence of parasitic forms on or in cockroaches (Greenberg, 1993). Personal hygiene has drastically reduced the prevalence of parasitic infections in our communities, but other factors that contribute immensely to transmission of such infections are neglected. This study revealed that cockroaches represent a reservoir of infectious parasites; three medically important parasites have been identified or isolated from their external and internal body surfaces, which are *Entamoeba histolytica, Moniliformis dubius* and *Strongyloides stercoralis.*

The overall prevalence of 18.41% recorded in this study is lower than 67% reported by Ajero *et al*. (2011) in Owerri, Nigeria, 94.2% in Hospitals in India by Fotedar *et al.* (1991) and 98% observed in Egypt by El-Sherbini and El-Shaebini (2011). The low prevalence in this study compared to that of Egypt, may be as reported by El-Sherbini and El-Sherbini (2011), that the area they conducted their research severely lacked hygiene services. According to them, the area they conducted their study had many piles of faecal matter in nearby mangrove swamp. This might have caused the high rate of carriage cockroaches observed in their study.

The study also revealed that cockroaches irrespective of the species do play a significant role in transmitting parasitic diseases, as more than 18% of the two cockroach species (*P.*

americana and *B. germanica*) vectored parasites and are capable of transmitting them to humans or animals. As reported by Iwuala and Onyeka (1997), these two species of cockroaches are the most common in Nigeria. Significant difference ($P \leq 0.01$) observed between the species as more parasites are transmitted by the *P. americana* which is similar to other studies carried out by Tawatsin *et al.* (2011) and Saichua *et al.* (2008) who gave the reason that the significant difference noted was as a result of the large surface area of the body of *P. americana* compared to that of *B. germanica.*

The fact that the female and male roaches were not significantly different in vectorial potential, probably attributed to the observation that the female roam in search of both food and sites to lay their eggs while the male roam in search of mates for reproduction. Thereby, they come in contact with contaminated materials as they roam, making them more vulnerable to be contaminated with pathogens. Similar observation was reported by Bala and Sule (2012) in Arkilla Area of Sokoto, Sokoto State, Nigeria.

Findings from this study also revealed that the different developmental stages of the cockroaches showed significant differences ($P \leq 0.01$) in their potential in carrying parasites of medical importance with the adult cockroaches had more parasites than the nymphs. The reason for this difference may be due to the fact that the adult cockroaches have wings, making them to be more mobile than the nymph cockroaches and hence more opportunity in contaminating itself with parasitic organisms (Bala and Sule, 2012).

Regarding the importance of cockroaches as carriers of parasitic worm, cyst or eggs, there are some reports of the presence of parasitic forms on or in cockroaches (Chinchilla *et al.,* 1994; Chan *et al.,* 2004).

The Low occurrence of *Entamoeba histolytica* compared to other parasites, observed in this study, might be due to the use of water and detergent and antiseptic which can affect the cyst of these parasites, which makes the cysts not to survive for a long period for it to be vectored by cockroaches.

Moniliformis dubius was found in Ahmadu Bello University Main Campus and none in all the cockroaches collected from SV. This is attributed to the large rodent population (that serve as the intermediate host) in ABU. Neafie and Marty (1993) report that rodents have been biologically involved and serve as a reservoir for this parasite. Data on the pathogenesis of this parasite are scarce (Gibson, 1998). Reports of human infection with *Moniliformis* species have been reported in an 18 month old child from Sistan and Baluchistan Province of Iran (Sahba *et al.,* 1970), in an older patient from Isfahan province (Moayedi *et al.,* 1971) and in a 2 years old girl in rural area of Birjand, Northeast Iran (Alireza *et al.,* 2008). This study is the first to report the isolation of this parasite from cockroaches and no report of infection by this parasite in Nigeria.

The low occurrence of *Strongyloides stercoralis* in ABU and SV has been attributed to improved sanitary conditions maintained by the inhabitants although presence of garbage heap, open drainage systems, open toilets, rubbish dumps abandoned for days are some of the factors responsible for the presence of this parasite in these two locations.

Strongyloides stercoralis and *Moniliformis dubius* are causative agents of human helminthiasis and acanthocephaliasis respectively while *E. histolytica* causes amoebiasis. Helminths were statistically non-significant from the protozoan; *S. stercoralis* had the

highest prevalence among the helminths externally while *Moniliformis dubius* had the highest prevalence internally.

The result showed that parasites obtained from the external body surface of cockroach are non-significant from those isolated from the internal body surface. Similar studies carried by Nagham *et al.* (2011) revealed significant difference ($P \leq 0.01$) in external and internal surfaces of cockroaches collected from hospital and houses and in Egypt by El-Sherbini and Gneidy (2012) who isolated external and internal parasites of 74.7% and 25.3% from cockroaches. The reason for the result obtained in this study may be due to ingestion faeces or contaminated food materials.

Worthy of note is that vectorial potential significantly associated with the source of cockroaches in this study, comparison of the points of collection in ABU and SV revealed no significant difference ($P>0.05$). The higher number of cockroaches vectoring parasites observed in the toilets is understandable because of the fact that cockroaches are more accessible to toilets (Pai *et al.,* 2005) where contamination with faecal matter is most likely as most of the areas in this study was noted to have toilets that are not covered especially water closet toilet type in ABU which were mostly opened type of water closet toilet, similar result was observed by El-Sherbini and Gneidy (2012) in Egypt where toilet recorded the highest number of parasitic contamination in water system (54 parasites) and pit toilet (21 parasites). However, toilets are followed by bathroom in prevalence; this is as a result of the proximity of toilets to bathrooms in the study areas. Although, cockroaches from kitchen have a low prevalence, this result was similar to the study carried by Tatfeng *et al.* (2005) which found out that cockroaches

trapped in the toilets of houses are more infected with bacteria and parasites than cockroaches from kitchens of houses. People have to be careful not to allow cockroaches' accessibility to kitchens, as they have the potential to vector and transmit parasites. They should also ensure they cover food and food utensils to reduce the rate of parasitic contamination by cockroaches.

Since this report revealed the presence of these parasites from the external and internal body surfaces of cockroaches in a developing environment like Ahmadu Bello University and Samaru Village it becomes imperative to urgently institute control measures on these insects through massive public health/enlightenment education on improving the existing standard of environmental sanitary conditions.

CHAPTER SIX

6.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

Results obtained from this study revealed low rates of helminths and protozoan are carried by cockroaches. The study showed that *Strongyloides stercoralis* is a major external parasite in these two locations while *Moniliformis dubius* was noted for its high internal infestation.

It was observed that there was no significant difference ($P>0.05$) in the isolates from external and internal body surfaces of cockroaches but significant difference between the adult and nymph, *Periplaneta americana* and *Blattella germanica* at $P\leq0.01$. No significant differences was observed between the distribution of male and female cockroaches of points of cockroach collection (toilet, bathroom, kitchen, rooms and outside) at ($P>0.05$). Significant difference ($P\leq0.05$) was observed in the load of parasites carried by cockroaches from ABU and SV.

6.2 Conclusions

1. Cockroaches have been confirmed in this study as carriers of cysts of *Entamoeba histolytica*, larvae of *Strongyloides stercoralis* and the cystacanth of *moniliformis* dubius with 18.41% of the cockroach carrying parasitic pathogens.

2. There is no significant difference in the prevalence of parasite carried in male and female, in adult and nymph and on external and internal body surfaces of cockroaches. However, the prevalence of parasitic carriage is statistically

significant in species of cockroaches with higher prevalence in *P. americana* than in *B.* germanica. Also, there is significant difference in the prevalence of parasite carriage in cockroaches captured from the two communities with Ahmadu Bello University Main Campus having a higher prevalence than Samaru Village.

6.3 Recommendation

Considering the presence of parasites carried by cockroaches, it is recommend that further control of infectious agents such as *Entamoeba histolytica, Moniliformis dubius* and *Strongyloides stercoralis* can be achieved with the following:

(a) Health education of people: training of people about safe sewage and waste disposal as unsafe sewage and waste disposal create breeding sites for cockroaches and to avoid littering of places with faeces, refuse dumps and garbage. This could be done by observation of good personal hygiene by subjects, household and locations members as well as construction of proper drainage system to allow appropriate flow of water from toilets and bathrooms.

(b) Reducing contact to water, food items and utensils: Cockroaches are attracted to areas where food and water are easily accessible. Homeowners should reduce cockroach attractants such as pet food dishes, drains, dishwashers, trash cans, etc. Limiting food and water source by storing them in tightly sealed containers and avoiding dirty dishes in sink overnight by cleaning storing them properly.

(c) Use of insecticides: occasional use of insecticides to reduce cockroach population is recommended. This is done by finding their shelters and hiding places and treating these locations. Thoroughly clean the house and apply an approved insecticide.

Insecticide use is simple and convenient when infestation is small, but when severe, several treatments is required to achieve desired result.

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APPENDICES

Appendix 1: Prevalence of Parasites Based On Sex of Cockroach Species from Locations

Location	Species	Sex			ANOVA	P value
		Male±S.D	**Female±S.D**	**Total±S.D**	Location	0.006**
ABU	*P. americana*	6.33±4.50	6.67±1.51	6.50±3.21	Species	0.000**
	B. germanica	1.17±2.40	1.00±0.63	1.08±1.68	Sex	0.344n.s
SV	*P. americana*	1.25±1.50	3.25±2.75	2.25±2.32	Location x Species	0.012*
	B. germanica	0.50±0.58	1.25±0.96	0.88±0.84	Location x Sex	0.401n.s
Total	*P. americana*	4.30±4.35	5.30±2.63	4.80±3.53	Species x Sex	0.568n.s
	B. germanica	0.90±1.85	1.10±0.74	1.00±1.38	Location x Species x Sex	0.806n.s

* - significant (P≤0.05)

** - highly significant (P≤0.01)

ABU – Ahmadu Bello University

SV – Samaru Village

Appendix 2: Prevalence of Parasites Based On Developmental Stages of Cockroach Species from Locations

Location	**Species**	**Stage of Development**			ANOVA	P value
		Adult±S.D	**Nymph±S.D**	**Total±S.D**	Location	0.002**
ABU	*P. americana*	11.17±3.66	1.83±1.33	6.50±5.54	Species	0.000**
	B. germanica	2.00±2.10	0.17±0.41	1.08±1.73	Stage	0.000**
SV	*P. americana*	3.75±3.30	0.75±0.96	2.25±2.77	Location x Species	0.006**
	B. germanica	1.50±1.50	0.50±0.58	0.88±1.13	Location x Stage	0.010*
Total	*P. americana*	8.20±5.07	1.40±1.27	4.80±5.01	Species x Stage	0.001**
	B. germanica	1.70±1.83	0.30±0.48	1.00±1.49	Location x Species x Stage	0.062*

* - significant (P≤0.05)

** - highly significant (P≤0.01)

ABU – Ahmadu Bello University

SV – Samaru Village

Appendix 3: Prevalence of Parasites Based On Sex of Cockroaches Species from Sampling Locations

ANOVA P values	***Moniliformis dubius***	***Strongyloides stercoralis***	***Entamoeba histolytica***
Location	0.000**	0.605n.s	0.686n.s
Species	0.000**	0.009**	0.421n.s
Sex	0.940n.s	0.252n.s	0.840n.s
Location x Species	0.000**	0.551n.s	0.421n.s
Location x Sex	0.940n.s	0.322n.s	0.316n.s
Species x Sex	0.940n.s	0.286n.s	0.840n.s
Location x Species x Sex	0.940n.s	0.551n.s	0.316n.s
MD – *Moniliformis dubius*	SS – *Strongyloides stercoralis*	EH – *Entamoeba histolytica*	
	** - highly significant (P≤0.01)	n.s – non-significant	

Appendix 4: Prevalence of Parasites Based on Developmental Stage of Cockroaches Species from Sampling Locations

ANOVA P values	***Moniliformis dubius***	***Strongyloides stercoralis***	***Entamoeba histolytica***
Location	0.000**	0.641n.s	0.674n.s
Species	0.000**	0.018*	0.402n.s
Stage of Development	0.000**	0.001**	0.147n.s
Location x Species	0.000**	0.591n.s	0.402n.s
Location x Stage of Development	0.000**	0.641n.s	0.833n.s
Species x Stage of Development	0.000**	0.025*	0.147n.s
Location x Species x Stage of Development	0.000**	0.693n.s	0.833n.s
MD – *Moniliformis dubius*	SS – *Strongyloides stercoralis*	EH – *Entamoeba histolytica*	
* - significant (P≤0.05)	** - highly significant (P≤0.01)	n.s – non-significant	

Appendix 5: Distribution of Medically Important Parasites by Species of Cockroaches in the Study Areas.

		t value	p value	df
t - test	*P. americana* Between ABU and SV	2.882*	0.020	8
	B. germanica Between ABU and SV	0.298n.s	0.773	8
	Within ABU (*P. americana* and *B. germanica*)	5.895**	0.002	5
	Within SV (*P. americana* and *B. germanica*)	1.897n.s	0.154	3
	P. americana and *B. germanica* (Total)	3.866**	0.004	9

Note: n.s = significant at 0.05

* = significant at 0.01

** = significant at 0.01

ABU = Ahmadu Bello University SV = Samaru Village

Appendix 6: Distribution of Medically Important Parasites by Gender of Cockroach in the Study Areas.

		t value	p value	df
t – test	Male Between ABU and SV	0.116n.s	0.116	8
	Female Between ABU and SV	1.788n.s	0.112	8
	Within ABU (Male and Female)	0.044n.s	0.967	5
	Within SV (Male and Female)	-1.680n.s	0.192	3
	Male and Female (Total)	-0.564n.s	0.587	9
Note:	n.s = non-significant at 0.05			
	ABU = Ahmadu Bello University	SV = Samaru Village		

Appendix 7: Occurrence of Medically Important Parasites in the Different Developmental Stages of Cockroaches in the Study Areas.

		t value	p value	df
t - test	Adult Between ABU and SV	2.561*	0.034	8
	Nymph Between ABU and SV	0.614n.s	0.557	8
	Within ABU (Adult and Nymph)	4.755**	0.005	5
	Within SV (Adult and Nymph)	-2.412n.s	0.095	3
	Adult and Nymph (Total)	1.793n.s	0.107	9

Note: n.s = non-significant at 0.05

* = significant at 0.05

** = significant at 0.01

ABU = Ahmadu Bello University SV = Samaru Village

Appendix 8: Distribution of Medically Important Parasites by Body Surfaces of Cockroach Isolated in the Study Areas.

		t value	p value	df
t - test	External Between ABU and Samaru	1.742n.s	0.120	8
	Internal Between ABU and Samaru	2.345*	0.047	8
	Within ABU (External and Internal)	-0.596n.s	0.577	5
	Within SV (External and Internal)	1.253n.s	0.299	3
	External and Internal (Total)	0.141n.s	0.891	9
Note:	n.s = non-significant at 0.05			
	* = significant at 0.05			
	ABU = Ahmadu Bello University	SV = Samaru Village		

Appendix 9: Distribution of Parasites from Body Surfaces of Cockroaches from the Study Areas.

		t value	p value	df
t – test	Between External and Internal Parasites	0.459n.s	0.691	2

Note: n.s = non-significant at 0.05

Appendix 10: Occurrence of Medically Important Parasites Based on Point of Collection of Cockroaches in the Study Areas (n=63 per sampling area).

Point of	Locations			t - test			ANOVA	
Collection	**ABU±S.D**	**SV±S.D**	**Total±S.D**	**t value**	**p value**	**df**	**Source**	**P value**
Toilet	8.17±4.17	2.75±2.06	6.00±4.35	2.217n.s	0.057	8	Location	0.110n.s
Bathroom	4.00±1.67	1.25±1.50	2.90±2.08	2.062n.s	0.073	8	Point of collection	0.146n.s
Kitchen	0.17±0.41	0.00±0.00	0.10±0.32	0.800n.s	0.447	8	Location x point of collection	0.079n.s
Room	2.00±2.10	2.25±2.63	2.10±2.18	0.651n.s	0.533	8	n.s – non-significant at P>0.05	
Outside	2.33±3.33	0.00±0.00	1.40±2.76	2.240n.s	0.055	8	* - significant at P≤0.05	
Total	3.33±3.71	1.25±1.86	2.50±3.25	1.479n.s	0.177	8	** - significant at P≤0.01	
	ABU – Ahmadu Bello University			SV – Samaru Village				

Appendix 11: Distribution of *Entamoeba histolytica* from External and Internal Body Surfaces of Cockroaches from the Study Areas.

		t value	p value	df
t – test	External Between ABU and Samaru	-1.983n.s	0.083	8
	Internal Between ABU and Samaru	0.642n.s	0.539	8
	Within ABU (External and Internal)	-1.349n.s	0.235	5
	Within SV (External and Internal)	1.732n.s	0.182	3
	External and Internal (Total)	-0.558n.s	0.590	9

Note:
n.s = non-significant at 0.05
* = significant at 0.05
** = significant at 0.01
ABU = Ahmadu Bello University
SV = Samaru Village

Appendix 12: Distribution of *Moniliformis dubius* from External and Internal Body Surfaces of Cockroaches from the Study Areas.

		t value	p value	df
t – test	External Between ABU and Samaru	3.061*	0.016	8
	Internal Between ABU and Samaru	3.055*	0.016	8
	Within ABU (External and Internal)	-0.877n.s	0.421	5
	Within SV (External and Internal)			
	External and Internal (Total)	- 0.884n.s	0.400	9
Note:	n.s = non-significant at 0.05			
	* = significant at 0.05			
	** = significant at 0.01			
	ABU = Ahmadu Bello University	SV = Samaru Village		

Appendix 13: Distribution of *Strongyloides stercoralis* from External and Internal Body Surfaces of Cockroaches from the Study Areas.

		t value	p value	df
t – test	External Between ABU and Samaru	0.125n.s	0.904	8
	Internal Between ABU and Samaru	0.618n.s	0.554	8
	Within ABU (External and Internal)	2.573*	0.050	5
	Within SV (External and Internal)	1.617n.s	0.204	3
	External and Internal (Total)	3.107*	0.013	9
Note:	n.s = non-significant at 0.05			
	* = significant at 0.05			
	** = significant at 0.01			
	ABU = Ahmadu Bello University	SV = Samaru Village		

Appendix 14: Mean Load of Parasites per Cockroach from Body Surfaces of Cockroaches Collected from Study Area (n = 630 per parasite).

		t value	p value	df
t - test	Between External and Internal Parasites	1.029n.s	0.412	2
	Between Helminths and Protozoa External	1.169n.s	0.450	1
	Between Helminths and Protozoa Internal	7.875n.s	0.080	1

Note: n.s = non-significant at 0.05

* = significant at 0.05

** = significant at 0.01

ABU = Ahmadu Bello University

SV = Samaru Village

Appendix 15: Mean Load of Parasites from Sampling Areas in the Two District

Parasites	**Locations**			**t - test**		
	ABU±S.D	**SV±S.D**	**Total±S.D**	**t value**	**p value**	**df**
Moniliformis dubius	58.83±44.80	0.00±0.00	35.30±45.15	2.573*	0.033	8
Strongyloides stercoralis	98.17±97.56	35.25±34.06	73.00±82.04	1.220n.s	0.257	8
Entamoeba histolytica	1.67±3.20	1.00±1.41	1.40±2.55	0.386n.s	0.710	8
Total	52.89±71.10	12.08±24.70	36.57±60.07			

ANOVA	**P value**
Between Location	0.180n.s
Between Parasites	0.220n.s
Between Location x Parasites	0.336n.s

n.s = non-significant at 0.05 * = significant at 0.05

** = significant at 0.01

ABU = Ahmadu Bello University SV – Samaru Village

Keys to Appendices 16 - 25

per - *Periplaneta americana*

ger - *Blattella germanica*

Ep1 - *Moniliformis dubius* from External Body Surfaces

Ep2 - *Strongyloides stercoralis* from External Body Surfaces

Ep3 - *Entamoeba histolytica* from External Body Surfaces

Ip1 - *Moniliformis dubius* from Internal Body Surfaces

Ip2 - *Strongyloides stercoralis* from Internal Body Surfaces

Ip3 - *Entamoeba histolytica* from Internal Body Surfaces

Appendix 16: AKENZUA HALL, ABU

s/no	species	sex	stage	locatn	cllpoint	Ep1	Ep2	Ep3	Ip1	Ip2	Ip3
1	per	female	adult	akenzua	bathroom	0	0	0	0	0	0
2	per	female	adult	akenzua	bathroom	0	0	0	1	0	0
3	per	male	adult	akenzua	bathroom	0	0	0	0	0	0
4	per	female	adult	akenzua	bathroom	0	0	0	0	0	0
5	per	male	nymph	akenzua	outside	0	0	0	0	0	0
6	per	female	adult	akenzua	outside	0	0	0	0	0	0
7	per	female	adult	akenzua	bathroom	1	0	0	0	0	0
8	per	male	adult	akenzua	outside	0	0	0	0	0	0
9	per	male	adult	akenzua	outside	0	0	0	0	0	0
10	per	female	adult	akenzua	bathroom	2	0	0	1	0	0
11	per	male	adult	akenzua	toilet	0	0	0	0	0	0
12	per	male	adult	akenzua	toilet	0	0	0	0	0	0
13	per	female	nymph	akenzua	outside	0	0	0	0	0	0
14	per	female	adult	akenzua	bathroom	0	0	0	0	0	0
15	per	female	nymph	akenzua	bathroom	0	0	0	0	0	0
16	per	male	adult	akenzua	bathroom	0	0	0	0	0	0
17	per	male	adult	akenzua	bathroom	0	0	0	0	0	0
18	per	male	adult	akenzua	bathroom	0	0	0	0	0	0
19	per	male	adult	akenzua	bathroom	0	0	0	0	0	0
20	per	female	adult	akenzua	bathroom	1	0	0	0	0	0
21	per	female	adult	akenzua	bathroom	0	0	0	0	0	0
22	per	male	nymph	akenzua	bathroom	0	0	0	0	0	0
23	per	female	adult	akenzua	bathroom	0	0	0	0	0	0
24	per	female	nymph	akenzua	toilet	0	0	0	0	0	0
25	per	female	adult	akenzua	toilet	0	0	0	0	0	0
26	per	male	adult	akenzua	toilet	0	0	0	0	0	0
27	per	male	adult	akenzua	bathroom	0	0	0	0	0	0
28	per	male	nymph	akenzua	bathroom	0	0	0	0	0	0
29	per	female	adult	akenzua	toilet	0	0	0	0	0	0
30	per	female	adult	akenzua	toilet	0	0	0	0	0	0
31	per	female	adult	akenzua	bathroom	0	0	0	0	0	0
32	per	male	adult	akenzua	bathroom	0	0	0	0	0	0
33	per	female	adult	akenzua	bathroom	2	0	0	0	0	0
34	per	female	adult	akenzua	toilet	0	0	0	0	0	0
35	per	female	nymph	akenzua	toilet	0	0	0	0	0	0
36	per	male	nymph	akenzua	toilet	0	0	0	0	0	0
37	per	female	nymph	akenzua	toilet	0	0	0	0	0	0
38	per	male	adult	akenzua	toilet	0	0	0	0	0	0
39	per	male	adult	akenzua	toilet	0	0	0	0	0	0
40	per	female	adult	akenzua	toilet	0	0	0	0	0	0

41	ger	female	adult	akenzua	kitchen	0	0	0	0	0	0
42	ger	female	adult	akenzua	kitchen	0	0	0	0	0	0
43	ger	female	adult	akenzua	kitchen	0	0	0	0	0	0
44	ger	male	adult	akenzua	room	0	0	0	0	0	0
45	ger	male	adult	akenzua	room	0	0	0	0	0	0
46	ger	female	adult	akenzua	room	0	0	0	0	0	0
47	ger	male	nymph	akenzua	room	0	0	0	0	0	0
48	ger	male	adult	akenzua	room	0	0	0	0	0	0
49	ger	female	adult	akenzua	room	0	0	0	0	0	0
50	ger	male	adult	akenzua	room	0	0	0	0	0	0
51	ger	male	adult	akenzua	kitchen	0	0	0	0	0	0
52	ger	female	nymph	akenzua	kitchen	0	0	0	0	0	0
53	ger	male	nymph	akenzua	room	0	0	0	0	0	0
54	ger	male	nymph	akenzua	room	0	0	0	0	0	0
55	ger	female	nymph	akenzua	kitchen	0	0	0	0	0	0
56	ger	female	adult	akenzua	room	0	0	0	0	0	0
57	ger	male	adult	akenzua	room	0	0	0	0	0	0
58	ger	female	adult	akenzua	room	0	0	0	0	0	0
59	ger	male	adult	akenzua	room	0	0	0	0	0	0
60	ger	male	adult	akenzua	room	0	0	0	0	0	0
61	ger	female	adult	akenzua	room	0	0	0	0	0	0
62	ger	female	adult	akenzua	room	0	0	0	0	0	0
63	ger	female	adult	akenzua	room	0	0	0	0	0	0

Appendix 17: SULEIMAN HALL, ABU

s/no	species	sex	stage	locatn	cllpoint	Ep1	Ep2	Ep3	Ip1	Ip2	Ip3
1	per	male	adult	suleiman	bathroom	0	0	0	1	0	0
2	per	male	adult	suleiman	bathroom	0	0	0	0	0	0
3	per	female	adult	suleiman	toilet	11	0	0	0	0	0
4	per	female	nymph	suleiman	bathroom	0	0	0	0	0	0
5	per	female	adult	suleiman	toilet	53	0	0	20	0	0
6	per	male	adult	suleiman	toilet	3	0	0	0	0	0
7	per	female	adult	suleiman	toilet	2	0	0	0	0	0
8	per	female	adult	suleiman	toilet	0	0	0	0	0	0
9	per	male	adult	suleiman	toilet	0	0	0	0	0	0
10	per	female	adult	suleiman	outside	0	0	0	0	0	0
11	per	male	adult	suleiman	toilet	1	0	0	0	0	0
12	per	female	nymph	suleiman	outside	0	0	0	0	0	0
13	per	female	adult	suleiman	toilet	1	0	0	0	0	0
14	per	male	adult	suleiman	outside	0	0	0	0	0	0
15	per	female	adult	suleiman	bathroom	0	0	0	0	0	0
16	per	female	adult	suleiman	toilet	8	0	0	0	0	0
17	per	male	nymph	suleiman	toilet	0	0	0	0	0	0
18	per	female	adult	suleiman	toilet	0	0	0	1	1	0
19	per	female	adult	suleiman	toilet	0	0	0	1	0	0
20	per	female	adult	suleiman	toilet	0	0	0	0	0	0
21	per	female	adult	suleiman	outside	0	0	0	0	0	0
22	per	male	nymph	suleiman	outside	0	0	0	0	0	0
23	per	male	adult	suleiman	outside	0	0	0	0	0	0
24	per	female	nymph	suleiman	outside	0	0	0	11	0	0
25	per	female	nymph	suleiman	bathroom	0	0	0	0	0	0
26	per	female	adult	suleiman	toilet	0	0	0	0	0	0
27	per	female	adult	suleiman	outside	0	0	0	0	0	0
28	per	male	adult	suleiman	bathroom	0	0	0	1	0	0
29	per	male	adult	suleiman	toilet	0	0	0	0	0	0
30	per	male	nymph	suleiman	bathroom	1	0	0	0	0	0
31	per	female	adult	suleiman	outside	0	0	0	0	0	0
32	per	male	adult	suleiman	bathroom	0	0	0	0	0	0
33	per	male	adult	suleiman	toilet	13	0	0	0	0	0
34	per	female	adult	suleiman	toilet	0	0	0	0	0	0
35	per	male	adult	suleiman	toilet	0	0	0	0	0	0
36	per	female	adult	suleiman	toilet	0	0	0	0	0	0
37	per	female	adult	suleiman	toilet	0	0	0	0	0	0
38	per	female	adult	suleiman	toilet	0	0	0	0	0	0
39	per	male	adult	suleiman	toilet	0	0	0	0	0	0
40	per	male	adult	suleiman	toilet	0	0	0	0	0	0

41	ger	female	adult	suleiman	kitchen	0	0	0	0	0	0
42	ger	female	adult	suleiman	kitchen	0	0	0	0	0	0
43	ger	male	nymph	suleiman	kitchen	0	0	0	0	0	0
44	ger	female	adult	suleiman	room	0	0	0	0	0	0
45	ger	male	adult	suleiman	kitchen	0	0	0	0	0	0
46	ger	male	adult	suleiman	bathroom	0	0	0	0	0	0
47	ger	male	nymph	suleiman	room	0	0	0	0	0	0
48	ger	female	nymph	suleiman	room	0	0	0	0	0	0
49	ger	male	nymph	suleiman	bathroom	0	0	0	0	0	0
50	ger	male	adult	suleiman	kitchen	0	0	0	0	0	0
51	ger	male	nymph	suleiman	kitchen	0	0	0	0	0	0
52	ger	male	adult	suleiman	kitchen	0	0	0	0	0	0
53	ger	female	adult	suleiman	kitchen	0	0	0	0	0	0
54	ger	female	adult	suleiman	room	0	0	0	0	0	0
55	ger	male	adult	suleiman	room	0	0	0	0	0	0
56	ger	female	adult	suleiman	room	0	7	0	0	0	0
57	ger	female	adult	suleiman	bathroom	0	0	0	0	0	0
58	ger	female	adult	suleiman	bathroom	0	0	0	0	0	0
59	ger	male	adult	suleiman	bathroom	0	0	0	0	0	0
60	ger	male	adult	suleiman	room	0	0	0	0	0	0
61	ger	female	nymph	suleiman	bathroom	0	0	0	0	0	0
62	ger	male	adult	suleiman	room	0	0	0	0	0	0
63	ger	female	adult	suleiman	bathroom	0	0	0	0	0	0

Appendix 18: YAR'ADUA HALL, ABU

s/no	species	sex	stage	locatn	cllpoint	Ep1	Ep2	Ep3	Ip1	Ip2	Ip3
1	per	female	adult	Yar'adua	toilet	0	0	0	0	0	0
2	per	female	adult	Yar'adua	toilet	0	0	0	0	0	0
3	per	male	adult	Yar'adua	toilet	0	0	0	0	0	0
4	per	female	adult	Yar'adua	toilet	0	2	0	0	0	0
5	per	female	adult	Yar'adua	bathroom	0	0	0	0	0	0
6	per	male	adult	Yar'adua	bathroom	3	0	0	0	0	0
7	per	female	adult	Yar'adua	toilet	0	12	0	0	0	0
8	per	female	adult	Yar'adua	toilet	5	0	0	0	0	0
9	per	male	adult	Yar'adua	outside	0	0	0	0	0	0
10	per	female	adult	Yar'adua	toilet	0	0	0	0	0	0
11	per	male	adult	Yar'adua	toilet	0	0	0	0	0	0
12	per	male	adult	Yar'adua	toilet	0	0	0	0	0	0
13	per	male	adult	Yar'adua	outside	0	0	0	0	0	0
14	per	male	adult	Yar'adua	toilet	4	0	0	0	0	0
15	per	female	adult	Yar'adua	toilet	0	8	0	0	0	0
16	per	male	adult	Yar'adua	toilet	0	2	0	0	0	0
17	per	male	adult	Yar'adua	bathroom	0	0	0	0	0	0
18	per	female	adult	Yar'adua	toilet	1	0	0	0	0	0
19	per	female	adult	Yar'adua	bathroom	0	0	0	0	0	0
20	per	male	adult	Yar'adua	toilet	0	0	0	0	0	0
21	per	male	adult	Yar'adua	toilet	0	0	0	0	0	0
22	per	female	adult	Yar'adua	toilet	0	0	0	0	0	0
23	per	female	nymph	Yar'adua	toilet	0	0	0	0	0	0
24	per	male	nymph	Yar'adua	bathroom	0	0	0	0	0	0
25	per	male	nymph	Yar'adua	toilet	0	0	0	0	0	0
26	per	male	adult	Yar'adua	bathroom	0	0	0	0	0	0
27	per	female	nymph	Yar'adua	toilet	0	0	0	0	0	0
28	per	male	adult	Yar'adua	toilet	0	0	0	0	0	0
29	per	female	adult	Yar'adua	toilet	0	0	0	0	0	0
30	per	male	nymph	Yar'adua	toilet	0	0	0	0	0	0
31	per	male	adult	Yar'adua	toilet	0	0	0	0	0	0
32	per	female	adult	Yar'adua	toilet	0	0	0	0	0	0
33	per	male	adult	Yar'adua	bathroom	0	0	0	0	0	0
34	per	female	adult	Yar'adua	toilet	0	0	0	0	0	0
35	per	male	adult	Yar'adua	toilet	0	0	0	0	0	0
36	per	male	nymph	Yar'adua	toilet	0	0	0	1	0	0
37	per	female	adult	Yar'adua	toilet	0	0	0	0	0	0
38	per	female	adult	Yar'adua	toilet	0	0	0	0	0	0
39	per	male	adult	Yar'adua	toilet	0	0	0	0	0	0
40	per	female	adult	Yar'adua	toilet	0	0	0	1	0	0

41	ger	female	adult	Yar'adua	room	0	0	0	0	0	0
42	ger	female	adult	Yar'adua	room	0	0	0	0	0	0
43	ger	male	adult	Yar'adua	room	0	0	0	0	0	0
44	ger	male	nymph	Yar'adua	room	0	0	0	0	0	0
45	ger	male	adult	Yar'adua	room	0	0	0	0	0	0
46	ger	female	adult	Yar'adua	room	0	0	0	0	0	0
47	ger	female	adult	Yar'adua	room	0	0	0	0	0	0
48	ger	female	adult	Yar'adua	room	0	0	0	0	0	0
49	ger	male	adult	Yar'adua	room	0	6	0	0	0	0
50	ger	female	adult	Yar'adua	room	0	0	0	0	0	0
51	ger	female	adult	Yar'adua	room	0	0	0	0	0	0
52	ger	female	adult	Yar'adua	room	0	2	0	0	0	0
53	ger	male	adult	Yar'adua	room	0	0	0	0	0	0
54	ger	female	adult	Yar'adua	room	0	0	0	0	0	0
55	ger	male	adult	Yar'adua	room	0	0	0	0	0	0
56	ger	male	adult	Yar'adua	room	0	0	0	0	0	0
57	ger	female	adult	Yar'adua	room	0	0	0	0	0	0
58	ger	male	adult	Yar'adua	room	0	0	0	0	0	0
59	ger	female	nymph	Yar'adua	room	0	0	0	0	0	0
60	ger	female	nymph	Yar'adua	room	0	0	0	0	0	0
61	ger	male	adult	Yar'adua	room	0	0	0	0	0	0
62	ger	male	adult	Yar'adua	room	0	0	0	0	0	0
63	ger	male	nymph	Yar'adua	room	0	0	0	0	0	0

Appendix 19: DANFODIO HALL, ABU

s/no	species	sex	stage	locatn	cllpoint	Ep1	Ep2	Ep3	Ip1	Ip2	Ip3
1	per	female	adult	Danfodio	toilet	0	0	0	0	0	0
2	per	female	adult	Danfodio	toilet	0	0	0	2	0	0
3	per	male	adult	Danfodio	outside	0	13	0	1	0	0
4	per	female	adult	Danfodio	bathroom	0	0	0	0	0	0
5	per	male	adult	Danfodio	toilet	0	0	0	0	0	0
6	per	male	adult	Danfodio	toilet	0	0	0	11	0	0
7	per	female	adult	Danfodio	room	0	0	0	0	0	0
8	per	female	adult	Danfodio	toilet	0	0	0	14	0	0
9	per	male	adult	Danfodio	toilet	0	0	0	0	0	0
10	per	female	nymph	Danfodio	toilet	0	0	0	2	0	0
11	per	male	adult	Danfodio	bathroom	0	0	0	0	0	0
12	per	female	adult	Danfodio	bathroom	0	0	0	0	0	0
13	per	female	nymph	Danfodio	room	0	0	0	0	0	0
14	per	female	adult	Danfodio	toilet	0	3	0	2	0	0
15	per	male	adult	Danfodio	toilet	0	0	0	0	0	0
16	per	male	adult	Danfodio	outside	0	0	0	0	0	0
17	per	female	adult	Danfodio	toilet	0	0	0	4	0	0
18	per	male	adult	Danfodio	bathroom	0	0	0	0	0	0
19	per	male	adult	Danfodio	bathroom	0	0	0	0	0	0
20	per	female	adult	Danfodio	bathroom	0	0	0	10	0	0
21	per	female	nymph	Danfodio	bathroom	0	0	0	0	0	0
22	per	male	nymph	Danfodio	outside	0	0	0	0	0	0
23	per	female	adult	Danfodio	bathroom	0	0	0	1	0	0
24	per	female	adult	Danfodio	toilet	0	0	0	0	0	0
25	per	male	adult	Danfodio	toilet	0	110	0	0	0	0
26	per	female	adult	Danfodio	room	0	0	0	0	0	0
27	per	male	adult	Danfodio	bathroom	0	0	0	0	0	0
28	per	female	adult	Danfodio	toilet	0	0	0	0	0	0
29	per	male	adult	Danfodio	bathroom	0	0	0	2	0	0
30	per	female	adult	Danfodio	outside	0	0	0	0	0	0
31	per	female	adult	Danfodio	toilet	0	12	0	4	0	0
32	per	male	nymph	Danfodio	bathroom	0	0	0	0	0	0
33	per	male	adult	Danfodio	toilet	0	0	0	0	0	0
34	per	female	nymph	Danfodio	bathroom	0	0	0	0	0	0
35	per	female	adult	Danfodio	bathroom	0	0	0	6	0	0
36	per	male	adult	Danfodio	bathroom	0	0	0	0	0	0
37	per	female	adult	Danfodio	bathroom	0	0	0	0	0	0
38	per	male	adult	Danfodio	bathroom	0	0	0	0	0	0
39	per	male	nymph	Danfodio	bathroom	0	0	0	1	0	0
40	per	male	adult	Danfodio	bathroom	0	0	0	0	0	0

41	ger	female	adult	Danfodio	room	0	0	0	0	0	0
42	ger	male	adult	Danfodio	room	0	0	0	0	0	0
43	ger	female	adult	Danfodio	room	0	0	0	0	0	0
44	ger	female	adult	Danfodio	room	0	5	0	0	0	0
45	ger	male	adult	Danfodio	room	0	0	0	0	0	0
46	ger	female	adult	Danfodio	room	0	0	0	0	0	0
47	ger	male	adult	Danfodio	room	0	0	0	0	0	0
48	ger	female	adult	Danfodio	room	0	0	0	0	0	0
49	ger	male	adult	Danfodio	room	0	0	0	0	0	0
50	ger	male	adult	Danfodio	room	0	0	0	0	0	0
51	ger	female	nymph	Danfodio	room	0	0	0	0	0	0
52	ger	female	nymph	Danfodio	kitchen	0	0	0	0	0	0
53	ger	male	adult	Danfodio	kitchen	0	0	0	0	0	0
54	ger	female	adult	Danfodio	room	0	0	0	0	0	0
55	ger	female	adult	Danfodio	room	0	0	0	0	0	0
56	ger	female	adult	Danfodio	room	0	0	0	0	0	0
57	ger	male	adult	Danfodio	room	0	0	0	0	0	0
58	ger	male	adult	Danfodio	room	0	0	0	0	0	0
59	ger	female	adult	Danfodio	kitchen	0	0	0	0	0	0
60	ger	male	adult	Danfodio	kitchen	0	0	0	0	0	0
61	ger	female	adult	Danfodio	room	0	0	0	0	0	0
62	ger	female	adult	Danfodio	room	0	0	0	0	0	0
63	ger	male	adult	Danfodio	room	0	0	0	0	0	0

Appendix 20: QUEEN AMINA HALL, ABU

s/no	species	sex	stage	locatn	cllpoint	Ep1	Ep2	Ep3	Ip1	Ip2	Ip3
1	per	male	adult	Amina	bathroom	0	0	0	0	0	0
2	per	female	adult	Amina	toilet	7	0	0	0	0	0
3	per	male	adult	Amina	toilet	4	0	0	0	0	0
4	per	female	adult	Amina	bathroom	0	0	0	0	0	0
5	per	male	adult	Amina	bathroom	0	0	0	0	0	0
6	per	male	nymph	Amina	bathroom	0	0	0	0	0	0
7	per	male	adult	Amina	toilet	0	19	0	0	0	0
8	per	male	nymph	Amina	outside	0	0	0	14	0	0
9	per	female	adult	Amina	outside	0	0	0	0	0	0
10	per	female	adult	Amina	toilet	0	22	0	0	0	0
11	per	male	adult	Amina	bathroom	0	7	0	0	0	0
12	per	female	adult	Amina	toilet	0	2	0	0	0	0
13	per	female	nymph	Amina	toilet	0	0	0	0	0	0
14	per	female	adult	Amina	outside	0	0	0	0	0	0
15	per	female	adult	Amina	outside	0	0	0	0	0	0
16	per	male	adult	Amina	bathroom	0	0	0	0	0	0
17	per	female	nymph	Amina	bathroom	0	0	0	0	0	0
18	per	male	adult	Amina	outside	0	0	0	0	0	0
19	per	female	adult	Amina	bathroom	0	0	0	0	3	0
20	per	male	adult	Amina	toilet	0	0	0	1	0	0
21	per	male	adult	Amina	toilet	11	0	0	0	0	0
22	per	female	adult	Amina	toilet	5	0	0	3	0	0
23	per	female	nymph	Amina	outside	0	0	0	1	0	0
24	per	male	adult	Amina	toilet	0	6	0	1	0	0
25	per	female	adult	Amina	toilet	0	0	0	0	0	0
26	per	female	adult	Amina	outside	0	0	0	0	0	0
27	per	female	adult	Amina	toilet	0	0	0	0	0	0
28	per	male	adult	Amina	bathroom	0	4	0	1	1	0
29	per	male	nymph	Amina	bathroom	0	0	0	0	0	0
30	per	male	nymph	Amina	toilet	0	0	0	0	0	0
31	per	male	nymph	Amina	toilet	0	0	0	1	0	0
32	per	female	adult	Amina	toilet	0	0	0	0	0	0
33	per	female	adult	Amina	outside	0	0	0	0	0	0
34	per	male	adult	Amina	bathroom	0	3	0	0	0	0
35	per	male	nymph	Amina	bathroom	0	0	0	1	0	0
36	per	male	adult	Amina	toilet	0	0	0	0	0	0
37	per	male	adult	Amina	toilet	6	0	0	0	0	0
38	per	female	adult	Amina	bathroom	0	0	0	0	0	0
39	per	male	adult	Amina	bathroom	0	0	0	0	0	0
40	per	female	adult	Amina	bathroom	0	0	0	0	0	0

41	ger	female	adult	Amina	room	0	0	0	0	0	0
42	ger	male	adult	Amina	room	0	0	0	0	0	0
43	ger	male	adult	Amina	room	0	0	0	0	0	0
44	ger	male	adult	Amina	kitchen	0	0	0	0	0	3
45	ger	female	nymph	Amina	kitchen	0	0	0	0	0	0
46	ger	male	adult	Amina	room	0	0	0	0	0	3
47	ger	female	adult	Amina	room	0	0	0	0	0	0
48	ger	female	adult	Amina	kitchen	0	0	0	0	0	0
49	ger	male	adult	Amina	room	0	0	0	0	0	2
50	ger	female	adult	Amina	room	0	0	0	0	0	0
51	ger	female	adult	Amina	room	0	0	0	0	0	0
52	ger	female	adult	Amina	room	0	0	0	0	0	0
53	ger	female	adult	Amina	room	0	0	0	0	0	0
54	ger	male	adult	Amina	room	0	0	0	0	0	0
55	ger	male	adult	Amina	room	0	0	0	0	0	0
56	ger	female	adult	Amina	kitchen	0	0	0	0	0	0
57	ger	male	adult	Amina	room	0	0	0	0	0	0
58	ger	male	nymph	Amina	kitchen	0	0	0	0	0	0
59	ger	female	nymph	Amina	kitchen	0	0	0	0	0	0
60	ger	female	nymph	Amina	kitchen	0	0	0	0	0	0
61	ger	male	nymph	Amina	room	0	0	0	0	3	0
62	ger	male	adult	Amina	room	0	0	0	0	120	0
63	ger	male	adult	Amina	room	0	0	0	0	40	0

Appendix 21: RIBADU HALL, ABU

s/no	species	sex	Stage	locatn	cllpoint	Ep1	Ep2	Ep3	Ip1	Ip2	Ip3
1	per	male	Adult	Ribadu	toilet	0	0	0	13	0	0
2	per	male	Adult	Ribadu	toilet	23	0	0	3	0	0
3	per	female	Nymph	Ribadu	bathroom	0	0	0	0	0	0
4	per	female	Adult	Ribadu	bathroom	0	0	0	0	0	0
5	per	male	Adult	Ribadu	bathroom	0	0	0	0	0	0
6	per	female	Adult	Ribadu	bathroom	0	0	0	0	0	0
7	per	female	Adult	Ribadu	bathroom	0	0	0	0	0	0
8	per	female	Adult	Ribadu	toilet	0	63	0	0	0	0
9	per	male	Adult	Ribadu	toilet	4	0	0	1	0	0
10	per	female	Adult	Ribadu	toilet	0	0	0	0	0	0
11	per	male	Adult	Ribadu	outside	0	0	0	2	0	0
12	per	female	Adult	Ribadu	outside	0	0	0	0	0	0
13	per	male	nymph	Ribadu	toilet	0	7	0	6	0	0
14	per	male	adult	Ribadu	toilet	4	0	0	0	0	0
15	per	male	adult	Ribadu	outside	0	0	0	0	0	0
16	per	female	nymph	Ribadu	bathroom	0	0	0	0	0	0
17	per	male	nymph	Ribadu	toilet	0	0	0	0	0	0
18	per	female	adult	Ribadu	toilet	0	0	0	0	0	0
19	per	female	adult	Ribadu	toilet	0	0	0	0	0	0
20	per	male	adult	Ribadu	bathroom	0	11	0	0	0	0
21	per	female	adult	Ribadu	toilet	0	17	0	3	0	0
22	per	female	nymph	Ribadu	outside	0	0	0	0	0	0
23	per	male	nymph	Ribadu	bathroom	0	0	0	0	0	0
24	per	male	adult	Ribadu	outside	0	0	0	0	0	0
25	per	female	adult	Ribadu	bathroom	0	0	0	11	2	0
26	per	male	adult	Ribadu	bathroom	0	28	0	0	0	0
27	per	female	adult	Ribadu	outside	0	0	0	0	0	0
28	per	male	adult	Ribadu	toilet	0	3	0	0	7	0
29	per	male	nymph	Ribadu	toilet	0	2	0	0	0	0
30	per	male	adult	Ribadu	toilet	0	0	0	2	0	0
31	per	male	adult	Ribadu	toilet	0	0	0	0	0	0
32	per	female	adult	Ribadu	toilet	0	0	0	0	0	0
33	per	female	adult	Ribadu	bathroom	0	8	0	6	0	0
34	per	male	adult	Ribadu	bathroom	0	0	0	0	0	0
35	per	female	adult	Ribadu	toilet	0	0	0	0	0	0
36	per	female	adult	Ribadu	toilet	0	16	0	0	0	0
37	per	male	adult	Ribadu	bathroom	0	0	0	0	0	0
38	per	female	adult	Ribadu	toilet	0	0	0	0	0	0
39	per	female	adult	Ribadu	bathroom	0	12	0	0	0	0
40	per	male	adult	Ribadu	toilet	0	0	0	0	0	0

41	ger	male	adult	Ribadu	room	0	0	0	0	0	0
42	ger	female	adult	Ribadu	kitchen	0	0	0	0	0	0
43	ger	male	adult	Ribadu	kitchen	0	0	0	0	0	0
44	ger	male	adult	Ribadu	room	0	0	0	0	0	0
45	ger	female	adult	Ribadu	room	0	0	0	0	0	0
46	ger	female	adult	Ribadu	room	0	0	0	0	0	0
47	ger	female	adult	Ribadu	kitchen	0	0	0	0	0	0
48	ger	male	nymph	Ribadu	kitchen	0	0	0	0	0	0
49	ger	male	nymph	Ribadu	kitchen	0	0	0	0	0	0
50	ger	female	nymph	Ribadu	kitchen	0	0	0	0	0	0
51	ger	female	adult	Ribadu	room	0	0	0	0	0	0
52	ger	female	adult	Ribadu	room	6	0	0	0	0	0
53	ger	male	adult	Ribadu	room	0	0	0	0	0	0
54	ger	male	adult	Ribadu	room	0	0	0	0	0	0
55	ger	male	adult	Ribadu	kitchen	0	0	0	0	0	0
56	ger	female	adult	Ribadu	room	0	0	0	0	0	0
57	ger	female	adult	Ribadu	room	2	0	0	0	0	2
58	ger	female	adult	Ribadu	kitchen	0	0	0	0	0	0
59	ger	female	adult	Ribadu	kitchen	0	0	0	0	0	0
60	ger	male	adult	Ribadu	kitchen	0	0	0	0	0	0
61	ger	female	adult	Ribadu	room	0	0	0	0	0	0
62	ger	male	nymph	Ribadu	kitchen	0	0	0	0	0	0
63	ger	male	adult	Ribadu	room	0	0	0	0	0	0

Appendix 22: DANRAKA, SAMARU VILLAGE

s/no	species	sex	stage	locatn	cllpoint	Ep1	Ep2	Ep3	Ip1	Ip2	Ip3
1	per	male	adult	Leather	room	0	0	0	0	0	0
2	per	male	adult	Leather	room	0	0	0	0	0	0
3	per	female	adult	Leather	bathroom	0	0	0	0	0	0
4	per	male	adult	Leather	bathroom	0	0	0	0	0	0
5	per	male	adult	Leather	room	0	0	0	0	0	0
6	per	female	adult	Leather	room	0	0	0	0	0	0
7	per	female	nymph	Leather	room	0	0	0	0	0	0
8	per	male	adult	Leather	toilet	0	0	0	0	0	0
9	per	male	adult	Leather	toilet	0	0	0	0	0	0
10	per	female	nymph	Leather	toilet	0	0	0	0	0	0
11	per	female	adult	Leather	bathroom	0	0	0	0	0	0
12	per	female	nymph	Leather	toilet	0	0	0	0	0	0
13	per	female	nymph	Leather	toilet	0	0	0	0	0	0
14	per	male	adult	Leather	bathroom	0	0	0	0	0	0
15	per	male	adult	Leather	toilet	0	0	0	0	0	0
16	per	female	adult	Leather	toilet	0	0	0	0	0	0
17	per	male	adult	Leather	toilet	0	0	0	0	0	0
18	per	female	adult	Leather	room	0	0	0	0	0	0
19	per	female	adult	Leather	bathroom	0	0	0	0	0	0
20	per	female	adult	Leather	bathroom	0	0	0	0	0	0
21	per	female	adult	Leather	toilet	0	0	0	0	0	0
22	per	female	adult	Leather	room	0	0	0	0	0	0
23	per	female	adult	Leather	room	0	0	0	0	0	0
24	per	male	adult	Leather	toilet	0	0	0	0	0	0
25	per	female	adult	Leather	toilet	0	0	0	0	0	0
26	per	male	adult	Leather	room	0	0	0	0	0	0
27	per	male	nymph	Leather	toilet	0	0	0	0	0	0
28	per	female	adult	Leather	bathroom	0	0	0	0	0	0
29	per	male	adult	Leather	toilet	0	0	0	0	0	0
30	per	female	adult	Leather	bathroom	0	0	0	0	0	0
31	per	male	adult	Leather	toilet	0	0	0	0	0	0
32	per	male	adult	Leather	toilet	0	0	0	0	0	0
33	per	male	adult	Leather	bathroom	0	0	0	0	0	0
34	per	female	adult	Leather	toilet	0	0	0	0	0	0
35	per	female	adult	Leather	toilet	0	0	0	0	0	0
36	per	female	adult	Leather	bathroom	0	0	0	0	0	0
37	per	female	adult	Leather	toilet	0	0	0	0	0	0
38	per	female	nymph	Leather	toilet	0	0	0	0	0	0
39	per	female	adult	Leather	room	0	0	0	0	0	0
40	per	male	adult	Leather	room	0	0	0	0	0	0

41	ger	male	nymph	Leather	room	0	0	0	0	0	0
42	ger	female	adult	Leather	kitchen	0	0	0	0	0	0
43	ger	male	adult	Leather	room	0	0	0	0	0	0
44	ger	female	adult	Leather	kitchen	0	0	0	0	0	0
45	ger	female	adult	Leather	kitchen	0	0	0	0	0	0
46	ger	male	adult	Leather	kitchen	0	0	0	0	0	0
47	ger	male	adult	Leather	kitchen	0	0	0	0	0	0
48	ger	male	adult	Leather	room	0	0	0	0	0	0
49	ger	female	adult	Leather	room	0	0	0	0	0	0
50	ger	female	adult	Leather	kitchen	0	0	0	0	0	0
51	ger	female	adult	Leather	kitchen	0	0	0	0	0	0
52	ger	female	adult	Leather	room	0	0	0	0	0	0
53	ger	male	adult	Leather	kitchen	0	0	0	0	0	0
54	ger	female	adult	Leather	room	0	0	0	0	0	0
55	ger	female	nymph	Leather	room	0	0	0	0	0	0
56	ger	female	nymph	Leather	kitchen	0	0	0	0	0	0
57	ger	male	nymph	Leather	kitchen	0	0	0	0	0	0
58	ger	male	adult	Leather	kitchen	0	0	0	0	0	0
59	ger	female	adult	Leather	kitchen	0	0	0	0	0	0
60	ger	male	adult	Leather	kitchen	0	0	0	0	0	0
61	ger	female	adult	Leather	kitchen	0	0	0	0	0	0
62	ger	female	adult	Leather	kitchen	0	0	0	0	0	0
63	ger	male	adult	Leather	kitchen	0	0	0	0	0	0

Appendix 23: NEW LAYOUT, SAMARU VILLAGE

s/no	species	sex	stage	locatn	cllpoint	Ep1	Ep2	Ep3	Ip1	Ip2	Ip3
1	per	male	adult	New Layout	room	0	0	0	0	0	0
2	per	male	adult	New Layout	room	0	0	0	0	0	0
3	per	male	adult	New Layout	room	0	0	0	0	0	0
4	per	female	adult	New Layout	toilet	0	0	0	0	0	0
5	per	male	adult	New Layout	kitchen	0	0	0	0	0	0
6	per	male	nymph	New Layout	toilet	0	0	0	0	0	0
7	per	female	adult	New Layout	kitchen	0	0	0	0	0	0
8	per	female	adult	New Layout	room	0	0	0	0	0	0
9	per	female	nymph	New Layout	room	0	0	0	0	0	0
10	per	female	adult	New Layout	toilet	0	0	0	0	0	0
11	per	male	adult	New Layout	bathroom	0	0	0	0	0	0
12	per	male	nymph	New Layout	toilet	0	0	0	0	0	0
13	per	female	adult	New Layout	toilet	0	0	0	0	0	0
14	per	female	adult	New Layout	toilet	0	0	0	0	9	0
15	per	female	adult	New Layout	toilet	0	0	0	0	0	0
16	per	female	adult	New Layout	kitchen	0	0	0	0	0	0
17	per	female	adult	New Layout	toilet	0	0	0	0	0	0
18	per	male	adult	New Layout	bathroom	0	0	0	0	0	0
19	per	female	adult	New Layout	bathroom	0	0	0	0	0	0
20	per	male	adult	New Layout	toilet	0	0	0	0	0	0
21	per	male	adult	New Layout	bathroom	0	0	0	0	0	0
22	per	female	nymph	New Layout	toilet	0	0	0	0	0	0
23	per	female	nymph	New Layout	room	0	0	0	0	0	0
24	per	female	nymph	New Layout	room	0	0	0	0	0	0
25	per	female	nymph	New Layout	toilet	0	0	0	0	0	0
26	per	female	nymph	New Layout	bathroom	0	0	0	0	0	0
27	per	male	adult	New Layout	bathroom	0	0	0	0	0	0
28	per	female	adult	New Layout	toilet	0	0	0	0	3	0
29	per	male	adult	New Layout	toilet	0	0	0	0	0	0
30	per	female	adult	New Layout	toilet	0	0	0	0	0	0
31	per	female	adult	New Layout	toilet	0	0	0	0	0	0
32	per	female	adult	New Layout	toilet	0	0	0	0	0	0
33	per	male	adult	New Layout	bathroom	0	0	0	0	0	0
34	per	female	adult	New Layout	toilet	0	0	0	0	0	0
35	per	male	adult	New Layout	toilet	0	0	0	0	0	0
36	per	female	adult	New Layout	toilet	0	0	0	0	0	0
37	per	male	adult	New Layout	toilet	0	0	0	0	0	0
38	per	female	nymph	New Layout	toilet	0	0	0	0	0	0
39	per	female	adult	New Layout	bathroom	0	0	0	0	0	0
40	per	female	adult	New Layout	toilet	0	0	0	0	0	0

41	ger	female	adult	New Layout	toilet	0	0	0	0	0	0
42	ger	male	adult	New Layout	bathroom	0	0	0	0	0	0
43	ger	male	adult	New Layout	toilet	0	0	0	0	0	0
44	ger	female	adult	New Layout	kitchen	0	0	0	0	0	0
45	ger	female	adult	New Layout	room	0	0	0	0	0	0
46	ger	female	adult	New Layout	kitchen	0	0	0	0	0	0
47	ger	male	adult	New Layout	toilet	0	0	0	0	0	0
48	ger	female	adult	New Layout	room	0	0	0	0	0	0
49	ger	female	adult	New Layout	room	0	0	0	0	0	0
50	ger	female	adult	New Layout	room	0	0	0	0	0	0
51	ger	female	adult	New Layout	room	0	0	0	0	0	0
52	ger	male	adult	New Layout	room	0	0	0	0	0	0
53	ger	male	adult	New Layout	room	0	0	0	0	0	0
54	ger	female	adult	New Layout	room	0	0	0	0	0	0
55	ger	female	nymph	New Layout	room	0	0	0	0	0	0
56	ger	male	adult	New Layout	room	0	0	0	0	0	0
57	ger	female	adult	New Layout	kitchen	0	0	0	0	0	0
58	ger	female	adult	New Layout	room	0	0	0	0	0	0
59	ger	female	adult	New Layout	kitchen	0	0	0	0	0	0
60	ger	male	adult	New Layout	room	0	0	0	0	0	0
61	ger	female	adult	New Layout	toilet	0	3	0	0	0	0
62	ger	male	adult	New Layout	room	0	0	0	0	0	0
63	ger	male	adult	New Layout	room	0	0	0	0	0	0

Appendix 24: HAYIN DAN YARO, SAMARU VILLAGE

s/no	species	sex	stage	locatn	cllpoint	ep1	ep2	ep3	ip 1	ip 2	ip 3
1	per	male	adult	HD Yaro	toilet	0	0	0	0	4	0
2	per	female	adult	HD Yaro	toilet	0	7	0	0	0	0
3	per	male	adult	HD Yaro	kitchen	0	0	0	0	0	0
4	per	male	adult	HD Yaro	toilet	0	0	0	0	0	0
5	per	female	adult	HD Yaro	toilet	0	0	0	0	0	0
6	per	male	adult	HD Yaro	room	0	0	0	0	0	0
7	per	female	nymph	HD Yaro	toilet	0	0	0	0	0	0
8	per	female	adult	HD Yaro	toilet	0	0	0	0	0	0
9	per	female	nymph	HD Yaro	room	0	0	0	0	0	0
10	per	male	adult	HD Yaro	kitchen	0	0	0	0	0	0
11	per	male	adult	HD Yaro	toilet	0	0	0	0	0	0
12	per	female	adult	HD Yaro	kitchen	0	0	0	0	0	0
13	per	female	adult	HD Yaro	toilet	0	3	0	0	0	0
14	per	male	adult	HD Yaro	bathroom	0	0	0	0	0	0
15	per	male	adult	HD Yaro	bathroom	0	3	0	0	0	0
16	per	male	adult	HD Yaro	kitchen	0	0	0	0	0	0
17	per	female	adult	HD Yaro	room	0	0	0	0	1	0
18	per	male	adult	HD Yaro	toilet	0	0	0	0	0	0
19	per	male	nymph	HD Yaro	toilet	0	2	0	0	0	0
20	per	male	adult	HD Yaro	toilet	0	0	0	0	0	0
21	per	male	adult	HD Yaro	toilet	0	0	0	0	0	0
22	per	female	adult	HD Yaro	bathroom	0	0	1	0	0	0
23	per	male	nymph	HD Yaro	room	0	0	0	0	0	0
24	per	male	adult	HD Yaro	toilet	0	0	0	0	0	0
25	per	female	adult	HD Yaro	bathroom	0	0	0	0	0	0
26	per	female	adult	HD Yaro	kitchen	0	0	0	0	0	0
27	per	male	adult	HD Yaro	room	0	0	0	0	0	0
28	per	female	adult	HD Yaro	room	0	0	0	0	0	0
29	per	female	nymph	HD Yaro	kitchen	0	0	0	0	0	0
30	per	male	nymph	HD Yaro	room	0	0	0	0	0	0
31	per	female	nymph	HD Yaro	kitchen	0	0	0	0	0	0
32	per	female	adult	HD Yaro	toilet	0	0	0	0	0	0
33	per	male	adult	HD Yaro	toilet	0	0	0	0	0	0
34	per	female	adult	HD Yaro	toilet	0	6	0	0	0	0
35	per	female	adult	HD Yaro	room	0	0	0	0	0	0
36	per	female	adult	HD Yaro	bathroom	0	0	0	0	0	0
37	per	male	adult	HD Yaro	toilet	0	0	0	0	0	0
38	per	female	nymph	HD Yaro	room	0	0	0	0	0	0
39	per	male	adult	HD Yaro	bathroom	0	0	0	0	0	0

40	per	male	adult	HD Yaro	toilet	0	0	0	0	0	0
41	ger	male	adult	HD Yaro	room	0	0	0	0	0	0
42	ger	female	adult	HD Yaro	kitchen	0	0	0	0	0	0
43	ger	male	adult	HD Yaro	kitchen	0	0	0	0	0	0
44	ger	female	adult	HD Yaro	bathroom	0	0	0	0	0	0
45	ger	female	adult	HD Yaro	room	0	0	0	0	0	0
46	ger	female	adult	HD Yaro	room	0	0	0	0	0	0
47	ger	male	adult	HD Yaro	bathroom	0	0	0	0	0	0
48	ger	female	adult	HD Yaro	room	0	0	0	0	0	0
49	ger	female	adult	HD Yaro	room	0	0	0	0	0	0
50	ger	male	nymph	HD Yaro	room	0	0	0	0	0	0
51	ger	female	adult	HD Yaro	room	0	7	0	0	0	0
52	ger	female	adult	HD Yaro	room	0	0	0	0	0	0
53	ger	male	adult	HD Yaro	room	0	0	0	0	0	0
54	ger	male	nymph	HD Yaro	room	0	5	0	0	0	0
55	ger	female	adult	HD Yaro	bathroom	0	0	0	0	0	0
56	ger	female	adult	HD Yaro	room	0	0	0	0	0	0
57	ger	male	adult	HD Yaro	room	0	0	0	0	0	0
58	ger	male	adult	HD Yaro	room	0	0	0	0	0	0
59	ger	male	adult	HD Yaro	bathroom	0	0	0	0	0	0
60	ger	female	adult	HD Yaro	room	0	13	0	0	0	0
61	ger	female	adult	HD Yaro	room	0	0	0	0	0	0
62	ger	male	adult	HD Yaro	room	0	0	0	0	0	0
63	ger	female	adult	HD Yaro	room	0	0	0	0	0	0

Appendix 25: HAYIN DOGO, SAMARU VILLAGE

s/no	species	Sex	stage	locatn	cllpoint	Ep1	Ep2	Ep3	Ip1	Ip2	Ip3
1	per	male	adult	Hayin Dogo	toilet	0	0	0	0	0	0
2	per	female	adult	Hayin Dogo	toilet	0	0	0	0	0	0
3	per	male	adult	Hayin Dogo	toilet	0	0	0	0	0	0
4	per	male	adult	Hayin Dogo	bathroom	0	0	0	0	0	0
5	per	female	adult	Hayin Dogo	toilet	0	0	0	0	0	0
6	per	female	adult	Hayin Dogo	toilet	0	0	0	0	0	0
7	per	female	adult	Hayin Dogo	room	0	1	0	0	0	0
8	per	female	nymph	Hayin Dogo	toilet	0	1	0	0	0	0
9	per	male	adult	Hayin Dogo	room	0	0	0	0	0	0
10	per	female	adult	Hayin Dogo	toilet	0	0	0	0	0	0
11	per	male	adult	Hayin Dogo	toilet	0	0	0	0	0	0
12	per	female	nymph	Hayin Dogo	toilet	0	0	0	0	0	0
13	per	male	nymph	Hayin Dogo	bathroom	0	0	0	0	0	1
14	per	male	adult	Hayin Dogo	bathroom	0	0	0	0	0	0
15	per	female	adult	Hayin Dogo	room	0	7	0	0	0	0
16	per	female	adult	Hayin Dogo	toilet	0	16	0	0	0	0
17	per	male	adult	Hayin Dogo	toilet	0	0	0	0	0	0
18	per	male	adult	Hayin Dogo	toilet	0	0	0	0	0	0
19	per	male	adult	Hayin Dogo	toilet	0	43	0	0	0	0
20	per	male	adult	Hayin Dogo	toilet	0	0	0	0	0	0
21	per	female	adult	Hayin Dogo	toilet	0	0	0	0	0	0
22	per	male	adult	Hayin Dogo	bathroom	0	0	0	0	0	0
23	per	female	adult	Hayin Dogo	toilet	0	0	0	0	0	0
24	per	female	nymph	Hayin Dogo	toilet	0	0	0	0	0	0
25	per	male	adult	Hayin Dogo	toilet	0	0	0	0	0	0
26	per	male	adult	Hayin Dogo	bathroom	0	0	0	0	0	0
27	per	male	adult	Hayin Dogo	toilet	0	0	0	0	0	0
28	per	female	adult	Hayin Dogo	bathroom	0	4	0	0	0	0
29	per	male	adult	Hayin Dogo	toilet	0	0	0	0	0	0
30	per	female	adult	Hayin Dogo	room	0	1	0	0	0	0
31	per	female	adult	Hayin Dogo	toilet	0	0	0	0	0	0
32	per	female	adult	Hayin Dogo	toilet	0	0	0	0	0	0
33	per	male	nymph	Hayin Dogo	toilet	0	0	0	0	0	0
34	per	male	adult	Hayin Dogo	toilet	0	0	0	0	0	0
35	per	male	adult	Hayin Dogo	toilet	0	0	0	0	0	0
36	per	male	adult	Hayin Dogo	room	0	0	0	0	0	0
37	per	male	nymph	Hayin Dogo	toilet	0	0	0	0	0	0
38	per	female	adult	Hayin Dogo	bathroom	0	0	0	0	0	0
39	per	male	adult	Hayin Dogo	room	0	0	0	0	0	0

40	per	female	adult	Hayin Dogo	toilet	0	0	0	0	0	0
41	ger	female	adult	Hayin Dogo	kitchen	0	0	0	0	0	0
42	ger	female	adult	Hayin Dogo	room	0	0	0	0	0	0
43	ger	female	adult	Hayin Dogo	bathroom	0	0	0	0	0	0
44	ger	male	nymph	Hayin Dogo	room	0	0	0	0	0	0
45	ger	male	adult	Hayin Dogo	room	0	0	0	0	0	0
46	ger	female	adult	Hayin Dogo	bathroom	0	0	0	0	0	0
47	ger	female	adult	Hayin Dogo	room	0	0	0	0	0	0
48	ger	male	adult	Hayin Dogo	room	0	0	0	0	0	0
49	ger	female	adult	Hayin Dogo	room	0	0	0	0	0	0
50	ger	female	adult	Hayin Dogo	room	0	0	0	0	0	0
51	ger	female	adult	Hayin Dogo	room	0	2	1	0	0	0
52	ger	male	nymph	Hayin Dogo	room	0	0	0	0	0	0
53	ger	male	nymph	Hayin Dogo	room	0	0	0	0	0	0
54	ger	male	adult	Hayin Dogo	room	0	0	0	0	0	0
55	ger	female	adult	Hayin Dogo	room	0	0	0	0	0	0
56	ger	male	adult	Hayin Dogo	room	0	0	0	0	0	0
57	ger	male	adult	Hayin Dogo	room	0	0	0	0	0	0
58	ger	male	adult	Hayin Dogo	bathroom	0	1	0	0	0	0
59	ger	male	nymph	Hayin Dogo	bathroom	0	0	0	0	0	0
60	ger	female	adult	Hayin Dogo	room	0	0	0	0	0	0
61	ger	female	adult	Hayin Dogo	room	0	0	0	0	0	0
62	ger	male	adult	Hayin Dogo	room	0	0	0	0	0	0
63	ger	female	adult	Hayin Dogo	room	0	0	1	0	0	0