PREVALENCE OF HYDATIDOSIS IN CATTLE AND CAMELS IN MAIDUGURI AND GASHUA ABATTOIRS NIGERIA

BY

REBECCA ARIN YAKUBU

DEPARTMENT OF ZOOLOGY,
AHMADU BELLO UNIVERSITY,
ZARIA, NIGERIA

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BY

Rebecca Arin YAKUBU, (B.SC. ZOOLOGY (ABU 1995) AMLST (FCVLT, VOM. 2002), MSC. ZOOLOGY (ABU 2007) PH.D/SCIE/04924/09/10 (P16LSZG9071)

A THESIS SUBMITTED TO SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY IN ZOOLOGY

DEPARTMENT OF ZOOLOGY,
FACULTY OF LIFE SCIENCES,
AHMADU BELLO UNIVERSITY,
ZARIA, NIGERIA

JANUARY, 2018

DECLARATION

I hereby declare that this thesis titled **"Prevalence of hydatidosis in cattle and camel in Maiduguri and Gashua, Nigeria"** is a record of my own research work under the supervision of Prof. I. H. Nock, Prof. I. S. Ndams and Prof. S.A. Luka. The work is original and has not been submitted in any form to any university for the award of any degree. Acknowledgements of all works consulted are duly made in the text by means of references.

_____ Date: _____

Rebecca Arin Yakubu

CERTIFICATION

This thesis titled **"Prevalence of hydatidosis in cattle and camel in Maiduguri and Gashua, Nigeria"** by Yakubu Rebecca Arin meets the regulation governing the award of Doctorate degree in Zoology of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

_____ Date_____

Prof. I.H Nock
Chairman, Supervisory Committee
Department of Zoology
Ahmadu Bello University, Zaria.

_____ Date_____

Prof. I. S. Ndams
Member, Supervisory Committee
Department of Zoology
Ahmadu Bello University, Zaria.

_____ Date_____

Prof. S. A. Luka
Member, Supervisory Committee
Department of Zoology
Ahmadu Bello University, Zaria.

_____ Date_____

Prof. I. S. Ndams
Head, Department of Zoology
Ahmadu Bello University, Zaria.

_____ Date_____

Prof. S. Z. Abubakar
Dean, School of postgraduate studies,
Ahmadu Bello University, Zaria.

DEDICATION

This work is dedicated to my beloved husband Paul Arin Yakubu and my children Rejoice Reyerikang Yakubu, Grace Kusikutek Yakubu and Anong Gabreiella Yakubu for being my source of inspiration

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ABSTRACT

Prevalence of hydatidosis in cattle and camels slaughtered in Maiduguri and Gashua abattoirs base on serological test and present of cysts was carried out in September to November 2012, and April to July 2013. Gross examination of lungs, liver, heart and kidneys for hydatid cyst was carried out by palpation on randomly selected animals and blood samples were collected for serology. Protein profiles of hydatid cyst fluid in camels were analysed using Sodium Dodecyl Sulphate Polyacrylamide Gel Electrophoresis (SDS-PAGE). A ten year retrospective study at the University of Maiduguri Teaching Hospital was carried out to determine records of human hydatidosis. A total of 805 animals were sampled; 560 from Maiduguri and 245 from Gashua, four hundred and sixty four (464) of the samples were camels while 341 were cattle. The overall prevalence of cystic was 13.8% (14.1% in Maiduguri and 13.1% in Gashua) and seroprevalence was 40.5% (44.8% in Maiduguri and 30.6% in Gashua). Maiduguri had the highest cyst prevalence in camels (25%), then Gashua (19%), while the lowest cyst prevalence (1%) was recorded in cattle slaughtered in Gashua. The highest seroprevalence (53%) was recorded in Maiduguri camels and the lowest (24.3%) was in cattle in Gashua. The association between location and age with either cyst prevalence or seroprevalence of hydatidosis was significant (P=0.00). There was no significant association (P>0.05) between cystic prevalence and seroprevalance with the sex of the animals. Gross examination of visceral organs showed that lungs and liver had cysts the heart, spleen and kidney had no cyst. The liver had the highest number of cysts 77(9.6%) and while the lungs had 51(6.3%). A total of the 50 cysts were collected, 46 from camels and 4 from cattle. 54% (27/50) were small cyst and 46(23/50) were medium cyst. 36% of

the cysts were fertile, 40% were infertile and 24% were calcified. The SDS-PAGE analysis of camel hydatid cysts fluids revealed protein bands at 64kda, 91kda, 160 kda and 200kda molecular units. While the purified revealed bands at 64kda, 91kda, 120kda, 160kda, and 200kda corresponding to antigen 5 and 160kda of a thermo stable antigen B. There was no record of human hydatidosis in the hospital records during the retrospective study. In conclusion, hydatidosis is prevalent in cattle and camels in Maiduguri and Gashua; location and age were highly associated with infection and no human record of hydatidosis was found in records of selected Hospitals within the study area. It was recommended that serological studies be conducted more frequently alongside post mortem findings in other states and in different species of farm animals.

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LIST OF ABBREVIATIONS

CDC	Centre for Disease Control
CE	Cystic Echinococcosis
CI	Confidence Interval
COCIN	Church of Christ in Nations
CT	Computed Tomography
ELISA	Enzyme Linked Immunosorbent Assay
ESP	Excretory Secretory Products
HCF	Hydatid Cyst Fluid
kDa	Kilodaltons
LCC	Local Church Council
MRI	Magnetic Ressonance Imaging
OR	Odds ratio
PAIR	Punction Aspiration Injection Re-aspiration
PHO	Panamerican Health Organization
SDS-PAGE	Sodium Dodecyl Sulphate PolyAcrylamide Gel Electrophoresis
χ^2	Chi-Sqaure

CHAPTER ONE

1.0 INTRODUCTION

Hydatidosis also called Echinococcosis or Echinococcal disease is a parasitic disease of tape worm, it belongs to the genus *Echinococcus*. The disease is one of the major zoonotic helminthosis of medical and public health importance (Carmena *et al.,* 2005; Ahmad *et al.,* 2017). Larval infection is characterized by long-term growth of metacestode (hydatid cyst) in the intermediate host (Zhang *et al.,* 2003). Out of the several species within the genus *Echinococcus* currently considered valid, the three major species of medical and public health importance are; *E. granulosus, E. multilocularis* and *E. vogeli* (Schatz *et al.,* 1995; Jenkin *et al.,* 2005). Of the three, *E. granulosus* is considered the most important species due to its worldwide distribution and impact in both human and animal health (Romig, 2003; Kebede *et al*., 2009). *Echinococcus multilocularis* is rare but most virulent while *E. vogeli is* very rare (Dandan, 2014). The members of the genus *Echinococcus* have indirect, two host life cycles. The adults are tapeworms usually 3–7mm and live in the small intestine of the definitive host, usually wild and domestic canids, and the fluid-filled hydatid cyst (metacestodes) develop in the internal organs, mainly liver and/or lungs of the intermediate host (usually herbivores or omnivorous) such as goats, sheep, cattle and camels (Soulsby, 1986; Jenkins *et al.,* 2005).

Humans are accidental intermediate and dead-end host (Jasseen *et al.,* 1990; Siracusana *et al.,* 2012) acquiring infection through consumption of food or water contaminated with

cestode eggs (Craig *et al.,* 1991; Torgerson *et al.,* 2003; Carmena *et al.,* 2005). Dogs become infected by eating infected visceral organs of the intermediate host.

The development of large fluid-filled cyst in the lungs, liver and other internal organs of the intermediate host leads to significant economic losses to the meat industry through reduction in carcass weight, decrease in hide value, decrease in milk production and reduced fertility (Lightower, 1989; Luka *et al.,* 2009). In Ethopia, a total annual economic loss from organ condemnation and carcass weight loss due to hydatidosis was estimated at 1,791,925.89 Ethiopian Birr (₦24,757,394.00) in 2000 (Torgerson, 2003; Regessa *et al.,*2010) and 1,848,849.76 ETB (₦25,543,859.00) in the year 2015 (Nasr and Pal, 2016). In Maiduguri, Nigeria, the weight in Kilogram and monetary value (Naira) of condemnable cattle liver due to hydatidosis was estimated at 268kg and ₦93,800.00 respectively in 2006 (Biu *et al.,* 2006).

The global economic loss due to cystic echinococcusis was estimated to be over 2 billion US$ in 2006 (Budke *et al.,* 2006). The World Health Organization (WHO) fact sheet updated April 2016, reported an estimated cost of 3 billion US$ for treating cases and losses in the livestock industry.

The distribution of the disease is common in areas with high dog population where humans maintain close contact with dogs, and where there are various animals which act as intermediate hosts (Mohammed and Nezhat, 2004; Abdul Latif *et al.,*2013). Other factors such as agricultural practices, poor disposal of cyst from infected livestock, lack of adequate control policy, uncontrolled movement of animal and difficulty in early

diagnosis also enhance the distribution of the disease (Dada and Belino, 1978; Elberbri *et al.,* 2015).

Diagnosis of the disease is based on combination of imaging techniques such as ultrasonography, computerized axial tomography and x-rays; immunodiagnosis such as complement fixation, agglutination and enzyme-linked immunosorbent assay and molecular biology methods such as polymerase chain reaction (PCR), sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE) and immunoblotting (Lightower *et al.*1984; Sbihi *et al.,* 1996; Kittelberger *et al.,* 2002). Fusion of techniques became necessary because routine parasitological, haematological and biochemical test do not offer proper diagnosis of hydatidosis (Khuroo, 2002). Furthermore, abattoir records do not give adequate information due to the practice of home slaughter and the uncooperative attitude of butchers during meat inspection in some endemic areas. Thus abattoir records which should be strictly regulated are important in the surveillance and control of hydatidosis (Dada *et al.,* 1981).

The disease is endemic in the Mediterranean countries, the Middle East, and African countries such as like Ethopia, Kenya, Tanzania and Uganda (Macpherson *et al.,* 1986; Tergut, 2001). China, Iran, Saudi Arabia and Australia are also endemic areas (Wang *et al.,* 2013; Torgerson, 2013).

In Nigeria, prevalence of 26.2%, 53% and 6.3% in Sokoto (Ogunsun *et al*., 2000; Okolugbo *et al*., 2014; Abdullahi *et al*., 2011). In Kano, Luka *et al.* (2009) and Rabiu and Jegede (2010) recorded prevalence of 38.9% and 20.5% respectively. Studies on the prevalence of the disease are under reported, as they are mostly based on post mortem

findings and abattoir records (Ajogi *et al.,* 1995) with the exception of the work by Luka *et al*. (2009) and Okolugbo *et al*. (2014) who used Enzyme Linked Immunosorbent Assay (ELISA). The lack of proper meat inspection at the abattoirs, the inability to locate small lesions in the liver or lungs of animals and the un-corporative attitude of butchers during meat inspection, often give inconclusive results and subsequently poor knowledge of the disease (Garba and Maigandi, 1995; Biu, *et al.,* 2006; Abdullahi, 2011). In Northern Nigeria, some of the few documents on the prevalence of hydatidosis include the documentation of Luka *et al.* (2009) and Okolugbo *et al*. (2014). This study was undertaken in order to provide baseline data for the assessment of the impact of the disease on the health of cattle and camels in the study area using physical examination in conjunction with the enzyme linked immunorsorbent assay (ELISA).

1.1 Statement of Research Problem

Studies on hydatidosis have over the years depended on physical examining of cysts in organs of slaughtered animals with the resultant limitation of examinating live animals for the disease. This limitation has caused poor assessment of prevalence of hydatiodosis such that available data are unreliable.

1.2 Justification of the Study

In Northern Nigeria, not much is documented on the prevalence of hydatidosis in cattle and camels which are readily available and cheap sources of meat, milk, hides and means of farming and transport (Kadim *et al.,* 2008; Tarefa, 2014). Also, studies on the prevalence of the diseases are mostly based on post mortern findings and abattoir records.

This study is to broaden the scope of research on hydatidosis through the provision of data needed to define the prevalence status and public health significant of the disease

using physical examination in conjunction with the enzyme linked immunosorbent assay (ELISA).

1.3 Aim

The aim of the study is to evaluate the status of hydatidosis in camels and cattle slaughtered in Maiduguri and Gashua abattoirs and retrospectively in humans using hospital records.

1.4 Objectives

The objectives of the study are to determine:

i. the prevalence of hydatid cyst in organs of cattle and camels slaughtered in Maiduguri and Gashua abattoirs.
ii. the age and sex specific prevalence of hydatidosis based on visceral inspection (cystic prevalence) of cattle and camels in Maiduguri and Gashua abattoirs.
iii. the antigenic profiles of hydatid cyst fluids from camels and cattle collected in the study area.
iv. the seroprevalence of hydatidosis in cattle and camels slaughtered in Maiduguri and Gashua abattoirs in relation to age and sex.
v. the prevalence of hydatidosis in humans through restrospective study of hospital records in selected general hospitals in Maiduguri and Gashua.

1.5 Hypotheses

i. The cystic prevalence of hydatidosis in organs of cattle and camels in the study area is low.
ii. The cystic prevalence of hydatidosis is not associated with age and sex of cattle and camels.

iii. The antigenic profile of hydatid cyst fluids from camels and cattle are the same.

iv. The sero prevalence of hydatisosis is low and not influence by age and sex of animals.

v. Human hydatidosis does not occur in the study area.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Brief history of echinococcosis

Echinococcosis is a disease that was recognized by ancient scholars such as Aretaus and Galen in the 1st and 2nd century and Hippocrates and Rhazes in the 4th century (Cox, 2002). In the 17th century, Francesco Redi figured out the cause of echinococcosis when he illustrated that the hydatid cyst of echinoccocosis were of animal origin. Pierre Simon Palla in 1766, predicted that hydatid cysts were actually larval stages of Tape worms while in 1782, Goeze accurately described the cysts and the tapeworm head (Connoly, 2006; PVRI Chronicle, 2014; Eckert and Thompson, 2017).

Batch in 1786, accurately described *E. granulosus* and Rudolf Leuckart identified *E. multilocularis* in1863 (Tappe *et al.,* 2008). In 1853, Carl Von Siebold demonstrated that cyst from sheep lead to adult tapeworms in dogs (Connoly, 2006; WHO, 2016).

Although Echinoccosis was well known, it was not until the mid1900's that the distinct features of *E. granulosus* and *E. Multicularis*, their lifecycle and pathology were fully described thereby generating more research interest on echinococcosis.

2.2 Aetiology

Hydatidosis is a zoonotic infection caused by the larval stage (hydatid) of tapeworms of the genus *Echinococcus* found in the small intestine of carnivores. In carnivores, the worm has very little effect if any. However, in the intermediate host, the effect can be great depending on the organs involved (Craig *et al.,* 2007; Cringoli *et al.,* 2007).

Although several species of *Echinococcus* have been described, only four of them namely; *E. granulosus, E. multilocularis, E. oligarthrus* and *E. vogeli* are recognized as taxonomically relevant and only *E. granulosus* and *E. multilocularis* are pathogenic to humans and other domestic animals (Craig, 2004; Da Silva, 2010). Clinically, there are three broad morphological forms of echinococcosis that are recognised; cystic echinococcosis cause by *E. granulosus*, alveolar echinococcosis cause by *E. multilocularis* and polycystic echinococcosis caused by *E. oligarthrus* and *E. vogeli* (Thompson and Mcmanus, 2002; Khuroo, 2002; Reather and Hanel, 2003). World Health Organization (WHO) proposed the designation of CE for cystic echinococcosis, AE for alveolar echinococcosis and PE for polycystic echinococcosis in order to differentiate the disease caused by the most pathogenic species (Macpherson *et al*., 2003; Reather and Hanel, 2003; Eckert and Deplazes, 2004).

2.3 Classification of *Echinoccocus* Species

The genus *Echinoccoccus* belongs to phylum platyhelminthes (flatworms); class cestoda, order cyclophyllidea and family teaniidae. Although the classifisation of *Echinococcus* has been a big challenge for many years because of limited morphological description and lack of evidence for geographical or ecological segregation of the parasite as all were conventionally assigned to *E. granulosus* (Thompson and Mcmanus, 2002). The recent application of molecular tools has help to resolved most of these issues by given current information on species, strains and genotypes of *Echinococcus* (Thompson and Lymbery, 1988; Thompson and Mcmanus, 2002; Eckert and Thompson, 2017).

Jenkins *et al*. (2005); Xiao *et al.* (2005) and Omer *et al.* (2013) reported that seven species of the genus *Echinococcus* recognised are; *E. granulosus, E. multilocularis, E.*

vogeli, E. oligarthrus, E. equine, E. ortlepps and E. Schiquicus; phylogenetic studies have evaluated the status of *Echinococcus* species and confirmed *E. granulosus, E. multilocularis, E. oligarthrus,* and *E. vogeli* while *E. felidis* and *E. shiquicus* as sister species of *E. granulosus sensu lato* and *E. multilocularis* respectively (Mcmanus *et al*., 2002; Casulli *et al.,* 2012; Amer *et al.,* 2015). However, *E. granulosus* is the most important species infecting humans and lifestock and exist as a series of genetically distinct strains/genotypes. Examples are *E. granulosus* Sensu Stricto (common sheep strain G1), *E. equines* (horse strain), *E. ortleppi* (cattle strain) *E. canadensis* (camel/pig strain) and *E. fidelis* (lion strain) (Harandi *et al.,* 2003*;* Lavikainen *et al*., 2003; Omer *et al.,* 2013).

2.3.1 Species and distribution of *Echinococcus granulosus* complex

The distinct genetic types of *E. granulosus* include two sheep strains (G1 and G2), two bovid strains (G3 and G5), horse strain (G4), a camelid strain (G6), a pig strain (G7), and a cervid strain (G8). A ninth genotype (G9) has been described in swine in Poland, (Mcmanus *et al.,* 2003) and a tenth strain (G10) in reindeer in Eurasia. The most frequent strain associated with human Cystic Echinococcosis is the common sheep strain (G1) that is widely distributed in all continents. Highest rates of infection are recorded in communities involved in extensive sheep farming and epidemiological studies suggest that this genetic variant is the principal strain infecting humans (Eckert *et al*., 2001; Thompson and Mcmanus, 2002) consequently; its presence coincides with areas which have high prevalence of human CE such as in Morocco, Tunisia, Kenya, Kazakhstan, Western China and Argentina.

The G2 strain is transmitted among sheep and infects humans also, but genetic differences biologically distinguish it from the G1 strain, conferring a different life cycle (Thompson and Mcmanus, 2002). The G3 strain which is diffused among buffalos and transmitted by water, has been recorded in South Asia (Macpherson and Wachira, 1997) but no susceptibility among humans has been found. The G4 strain, formerly known as *Echinococcus equinus*, appears to infect exclusively equines as intermediate hosts and no human cases have been documented (Thompson and Mcmanus, 2002) It is known to be diffused in the Mediterranean regions of Spain, Italy, Lebanon, and Syria, as well as in South Africa. The former cattle strain (G5), known as *Echinococcus ortleppi*, is transmitted by cattle in Europe, Asia, parts of Africa and South America and only one case in humans has been isolated in past years (Bowles *et al*., 1992), suggesting a less pathogenic risk for humans than the sheep strain of *E. granulosus*. G6-G10 strains are poorly distinguished from each other but they are clearly distinct from the common sheep strain (Thompson and Mcmanus, 2002). The G6 strain is known to principally affect camels and goats. Animal infection is diffused in the Middle East, Africa, southern Asia and South America (Thompson and Mcmanus, 2002) and cases of human infection have been found in Nepal, Iran, Mauritania, Kenya and Argentina (Thompson and Mcmanus, 2002). The G7 strain is transmitted by domestic pigs in Europe (Spain and Italy), Asia and South America, as well as the closely related genetic variant G9 that has been documented to affect Polish patients (Bowles *et al*., 1992) although the animal reservoir is unknown. The G8 strains are known to be transmitted between wolves and wild cervids in the northern regions of Europe, Asia and North America. Few cases of human infection have been documented with a lower prevalence of the disease than CE caused

by other forms of *E. granulosus* (Bowles *et al*., 1992). However, transmission between humans of this genetic variant seems to be low and further data is needed to better assess its pathogenicity. Finally, some other genetic variants which are poorly characterized have been found in several countries. For example, the wildlife "lion" strain transmitted among lions and wild ungulates has been documented in Africa but no human infection has been recorded.

2.4 Biology of *Echinococcus*

Adult *Echinococcus* worms are rather small not longer than 7mm. They have 3 segments, the last being the mature segment because it is gravid (filled with eggs) (John *et al.,* 2006). The head (scolex) has four suckers and a rostellum with about 25 –50 hooks (DPDX) for attachment. The worms are hermaphrodite having reproductive organs of both sexes and flame cells (excretory cells) on each proglottid. The two reproductive organs have a general opening called genital pore (Fig. 1).

The eggs are ovoid or spherical in shape and approximately 30 micrometers. The eggs contain the hexacanth larva or onchosphere (which name sterms from the fact that the embryo has six hooklets) with a thick capsule (John *et al.,* 2006) and are passed in the faeces of the definitive host. The hydatid cysts are known as metacestodes or bladder worms. The cysts are oval in shape and grow to 5-10cm within the first year and are able to survive within organs of the intermediate host for years (Mandell *et al.,* 2010). Cysts sometimes grow to be so large over several years or even decades and can contain several litres of fluid.

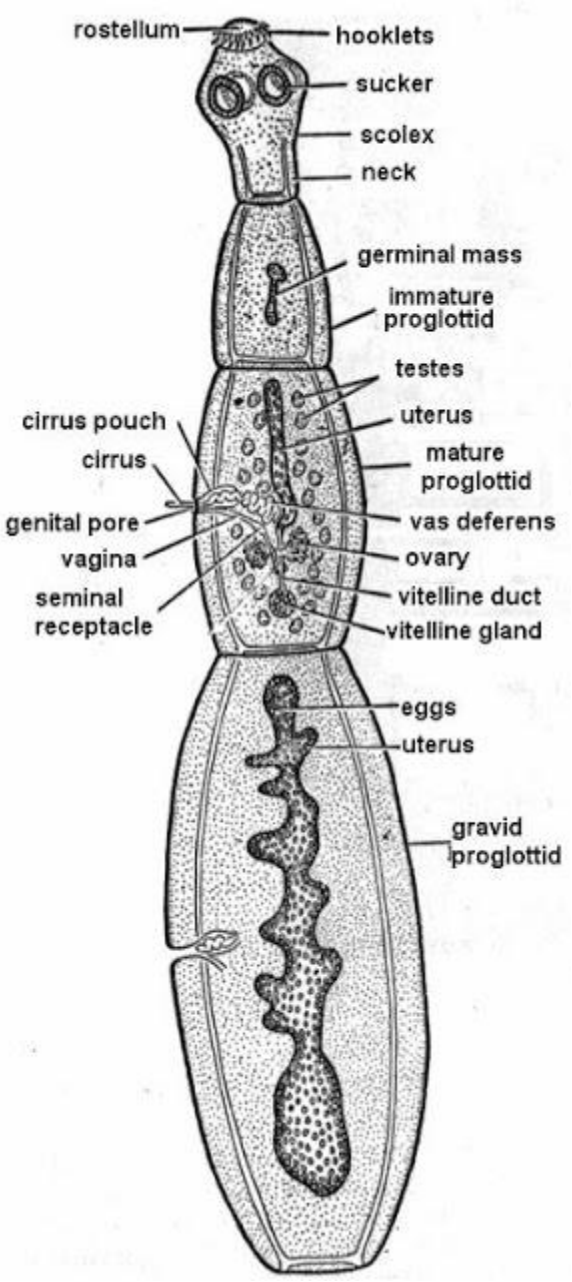


Figure 1: Diagram of *Echinococcus granulosus*
Source: https://en.wikipedia.org>wiki> echinococcus

Once a cyst has reached a diameter of 1cm its walls differentiates into a thick outer layer; a non-cellular membrane which covers the thin germinal epithelium. From the epithelium, cells begin to grow within the cyst. These cells then become vacuolated and are known as brood capsules, which are parts of the parasite from which protoscolices bud and often daughter cysts also form within the cyst (John *et al.,* 2006*;* Mandell *et al*., 2010).

Morphologically, species of *Echinococcus* differ with the major difference being the length of the tapeworm. *E. granulosus* is about 2-7mm, while *E. multicocularis* is often smaller and is 4mm or less (Eckert and Deplaze, 2004). On the other hand, *E. vogeli* is found to be up to 2-9mm long (CDC, 2010). In addition to the difference in length, there are also differences in the hydatid cysts of the different species. In *E. multilocularis*, the cysts have an ultra-thin lining membrane and the germinal epithelium may bud externally. Furthermore, *E. granulosus* cysts are unilocular and full of fluid and *E. multicularis* cysts contain little fluid and are multilocular. For *E. vogeli,* its hydatid cysts are large and are actually polycystic since the germinal membrane of the hydatid cyst is into sections, create new cyst. Like *E. granulosus* cysts, *E. vogeli* cysts are filled with fluid (John, 2006).

2.5 Lifecycle of the parasite

Echinococcus granulosus requires two hosts to complete its life cycle; the definitive host (dogs and other canids) and the intermediate host commonly sheep, cattle, horse and camel.The life cycle has 3 developmental stages; the adult tapeworm in the definitive host, the eggs in the environment and the metercestode in the intermediate host (Siracusano *et al.,*2012). The metacestode of *E. granulosus* when ingested attaches to the

mucosa membrane of the small intestine of the definitive host; it then develops into the adult worm which resides in the intestine. Gravid proglottids release eggs that are passed in the faeces of the definitive host. The eggs when ingested then hatch in the small intestine of the intermediate host and release the oncosphere that penetrates the intestinal wall and moves through the circulatory system into different organs, in particular the liver and lungs (Moro and Schantz, 2009). Once it has invaded these organs, the oncosphere develops into cyst. The cyst then slowly enlarges over several months and is commonly 5-10cm in diameter. Larger cysts have been recorded principally in man. Example of a cyst 50 cm in diameter containing 16 litres of fluid has been recorded (Soulby, 1986).

Enchinococcal cysts though grow slowly can cause clinical symptoms in human and can be life threatening (Mcmanus *et al.,* 2003). The definite host then becomes infected after ingesting cyst found in the organs of the infected intermediate host and the cycle is repeated (Fig. 2).

2.6 Transmission of the parasite

All disease causing species of *Echinococcus* are transmitted to intermediate host via the ingestion of parasite ova, while the definitive host gets infected by eating infected viscera of the intermediate host. Dogs are also infected by scavenging (Khanfar, 2004; Kebede *et al*., 2010). Humans are accidental intermediate host that become infected through direct contact with dogs, consumption of food and water, and by handling soil contaminated with parasite ova (MSDS, 2001). Humans are regarded as dead end host due to their inability to transmit the disease (Bristow *et al.*, 2012).

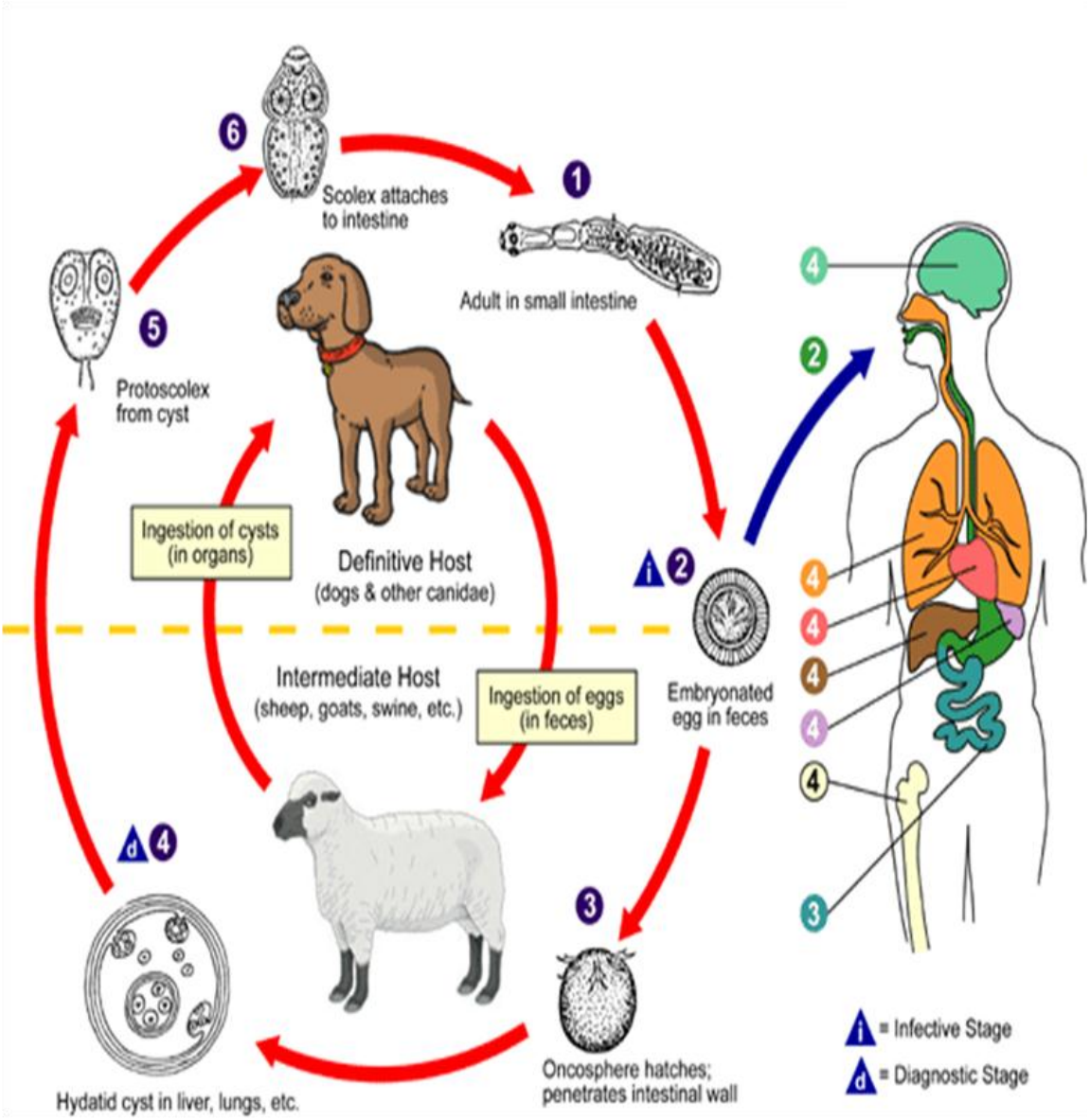


Figure 2: Life cycle of *Echinococcus granulosus*

Source: CDC Echinococcus lifecycle.svg.

1. Adult in small intestine
2. Embrayonated egg in fece
3. Oncosphere hatches penetrates in intestinal wall
4. Hydatid cyst in liver, lungs, etc
5. Protoscolex from cyst
6. Scolext attaches to intestine

Though there are no biological or mechanical vectors for the adult or larval form of any *Echinococcus* species, coprophagic flies, carrier birds and arthropods can act as mechanical vectors for the eggs (Eckert and Deplaze, 2004).

2.7 Diagnosis of the disease

A formal diagnosis of hydatidosis requires a combination of tools that involves imaging techniques, histopathology or nucleic acid detection and serology (Zhang *et al.,* 2003) because routine parasitological, haematological and biochemical test do not give adequate diagnosis (Khuroo, 2002). The results are non specific e.g. liver involvement may be reflected in an elevated bilirubin or alkaline phosphatase level. Leukocytosis may suggest infection of the cyst and Eosinophilia is present in 25% of all persons who are infected while hypogammaglobinomia is present in 30% (Shaikenov and Torgerson, 2002).

For diagnosis of cystic echinococcosis (CE), imaging is the main method while serological test such as the direct haemagglutination, enzyme linked immunosorbent assay, immunoblots or latex agglutination that use antigens specific for *E. granulosus* verify the imaging results. The imaging technique of choice for cystic echinococcosis is ultrasonography, because in addition to the fact that it visualize the cyst in the body organs, it is inexpensive, non-invasive and gives instant results (Besbe *et al.,* 2003; Macpherson and Milner, 2003; Brunett *et al.,* 2010). In addition to ultrasonography, both Magnetic Resonnance Imaging (MRI) and Computer Tomography (CT) scans are often used although MRI is often preferred to CT scan for diagnosing CE since it gives better visualization of the thin wall of the cystic mass (Knapp *et al.,* 2009). Dandan *et al.* (2014), reported that an intradermal skin test (Casoni test) was used and had a sensitivity

of 70% but now has been abandoned because of its low sensitivity, low accuracy and potential for severe local allergic reactions.

2.7.1 Parasitological methods of diagnosis

In cattle, diagnosis of cystic echinococcosis is mainly through post-mortem findings during meat inspection. The presence of hydatid cysts in internal organs is a very important tool of diagnosis in that it actually confirms the disease.

The most reliable method for diagnosis of *Echinococcus* species in the definitive hosts is by necropsy, because worm burdens can be accurately estimated and parasites collected for identification (Eckert and Deplaze, 2004). However, necropsy usually results in a biased sample, in that only unwanted dogs can be necropsied.

For many years, treatment and diagnosis of *E. granulosus* infection in dogs relied on the use of a single drug Arecoline hydro bromide, a substance obtained from an extract of nuts from the betel palm (*Areca catechu*) (Jenkins *et al.,* 2005). The drug causes rapid and strong contraction of the smooth muscle of the intestine which leads to the dislodgement of the tapeworms and they pass out in faeces for identification. However, the drug has several major disadvantages; it can be lethal to very young or old dogs, it may cause the pregnant females to abort, dogs with light infections may not pass the worms, the procedure is very time consuming and purging results are always an under-representation of the true picture of infection (Jenkins, 2005). This procedure is not sensitive as single treatment with the drug has been shown to diagnose less than 50% of *Echinococcus* infections (Simsik and Koroglu, 2004; Kandeel *et al*., 2009).

Faecal examination does not differentiate *E. granulosus* from other taenid species, hence it cannot be used to diagnose *E. granulosus* in dogs and other definitive hosts. The morphology of taeniid eggs is similar and therefore it is very difficult to differentiate on the basis of presence of eggs in faeces of dogs and other intermediate hosts.

2.7.2 Immunodiagnostic techniques

In the 1980s, an immunological method for detecting circulating antibodies against *E. granulosus* in serum was deviced (Jenkins and Rickard, 1984). Specific circulating antibodies against *E. granulosus* were readily detectable in dogs raised worm-free and mono-specifically infected with *E. granulosus* in Australia, but in populations of rural dogs in Kenya with natural infections of *E. granulosus* and other cestodes, detection of antibodies was unreliable (Jenkins *et al.*, 1990; Jenkins and Morris, 2003). The presence of antibodies in serum did not mean the dog was infected at the time of testing because the antibodies against taenid cestodes may remain detectable in the blood stream for weeks or months after worms have been lost (Jenkins and Rickard, 1984).

In the early 1990s, an immunological method of detecting substances (Coproantigen) released in the faeces of tape-worm infected definitive hosts was devised independently in England and Switzerland (Allan and Craig, 1989; Deplazes *et al.*, 1990; Adam and Aradaib, 2010). This method was adapted to detect Coproantigen of taenid cestodes including *E. granulosus* (Deplazes *et al.*, 1990; Deplazes *et al.*, 1992).

2.7.2.1 Coproantigen detection ELISA diagnostic test

In dogs, the diagnosis of *Echinococcus* species using coproantigen-detection ELISA method has a number of advantages over the use of Arecoline purgation as a diagnostic

test. Some of the advantages are the Coproantigen-detection ELISA has easier sample collection, is fast and requires less personnel. These factors make it suitable for surveillance of large dog populations (Abbasi *et al.*, 2003). Faecal samples for coproantigen testing can be collected in the field for some dogs hence eliminating the need of transporting the dogs to specific locations, unlike Arecoline purgation which requires taking dogs to specific purge sites and concentration of dogs in specific locations (Lopera *et al.*, 2003). The other advantage of coproantigens test is that it enables early detection in the course of infection (Jenkins *et al.*, 2000; Lopera *et al.*, 2003). The important advantage of coproantigen test over the antibody detection is that those coproantigen-positive dogs are infected at the time of the testing (Jenkins *et al.*, 2000) and the test can be carried out at room temperature. The coproantigen test can be used to test *E. granulosus* in wild carnivores which are not easy to capture. The detection of coproantigen of *E. multilocularis* has been performed in wild fox populations in Japan (Sakai *et al.*, 1998). In addition, several ELISA systems are available in various laboratories. There is a potential for refinement of the coproantigen ELISA. An interesting approach was described by Nonaka *et al*. (1996), who developed a sandwich ELISA based on a polyclonal capture antibody against excretory/secretory antigens of intestinal stages of *E. multilocularis* and a monoclonal detecting antibody (Kohno *et al*., 1995) directed to a homologous antigen. Recently, hydatid cyst fluid has been used as antigen for serological diagnosis in the intermediate (Golassa *et al.*, 2011).

2.7.2.2 Antigen for immunodiagnosis of *Echinococcus*

Accurate immunodiagnosis of *Echinococcus* infection requires highly specific and sensitive antigens to be used in immunodiagnostic assays. The choice of an appropriate

source of antigenic material is a crucial point in the improvement of the diagnostic features which are based on the developmental stages of the parasite and the host. The most common antigenic sources used for the immunodiagnosis of echinococcal disease are hydatid cyst fluid, somatic extracts and excretory-secretory products from protoscoleces or the adult *E. granulosus* (Carmena *et al*., 2006).

2.7.2.2.1 Hydatid cyst fluid antigens

Hydatid cyst fluid (HCF) is a complex mixture of glyco and lipoproteins, carbohydrates and salts. Some of its components come from the host (mainly albumin and immunoglobulins), while the remaining products are the result of the metabolic activity of the metacestode. HCF is considered the main antigenic source for the immunodiagnosis of human CE. For clinical practices, crude HCF has a high sensitivity, ranging typically from 75% to 95% (Zhang *et al*., 2003). However, its specificity is often unsatisfactory and cross-reactivity with sera from patients infected with other cestode (89%), nematode (39%) and trematode (30%) species is commonly observed (Eckert and Deplazes, 2004). It has now become more frequent to purify components such as the lipoproteins antigen B and antigen 5, the most relevant components of HCF for diagnostic purposes.

2.7.2.2.2 Protoscolex and adult somatic antigens

Initially, immunological responses to *E. granulosus* in the definitive host are directed against infective protoscoleces and later, against the adult parasite. Thus somatic extracts from protoscoleces and adult worms have been the most suitable source of antigens in the immunodetection of the infection in dogs and other canids. However, performance of the serological tests when using these antigenic preparations has been hampered by several

methodological problems. ELISA results showed highly variable sensitivities, ranging from 40 to 90% (Jenkins *et al*., 1990; Gasser *et al*., 1991). These studies also demonstrated that 25–60% of the sera from dogs infected with *E.granulosus* did not show significant levels of specific antibody, and revealed cross-reactivity with other parasite species (Gasser *et al.*, 1992). In addition, antigenic differences have been found in protoscoleces from different species of intermediate hosts (Rafiei and Craig, 2002). Several causes have been proposed to explain the low levels of specific serum antibodies, like sequestration of antibodies and formation of circulating immunocomplexes Gasser *et al.* (1993), parasite's immune evasion mechanisms Gasser *et al*. (1994), low immune response of the host Gasser *et al*. (1993) or host nutritional status (Gasser *et al.*, 1992).

To help address these issues, simultaneous detection of serum antibodies and circulating antigens has been suggested as an alternative to improve the diagnostic sensitivity of the assays (Spinelli *et al*., 1996). Previous studies demonstrated that antigenic components of 27 and 94 kDa from crude protoscolex extracts were specifically identified by 95% and 62% of dog sera experimentally infected with *E. granulosus*, respectively (Gasser *et al.*, 1989, 1992). Other polypeptides with molecular masses of 43, 35, 20, and 14 kDa demonstrated different levels of cross-reactivity with sera from dogs infected with other cestodes or nematodes. However, these results have not been corroborated in further studies using a larger number of sera. Due to the lack of specificity and sensitivity of the antigens currently available, serological tests are considered unreliable for the detection of *E. granulosus* in the definitive host. In an attempt to improve this situation, the secreted protein 14-3-3 Siles-Lucas *et al.* (2000), the fatty acid-binding protein EgDf1 Chabalgoity *et al*. (2000), and the fibrillar protein EgA31 Saboulard *et al*. (2003), all

antigens derived from the *E. granulosus* adult worm, have been expressed. These recombinant proteins exhibited strong immunogenic properties in dogs experimentally infected with the parasite. The evaluation of their potential use in developing new diagnostic tools and candidate vaccines against the echinococcal disease in the definitive host are currently under study. Although crude extracts exhibit poor specificity (Rafiei and Craig, 2002), several recombinant proteins have evidenced high diagnostic performances, particularly rEpC1 (Li *et al*., 2003) and rEgcMDH (Virginio *et al*., 2003). rEpC1 is a truncated sequence from *E. granulosus* protoscoleces that encodes a 8.4 kDa polypeptide, and rEgcMDH is a cestode cytosolic malate dehydrogenase homologue. Both recombinant antigens were tested using a large panel of serum samples and showed high levels of sensitivity and specificity. The evaluation of the diagnostic potential of these molecules for the detection of *E. granulosus* in the definitive and other intermediate hosts is yet to be determined. In contrast with human and dogs, very little research has been carried out to date to apply protoscoleces-derived antigens for the serodiagnosis of *E. granulosus* infection in ruminants, despite the fact that protoscoleces are part of the matured hydatid cysts. Specific serum antibody levels in naturally infected sheep are often low, probably because the immunological responses are inadequate in many animals or they are not maintained throughout the course of the infection (Lightowers and Gottstein, 1995). Additionally, serological cross-reactions between *E. granulosus* and other cestodes (mainly *T. hydatigena* and *T. ovis*) limit the specific diagnosis of the infection (Yong *et al*., 1984). In a study using a large panel of 1261 sheep sera, Kittelberger *et al*. (2002) found that crude protoscoleces extract exhibits a diagnostic sensitivity and specificity of 63% and 98%, respectively, which is considerably more

effective than AgB and the recombinant EG95 oncosphere protein. The authors indicated that this antigenic preparation should be useful for the detection of the presence of infected sheep on a flock basis, but not for identification of individual animals infected with *E. granulosus*. To date, no antigenic extract has exhibited satisfactory sensitivity and specificity for routine ovine serodiagnostic use.

2.7.2.2.3 Protoscolex and adult excretory-secretory products

Very little research has been directed towards the description of excretory-secretory products (ESP) from *E. granulosus* protoscoleces and adult worms. Recently, Carmena *et al.,* (2006) carried out the characterization of the protoscolex ESP, identifying 20 major protein components by SDS-PAGE. The extract showed phosphatase, lipase, and glucosidase enzymatic activities, but no protease activity could be detected. Two new *E. granulosus* antigens with molecular weights of 89 and 74 kDa were specifically recognized by sera from patients with hydatidosis, and are potential candidate diagnostic antigens in the inmunodiagnosis of human CE. Cross-reactivity studies using immunoblot inhibition and ELISA-inhibition assays have shown that protoscolex ESP share high proportion of antigenic components with protoscolex somatic extracts, and to a lesser extend with hydatid cyst fluid (Carmena *et al*., 2005b). Protoscolex and adult sources in the serodiagnosis of intestinal dog ESP have also been assayed as antigenic echinococcosis using ELISA and immunoblotting. When adult ESP was tested with sera from dogs naturally infected with *E.granulosus*, three components larger than 94 kDa, two triples of 68/94 and 39/43 kDa, and seven proteins less than 30 kDa in size were identified (Gasser *et al*., 1992). Using protoescolex ESP, Carmera *et al*., (2005a) found

seven antigenic components ranging in size from 46 to 130 kDa, with the 89 and 50 kDa polypeptides showing promising features as diagnostic antigens.

During the last two decades, the detection of *E. granulosus* in the definitive host has been mainly based on the detection of parasite ESP in faecal samples (coproantigens) by ELISA using antibodies against adult somatic antigens (Allan *et al.,* 1992), and excretory-secretory products from proglottids (Deplazes *et al*., 1992) or protoscoleces (Benito and Carmena, 2005). This technique has demonstrated to be the most reliable tool currently available for epidemiological purposes, improving considerably the diagnostic features of the traditional serological tests (Craig *et al*., 1995; Fraser and Craig, 1997). Additionally, the test is capable of detecting prepatent period as early as 7 days post infection in experimental infections (Ahmad and Nizami, 1998), and ELISA results correlate well with the worm burden in the dog intestine (Craig *et al*., 1995; Ahmad and Nizami, 1998). ELISA values decrease to negative levels 2–4 days after the elimination of the parasite, allowing the accurate determination of the current status of infection in the dog (Jenkins *et al*., 2000).

2.7.2.2.4 Oncosphere antigens

Oncospheres are the infective stage of *E. granulosus* in the intermediate host. Therefore, an elevated immune response against oncosphere-derived antigens is expected in the early stages of the infection. Gasser *et al*., (1994) identified three major components in oncosphere extracts using sera from dogs experimentally infected with *E. granulosus*. These polypeptides (37, 30, and 22 kDa) were apparently oncosphere-specific and the authors proposed their use for serological discrimination between prepatent and patent infection in dogs. In the same way, Gasser *et al*. (1992) found that some infected and

uninfected people from hydatid endemic areas had a higher anti-oncospheral antibody level than people from non-endemic regions, suggesting the possibility of using this antigenic extract in epidemiological surveys. Later work demonstrated strong antibody responses against purified oncosphere proteins in sera from experimentally infected sheep (Heath and Lawrence, 1996). Following this approach, a recombinant antigen vaccine was developed for use in ruminant intermediate hosts of *E. granulosus* (Lightowlers *et al.,* 1996). The recombinant antigen, termed G95, was cloned from mRNA obtained from the parasite oncospheres. The vaccine has been shown to be highly effective in animal trials (96–98% protection in immunized sheep), with almost complete immunity persisting for more than a year after vaccination (Lightowlers and Heath, 2004). In an attempt to identify the location of host-protective epitopes, truncated forms of EG95 have been prepared and tested for their ability to elicit host-protective responses (Woollard *et al.,* 2001). Although each of the truncated forms of EG95 induced specific antibodies, none of them were able to elicit protective immune responses, suggesting that the host-protective epitopes of EG95 are conformational. This fact demonstrates that the major proportion of the protective efficacy of EG95 requires the intact molecule. The gene encoding EG95, designated *eg*95-1, belongs to a small gene family which includes five other members that are also transcribed in the oncosphere (Chow *et al*., 2001). It has been suggested that the identification of the expressed protein in life-cycle stages other than the oncosphere may allow the development of potential vaccines against different stages of the parasite's life cycle (Chow *et al*., 2004). EG95 has also been used as a diagnostic antigen in serological tests for the detection of *E.granulosus* in sheep (Kittelberger *et al* ., 2002), but a very poor diagnostic sensitivity was obtained (5.2%). This suggests that

there are few specific serum antibodies present in the naturally infected sheep, demonstrating that EG95 is an unsuitable diagnostic marker of the disease in sheep.

2.7.3 DNA technology: Polymerase Chain Reaction (PCR)

Great potential for diagnosis of canine echinococcosis has been shown by DNA amplification through the development of stool based polymerase chain reaction (PCR) (copro-PCR) tests for both species-specific and strain-specific pre-patent and patent detection of adult *Echinococcus granulosus* infections (Naidich *et al.*, 2006; Zhang *et al.*, 2003).

Mitochondrial DNA-based detection of *Echinococcus* species has been shown to be an excellent tool for analysis of strain/genotypic variation in the genus, determining phylogenic relationship and informing taxonomic species questions (Thompson and McManus, 2002).

2.7.4 Ultrasound imaging technology (US)

Ultrasound imaging is used to asymptomatic cysts where cyst show up as sharp outlines and occasionally fluid levels can also be detected. Ultrasound imaging has been used in small ruminants like sheep in some studies and followed up with post-mortem examination.

2.7.5 Diagnosis of the disease in humans

In humans, the diagnosis of hydatidosis is highly dependent on imaging techniques (e.g. computed tomography scans, magnetic resonance imaging, ultrasound and radiography) to detect the space occupying lesions caused by the developing, dying or dead metacestodes of *Echinococcus* species (Macpherson *et al.,* 2003; Raether and Hanel,

2003; Eckert and Deplazes, 2004). Most cases of hydatidosis are discovered as incidental findings in routine diagnostic imaging procedures since most infected humans do not show any clinical signs unless the cysts enlarge sufficiently to have pathological effects. International classification of ultra sound images has been produced by the WHO expert working group and should, in principle, be used whenever ultrasound diagnosis is done.

Additionally, laboratory based diagnosis such as histology; cytology and serology provide confirmation of clinical infection and can be applied to aid epidemiological surveys of cystic hydatidosis in endemic regions. Such methods include serology where specific serum antibodies are detected and can be used in mass screening programs (Dottorini *et al.*, 1985; Todorov and Boeva, 1999; Wen and Craig, 1994; McManus *et al.*, 2003.). However, serological techniques are not hundred percent sensitive and specific and some cystic hydatidosis patients might not produce a marked antibody response (Dottorini *et al.*, 1985). Specificity for cystic hydatidosis serology can be a problem because of cross- reaction with inter-taeniid species (Shepherd and McManus; 1987; Siracusano *et al.*, 1991; Ito *et al.*, 1999). Serological positive sera can further be tested for confirmation of *Echinococcus* spp. and differentiated by western blotting (Lopera *et al.*, 2003).

2.8 Treatment of cystic echinococcosis

The most common form of treatment for cystic echinococcosis is open surgical removal of the cyst combined with chemotherapy using albendazole and/or mebendazole before and after surgery. But instances of where there are cysts in multiple organs or in risky location surgery becomes impractical.

For inoperable cases chemotherapy and/or PAIR (Puncture aspiration-injection re-aspiration) become alternative options of treatment (Eckert and Deplazes, 2004). PAIR is a minimal invasive procedure that involves 3 steps: puncture and needle aspiration of the cyst, injection of scolicidal solution for 20-30 minutes and cyst re-aspiration and final irrigation. Patients who undergo PAIR typical take albendazole or mebendzole from 7 days before and 28 day after procedure.

Incase of alternative treatment using only chemotherapy, albendazole is preferred twice a day for 1-5 months (DPDX, CDC, 2009). An alternative to albendazole is mebendazole for at least 3-6 months. Though surgery still remains as the standard for cystic Echinococcosis treatment, a number of studies suggest that PAIR with chemotherapy is more effective than surgery in terms of disease recurrence morbidity.

Lapraroscopic surgery, which provides excellent care rates with minimal morbidity and mortality, is reported by Jani, (2014) to be another alternative to open surgery. However, these drugs and procedures also have their complications which include; hepatoxicity, anaemia, thrombocytopenia, alopecia, embryotoxicity, teratogenicity and then spillage and seeding in relation to treatment and then spillage and seeding in relation to treatment and the following in relation to PAIR;- hemorhage, mechanical damage to other tissues, infection, allergic reaction or anaphylatic shocks, persistence of daughter cyst and sudden intra cystic decompression leading to bilary fistula. Chemical slerosing cholangitis is related to scolicidal agents (Dandan *et al.*, 2014). Thus, alot of care must be taken in medical centres in order for patients to be treated appropriately.

2.9 Prevention and control

In order to prevent transmission to dogs from intermediate host, dogs can be given anthelminthic vaccinations (Craig *et al.,* 2007; Moro and Schantz 2009). Clean slaughter and high surveillance of potential intermediate host during slaughter is vital in preventing the transmission of the parasite to the definitive host. Dogs and potential intermediate host should be kept separate as much as possible to avoid perpetuating infection (Moro and Schantz 2009; Li *et al*., 2014). This can be achieved by limiting the use of dogs as guards in herds. Fencing off of grazing areas can also help in preventing transmission of CE to cattle and other ruminants by preventing dogs from defecating on pasture. Dog control programme should be passed into law. For example, in countries such as Greece, a dog control program has been in effect since 1985 with emphasis on dog registration and stray dog collection, with preventive treatment of all owned dogs testing of sheep-herd dogs and treatment with praziquantal (Banda, 2013).

In Turkana District of Kenya, a hydatid control program has been in place since 1983, managed by the African Medical Research Foundation (Magambo *et al.*, 2006). In this region, the hydatid control program consists of three components namely human treatment (surgery, puncture, aspiration, injection and re-aspiration [PAIR] and chemotherapy), dog population control (killing of stray dogs, sterilization of female dogs and deworming of all owned dogs) and community education.

Public attitudes towards zoonoses play a major role for a successful implementation of prevention, control and management measures. The development of strategies to inform the public on risk and prevention of zoonoses must be based not only on the results of scientific research of risk factors but also on the analyses of the perception of the problem

by the public. This can differ from region to region and population specific situations (Hegglin *et al.*, 2008). According to a mathematical modelling, vaccination of intermediate host coupled with dosing definitive host with anthelminths is the most effective method for intervening with infection rates, (Moro and Schnatz, 2009). Boiling contaminated organs or veseral for 30 minutes has been proposed as a simple efficient and energy and time saving way to kill the inactions larvae (Li *et al*., 2014). Other preventive majors include: - proper education on hygiene, dietary regulation of pet dogs (stop habit of feeding viscera of intermediate host dogs. Regulate pet dog activity to prevent scavenging on abattoir waste and regulate livestock butchering by avoiding home slaughter.

In summary, the control programmes against cystic echinococcosis have traditionally relied on anti-helmethic dosing of dogs, improved slaughter hygiene and surveillance, and health education relating to human – dog behaviour (Cabrera *et al.*, 1996; Kachani *et al.*; 2003; Eckert and Deplazes, 2004). In principal therefore, *Echinococcus* vaccine would ideally prevent oncosphere development to hydatid cysts in sheep and other intermediate hosts, and thus stop the development of adult gravid tapeworms in dogs which are the definitive hosts (Lightowlers *et al.*, 2004; Zhang *et al.*, 2003). A defined recombinant vaccine (EG95) for ovine CE was developed in 1996 by the groups of Marshall Lightowler and David Heath in Australia and New Zealand. Field trails in Australia, New Zealand, Argentina, Italy and China in 8 to 10 years demonstrated more than 95% protection of at least 12 months in sheep (with colostral transfer of immunity) following two injections (Dempster and Harrison, 1995). Since EG95 vaccine against ovine hydatidosis is a reality, such a vaccine is require for dogs. Hydatidosis is a disease

that can be eradicated, but numerous factors are involved in the maintenance of the transmission cycle including behavioural and cultural factors that are often difficult to regulate or modify (Dakkak, 2010).

2.10 Signs and symptoms of hydatidosis

Infection with echinococcosis leads to the development of one or more hydatid cyst located mainly in the liver and lungs and less frequently in the kidneys, spleen, muscles etc (Dandan, 2014). The parasite load, the site and the size of the cysts determine the degree of symptoms. The asymptomatic incubation period of the disease can last many years until hydatid cysts grow to an extent that triggers clinical signs, (Dandan *et al.*, 2014*;* Elsebaise, 2006).

The non-specific symptoms of hydatidosis may include; non specific pain, cough, and low grade fever, sensation of abdominal fullness, anorexia, weight loss and weakness. Other signs depend on the location of the hydatid cyst and the pressure exerted on the surrounding tissues. Abdominal pain, nausea and vomiting are commonly experienced when hydatid cyst occurs in the liver. When the lung is affected; clinical signs may include chronic cough, chest pain and shortness of breath (WHO, 2014).

2.11 Economic importance of hydatidosis

Echinococcosis is of great economic importance both in human and livestock. In terms of monetary losses and disability adjusted life years (DALYS) is about $ 763,980,979 annually when under reported cases are considered (Budke *et al.*, 2006). The disease is of major public health and veterinary importance.

In livestock, it results in death, decrease meat and milk and fleece production. It also results in condemnation of infected organs in slaughter houses resulting in great economic losses (Jenkins *et al.,* 2005; Whahler *et al.,* 2012). Human hydatidosis has many important effects such as reduce or complete loss of income during illness, cost of treatment and convalescent period, economic and social losses associated with undiagnosed and untreated cases (Budke *et al.,* 2006; Torgerson and Budke 2003). In severe infection, the parasite may cause retarded performance and growth and reduced quality and yield of meat and milk (Getaw *et al.*, 2010). For instance, in Yugoslavia, a 10% reduction in milk yield and 5% in carcass weight due to hydatidosis has been described (Torgerson, 2003; SarIozkan and Yalcin, 2009) while in human site affects estimated 2-3 million people and results to an annual monetary loss of over $ 759,000 world index (Bristow *et al.,* 2012).

In Africa, the disease is widespread posing great challenges in most countries that practice large scale life stock farming (Omer *et al.,* 2010; Huttner *et al.,* 2009; Romig *et al.*, 2011). The cost of treatment in humans and animal losses in North African countries was estimated to be US $ 60 million per year, (Budke *et al.* 2006; Moro and Schantz, 2009). In Uruguay, the annual losses were estimated at US$ 6.2 million from the organs seizure and the loss of livestock productions (Torgerson *et al.,* 2000). In Queensland Australia, hydatid disease was thought to cost the meat industry, conservatively about US$2.7 million annually through lost from offal sale (McManus and Thompson, 2003). In Ethiopia an economic lost of 1.791, 925.89 Ethopian birr was encountered in 2000. In Maiduguri Nigeria, in 2006 a loss of N93,800.00 was encountered due to organ

condemnation of cattle liver and an estimated global lost of US $ 2billion in 2006 rising to 3 billion in 2016 (Regessa *et al.,* 2009; Biu *et al.,*2006; WHO, 2014).

2.12 Persistence, emergence or re-emergence of echinococcosis

Several factors associated with persistence, emergence or re-emergence of Echinococcosis has been described especially in the Miditterranian region (Batteli *et al.,* 2002; Jenkins and Romig, 2000). They include; the presence of large numbers of dog's i.e stray dogs infected with *Echinococcus*, easy access of dogs to organs of livestock infected with the cyst, insufficient facilities for slaughter and destruction of infected vesera, illegal or uninspected home slaughter, close association of dogs and other animals on small rural lots of land, uncontrolled animal movements within and between countries, poor living condition especially lack of social amenities like tap water, lack of adequate health education and economic instability and financial restriction in control and prevention (Eckert and Deplazes, 2004).

For example in Central Asian countries, the re-emergence of echinococcosis is clearly associated with the transition from a planned to a free-market economy since their independence from the former Soviet Union and its several consequences such as a decline of the economy and living standards, deterioration of veterinary and medical services owing to the lack of adequate funding and reforms in agriculture with increase of smaller livestock enterprises, uncontrolled slaughter and offal disposal (Stieger *et al*., 2002; Torgerson *et al*., 2003; Torgerson *et al*., 2002).

A lot of documented evidence for emergence or re-emergence of *Echinococcus* in several countries exists. In Bugaria for example, the annual incidence in children increased from

0.7 per 100,000 in 197–1982 to 5.4 in 1995 (Todorov and Boeva, 1999; Mehmet and Ender, 2015). In Kazakhtan, there was an increase from below 1,4 per 100,000 in 1988 – 1995 but 2.5 in 1997 and 5.9 in 2000 (Shaikenov and Torgerson, 2004; Torgerson *et al*., 2002).

Still in Kazakhstan, the prevalence was 13.6% in 5,968 sheep prior to independence and 37.0% in 5,968 sheep prior to independence and 37.0% in 917 sheep in 1999 – 2000 (Torgerson *et al*., 2002; Torgerson, 2003). Similarly in Kyrgystan the incidence per 100,000 increased from 5.4 cases in 1991 to 18 in 2000 that is about threefold increase (Torgerson *et al*., 2002). These data and many others from other countries provide strong evidence for a real increase or re-emergence of the incidences and prevalences in recent years, which are not attributable to improved diagnosis or reporting (Eckert and Deplazes, 2004).

2.13 Epidemiology of echinococcosis

Echinococcosis has a worldwide geographical distribution with endemic foci on every continent with greatest prevalence found in countries of temperate zones including several parts of the mediterranean zones including several parts of the mediterranean region, southern and central parts of Russia, central Asia and China. It's also endemic in Australia, some parts of America and North and East Africa (Grosso *et al.,* 2012).

2.13.1 America

The most common taxa of *Echinococcus* in North America are the cervid strain (G8) and the sheep strain (G1) cystic echinococcus was first diagnosed in Canada in 1950s in some tribes of native American such as Indians and Eskimo who were identified with

pulmonary hydatidosis (Webster and Carmena, 1967). In a review of 101 indigenous case of infection in Alaska it was estimated that 5% of moose in Ontario and British Columbia were infected with *Echinococcus* and 28% - 50% dogs in the Canadian territories were also infected (Lamy *et al.,* 1993; Moore *et al.,* 1994). In Alberta 22 definite cases of hydatidosis were documented in which 77% were females; 40% had pulmonary involvement and 50% hepatic involvement (Somily *et al.,* 2005).

The prevalence of hydatidosis in livestock in central Peruvian Arides is 89% in sheep and 80% in cattle in a livestock raising community (Moro *et al.,* 1997). While in dogs in endemic areas at ranges from 32%-44% and 46-88% (Moro *et al.,* 1999; Lopera *et al.,* 2003). A recorded surgical incidence of 1-2 cases per 100,000 and prevalence of asymptomatic cases between 3-9.3% in rural villages in central Peruvian highlands (Moro *et al.,* 1999). In 2000, there was a decrease in prevalence of bovine, sheep and canine hydatidosis in Chile for the entire century to 22.3%, 6.3 and 11% respectively after a control programme (PHO, 2004; Alvarez *et al.,* 2005; Serra *et al.,* 1996). For the southern part of Chile which is the major endemic area in Chile an annual surgical incidence range of 6-20 cases per 100,000 in August 2005 was reported and 162 per 100,000 in some regions (Apt *et al.,* 2000). The prevalence of cystic Echinococcus was found to be 7%, 12.5%, 9.8% and 6.0% in cattle, sheep, pigs and goats respectively in Argentina (Eckert *et al.,* 2001), while in humans, prevalence depends on the endemicity of the area ranging from 1.4 per 100,000 to 404,260 and 30 cases per 100,000 in Neuquen, Chubut and Rio Negro respectively (PHO,2004). A careful study of the prevalence of hydatidosis in Brazil in animals showed prevalence of 25.5% in cattle, 30.2% in sheep and from 11.4 to 38% in dogs and a seroprevalence of 6% in rural population and 3.5% in urban

population of humans in SeriaMadureira (Pastore *et al.,* 2003). The few data available to allow for conclusion of epidemiology in the American continent depend on control activities that are inconsistent deliberation of the economic and public health impact of echinococcosis in these areas (Grosso *et al*., 2012).

2.13.2 Western and Central Asia

The most common genetic variant in Iran is the G2 which infects sheep, goat, cattle and camels and the G6 strain has also been found in camels, sheep and cattle in the same area (Harandi *et al.,* 2003). In Kazaskstan, the prevalence of infection in sheep ranges for 20-25% in one year old sheep and 74-8% in 6 years old sheep. Among wild and village dogs infection rate is 23% and 6% respectively (Shaikenov and Torgerson, 2004). Human infection increased from 200 cases in 1990s to 1000 cases per year in recent time (Torgerson *et al.,* 2000; Torgerson *et al.,* 2002).

In Turkey, hydatidosis is a serious public health problem. The G1 strain is the predominant. Infection rate in dogs ranges between 0.32% in sheep, 13.3% to 35.08% in cattle (44.31% in cows and 24.39% in bulls) and 22.7% in goats (Umar *et al.,* 2003; Yildiz *et al.,* 2005*;* Kose *et al.,* 2008; Ogar *et al*., 2008). In Syria, a range of 9% and 15% occurred in dogs and between 5%-17% in livestock, in Israel, 5.4% to 14.2% in dogs, and 4.56%-10% in sheep and Palestine ranging between 7.9% and 14.3% in dogs (Seimenis *et al*., 2003; Shimshony, 1997; Furth, 1989; Abdel-Hafez *et al.,* 1997). Human infection rates were recorded as 1.76 per 100,000 in Jerusalem, 3.1 per 100,000 in Palestine and West Bank with highest rate of 4.9, 5.0 and 5.1 per 100,000 inhabitants found in Hebron, Iencho and Bethlehem respectively (Abdel-Hafez *et al.,* 1997; Abu-Hasan, 2002).

2.13.3 China

The sheep strain (G1) and the camel strain G6 are the only two strains of *Echinococcus* found in China (Bart *et al.,* 2006). The most endemic areas for *Echinococcus* species are the Western Xinjiang, Ninjxia, and linear Mongolia, with the highest prevalence occurring in the pastoral communities (Tiaoying *et al.,* 2005).

High prevalence of hydatid infection has been reported in sheep (99%), cattle (88%) and pigs (70%) (Grosso *et al.,* 2012). The domestic dog is considered the most important definitive host transmitting infection to humans as they are kept in large populations in northwestern China for pastoralism and cultural reasons (Tiaoying *et al.,* 2005). Cystic Echinococcosis in human was first reported in China. How the 21,560 cases in Xinjiang alone with a prevalence of 80 cases/100,000 inhabitants show that there has been an underestimation in the past years (Chi *et al.,* 1990*;* Ito *et al.,* 1999; Grosso *et al.,* 2012).

In female, infection rate is higher than males because of their role in the home activities which include feeding dogs, collecting yak dung for fuel and milking livestock (Tiaoying *et al.,* 2005; Wang *et al.,* 2013). The most important risk factors for cystic Echinococcosis is nomadic or seminomadic pastoral lifestyle (Grosso *et al.,* 2012). Due to the increase in number of diagnosed cases China is now recognized as a new focus for Echinococcosis research.

2.13.4 Australia

The most common strain currently found in Australia is the G1 (the sheep strain) and several areas have been documented at high risk of transmission (Pearson *et al.,* 2002; MCmanus *et al.,* 2003; Jenkin *et al*., 2005). The wild dog is the most common definitive

host while grey kangaroos and wallabies are the most common intermediate host (Grainger *et al.,* 1996*;* Jenkins *et al.,* 2003). Thus, wild life reservoirs play a main role in maintaining a constant source of transmission for domestic livestock, domestic dogs and humans (Grainger *et al.,* 1996*;* Jenkins *et al.,* 2003).

Sheep infection is still common in farms with a high number of poorly managed domestic dogs; additionally livestock are often hunted by wild dogs thus contaminating the pasture with eggs of the parasite even though dog sheep infection prevalence seems to be decreasing in the past years (Grosso *et al.,* 2012). A re-emergence of domestic transmission in some rural areas of south eastern regions occurred with 29% of 344 rural dogs and 18% of 218 victonan dogs tested positive (Jenkins *et al.,* 2006; Jenkins *et al.,* 2008).

Human hydatidosis appears stable in the whole country between 80 and 100 cases. Though human transmission has been a public health problem of rural people, there is increasing potentials for accidental exposure of urban residents due to the infiltration in urban centres by infected wildlife definitive host such as foxes and wild dogs. Assessment of accurate prevalence and incidence, as well as trend changes overtime is still very difficult because the report of hydatidosis does not depend on any monitoring system but only on individual cases.

2.13.5 Europe and the Mediterranean Basin

Cystic *Echinococcus* is a problem in all the Mediterranean regions with the exception of Malta and the area controlled by the government in southern Cyprus (Grosso *et al.,* 2012). In Cyprus cystic Echinococcosis had an annual surgical incidence rate of 12.9 per

100,000 inhabitants but after the 1st and 2nd eradication programs implemented in the 1990s, infection rate reduced from 1.95% in dogs examined in 1998-1999 to 0.012% in 2000-2003, from 23.58% to 6.61% in cattle, from 5.31 to 1.53% in sheep and those who maintained the control programme are able to keep the levels at virtually 0% (Bardonnet *et al.,* 2003).

In Europe, the most endemic areas have been documented to be the Mediterranean regions where annual incidence rates for human is 4-8 per 100,000 for countries like Bulgaria (Eckert *et al.,* 2001). In Serbia and Montenegro the most frequent intermediate hosts are pigs with an infection range of 4.6% and 57.6% (Ivanovic and Parolvic, 1999). Although no published data exist for human infection and the exact incidence of cystic *Echinococcus* in livestock, carnivores and humans (Guska *et al.,* 2007).

In Greece, investigation in sheep and goats in peloponesus shared that sheep were infected with G1 strain and G3 (buffalo) strain while goats harboured the G7 (pig) strain (Varcasia *et al.,* 2007). The prevalence in farm animals between mid 1980s to mid 1990s was between 82% and 56.6% in cattle, 80% and 100% in sheep, 24% and 15.4% in goats and 5% and 9.3% in pigs while in human, surgical cases were 12.9 per 100,000 inhabitants in 1984 and up to 29% in 1999 (Sotiraki *et al.,* 2003). Similarly, in 1998 a prevalence of 31.3% in sheep, 10.3% in goats, 0.6% in pigs and 0% in cattle was recorded. In a survey on sheep in Central Greece from 2002 to 2006 an incidence rate of 39.3% was recorded (Christodulopoulos *et al.,* 2008).

In humans, an overall incidence rate was estimated to increase from 9.77 per 100,000 in 1967 to 10.59 per 100,000 in 1983 (Matsaniotis *et al.,* 1983; Papadopoulos, 1985).

Incidence rates steadily reduced in 2007 to 0.122 per 100,000 inhabitants (World Animal Health Information data base, 2007). Grosso *et al.,* 2012 reported that no published data is available but personal communication with surgeons gave an estimate of about 800 cases of cystic Echinococcosis diagnosed yearly.

In the United Kingdom a recent re-emergence of *E. granulosus* in Wales has been reported noting a rise in prevalence in rural dogs between 1989 and 2002 of 3.4% to 8.1% (Buishi *et al.,* 2005). In Spain, the G1, G7 (pig strain) and G4 equine strain are the most common strains that infect cattle, sheep, goats, pigs and horses. 8% infection rate in Alara was documented for the dog definitive host and 15% in Iberian wolves (Daniel *et al.,* 2004; Benito *et al.,* 2006).

In Laroja region, the overall prevalence of 20.3% in adult sheep and up to 23% in sheep and cattle in the north western, central and western parts of the country was reported (Jimenez *et al.,* 2002). Pardo *et al.* (2005), reported an incidence of 10.8 per 100,000 inhabitants between 1980s and 2,000 while Jimenez *et al.* (2002) report a decrease from 19 to 4 cases per 100,000 inhabitants in Lajora region and in the rest of the country prevalence ranges between 1.1 and 3.4 cases per 100,000 inhabitants (Pardo *et al.,* 2005). A survey in 1990s in France showed a prevalence of 2.5% in livestock and less than 0.28 per 100,000 in humans (Bichet and Dorchies 1998). In recent years, the European Centre for Disease prevention and Control reported 17 human cases in 2005.

The G1 (sheep), G2 (Tasmanian sheep), G3 (buffalo), G4 (horse) and G7(pig) strain are the mot common strains found in livestock of several regions of Italy where the prevalence rate of infection in sheep has been reported to be 5-28% in Basilicata, 22% in

abnizzo and 47% in Tuscany (Garippa *et al.,* 2004). In Sicily, infection rate was found to be 67.1% in cattle, 11.13%-57.6% of sheep and 5.6%-19% of shepherd dogs (Poglayan *et al.,* 2003*;* Giannetto *et al.,* 2004).

In Sardinia a prevalence of 70-92.8% in sheep, 9.4% in cattle, 9.4-11.1% in pigs and 1% of horses and 3%-19% of dogs (Garippa *et al.,* 2004; Scala *et al.,* 2006; Varcasia *et al.,* 2004).

In central Italy, prevalence values usually ranges from 20.2% to 47%-81% in sheep, from 7.34%-15.3% in cattle, 71.9% in goats and 0.82% in pigs (Bio *et al.,* 2004; Fioretti *et al.,* 2004). Garippa, (2006) reported prevalence of 20.2% and 15.3% in sheep and cattle respectively in Abruzzo. On the other hand, prevalence was low for several animals in Emilia Romagna: 0.39-0.54% in cattle, 0.30% in sheep, 0.39% in goats, 0.34% in horses and 0.95 per million in pigs, (Faggioli *et al.,* 2001). Regardless of all these findings, the national occurrence of cystic Echinococcosis in farm animals can be considered low with prevalence of 0.52% in cattle, 1.30% in sheep, 0.6% in horses, (Garripa *et al*., 2005; EFSA, 2006). The incidence of human hydatidosis is 1.3 cases per 100,000 inhabitants with maximum case of 4-8 in 100,000 inhabitants in Sardina (Pozio, 2008). Annual mean incidence rate of surgical cases have been reported to be 6.6-10.6 per 100,000 inhabitants in Sardinia (Gabriele *et al.,* 2004; Conchedda *et al.,* 2008), 1.57-5.6 in Emilia Romagna, 1.22 in Lombardia, 2.30 in Sicily, 2.22 Apulia, 1.76 besilicata and 0.46 in Campania (Gabriele *et al.,* 2004). In this region, risk factors for infection are now considered to be widespread due to use of extensive or semi extensive sheep form illegal slaughtering and high members of sheep, dogs and other type of dogs.

2.13.6 Africa

Several taxa of *Echinococcus* exist in Africa even though most regions of Africa have limited information (Macpherson and Wuchira, 1997; Ibrahem and Craig 1998). The sheep strain (G1) and camel strain (G6) are the common strains in Africa but not much is documented on *Echinococcus* and wild life. Buishi *et al.,* (2005) reported a prevalence of 25.8% in stray dogs and 21% in own dogs in Libya while Ben Musa and Sadek, (2007) reported a prevalence of 58% in the same area. In Africa, several animals especially camels are frequently infected with *Echinococcus* (Kassen and Godoura, 2006) while infection rates in livestock varied from 1.7% to 33.4 in sheep, 1.0% to 13.9% in cattle, 1.4% to 40.0% in camels and 0% to 18% in goats (Al-Khalidi, 1998).

Currently there is low endemicity in Egypt with a mean prevalence in dogs ranging between 3.2% in urban areas and 6% in rural areas (Grosso *et al.*, 2012*; El* Shazly *et al*., 2007). Higher prevalence occurred in Cairo with about 15% of dogs infected and an overall prevalence of 0.3% in sheep and goats, 0.68% in pigs, 6.4% in cars and buffalos, 2.53% in camels and 10.62% in donkeys (Haridy *et al.,* 2006, 2008). In humans, a retrospective hospital study showed an annual surgical incidence ranging between 1.34 and 2.60 per 100,000 inhabitants (Kandeel *et al.,* 2004).

In a series of studies carried out in Tunisia between 1999 and 2007 prevalence of infection was 10.41% in lambs (6-12 month), 72.42% in sheep aged 1-2years and 83.83 – 100% in sheep over 2 years (Lahmar *et al.,* 2004) while in Algeria, prevalence of 24.8% was recorded in camels, 13.9% in cattle and 6.0% in horses (Bardonnet *et al.,* 2003). Infection rate in dogs ranges from 22.0% to 62.8% in Morocco. In a more recent study prevalence of cystic Echinococcus revealed 10.58% in sheep, 1.88% in goats, 22.98% in

cattle, 12.03% in camels and 17.80% in equines, mostly in Middle Atlas (48.72% in cattle) and in North west (37.61% in cattle and 31.65% in sheep) (Azlaf and Dakkak., 2006). In humans, an animal rate of 4.55 surgical cases per 100,000 inhabitants was reported in 2006.

In Nigeria, there is dearth of information on the epidemiology of hydatisosis especially with respect to species and strain characterization. Although a few researchers have tried to establish the existence of hydatidosis in Nigeria like in other African countries. For instance in Sokoto, Abdullahi *et al.* (2002) reported a prevalence of 42% in camels slaughtered at the abattoir, 39.14% among young and 42.37% in older ones. Dada, (1980) reported prevalence of 1.2% in dogs and 7.1% in sheep, 18.4% in goats, 1.5% in cattle, 70.9% in camel and pigs 5%. Infection of dogs with *Echinococcus* was reported for the first time in Kano in 1979 of which 6.21% of dogs harboured the infection. An abattoir based study was conducted by Abdullahi *et al.,* (2011) in Sokoto for the incidence of hydatid cyst in food animals an incidence of 0.07% in cattle, 8.9% in camels, 0.14 % in sheep and 0.03% in goats was reported. Also in a prevalence report by Okalugbo *et al.* (2013) in Sokoto a prevalence of 44.4% in camel and 1.8% in cattle was documented. Similarly, Luka *et al.,* (2009) conducted a survey on prevalence in sheep and reported a prevalence of 36.2% in Kano State. In Damaturu Yobe state, Tijjani*et al.* (2010) in a short communication reported a 0.01% prevalence in sheep and Dada and Belino, (1979) conducted prevalence study on sheep and reported 18.9% while in Maiduguri Maiduguri State, Ajogi and Adamu (1998) reported a prevalence of 2.0% in dry and 2.1% in rainy seasons in a post-mortem examination of clinically healthy camels at slaughter.

Little has been documented on the prevalence of echinococcosis in camels and cattle in Nigeria especially in Maiduguri, Maiduguri State and Gashua, Yobe State thus the need for proper documentation on the state of hydatidosis in these areas.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

The study was carried out in Maiduguri abattoir, Borno State and Gashua abattoir in Yobe State. Maiduguri is the capital and largest city of Borno State in north eastern Nigeria. The city sits along the seasonal Ngadda River which runs into Firki swamps in the areas around Lake Chad. Maiduguri was founded in 1907 as a military outpost by the British. It is situated at latitude 11^{o}84'N and longitude 13^{o}.16'E (Fig 3), (World Atlas.com, 2015). Maiduguri covers an area of 27,374 and with a population of 5.926 million in 2006. The climate is divided into 3 seasons: cool dry harmattan (October-March) hot dry season (April-June) and rainy season (July-September).

The annual rainfall is estimated to be less than 500mm in extreme north around Lake Chad and lasts less than 80 days and 800mm on the Biu Plateau lasting about 140 days (i.e extreme south). The Sahel and the Sudan savannah are the two vegetation types identified in the state, the vegetation consist mainly of open acacia trees in the northern part while in the wet southern part, shrub is interspace with tall trees and woodland *(northernnigeria tourism.com)*.

The Maiduguri abattoir is situated close to the cattle market called Kasuwan shanu. The abattoir is fenced with two large slaughter halls for cattle and small ruminants (goats and sheep). There are also two large slaughter slabs with pillars used for camels with poor drainage system. There are offices for staff and the chief veterinarian. The wastes from the offals are emptied very close to the slaughter halls and slabs. During sampling, many

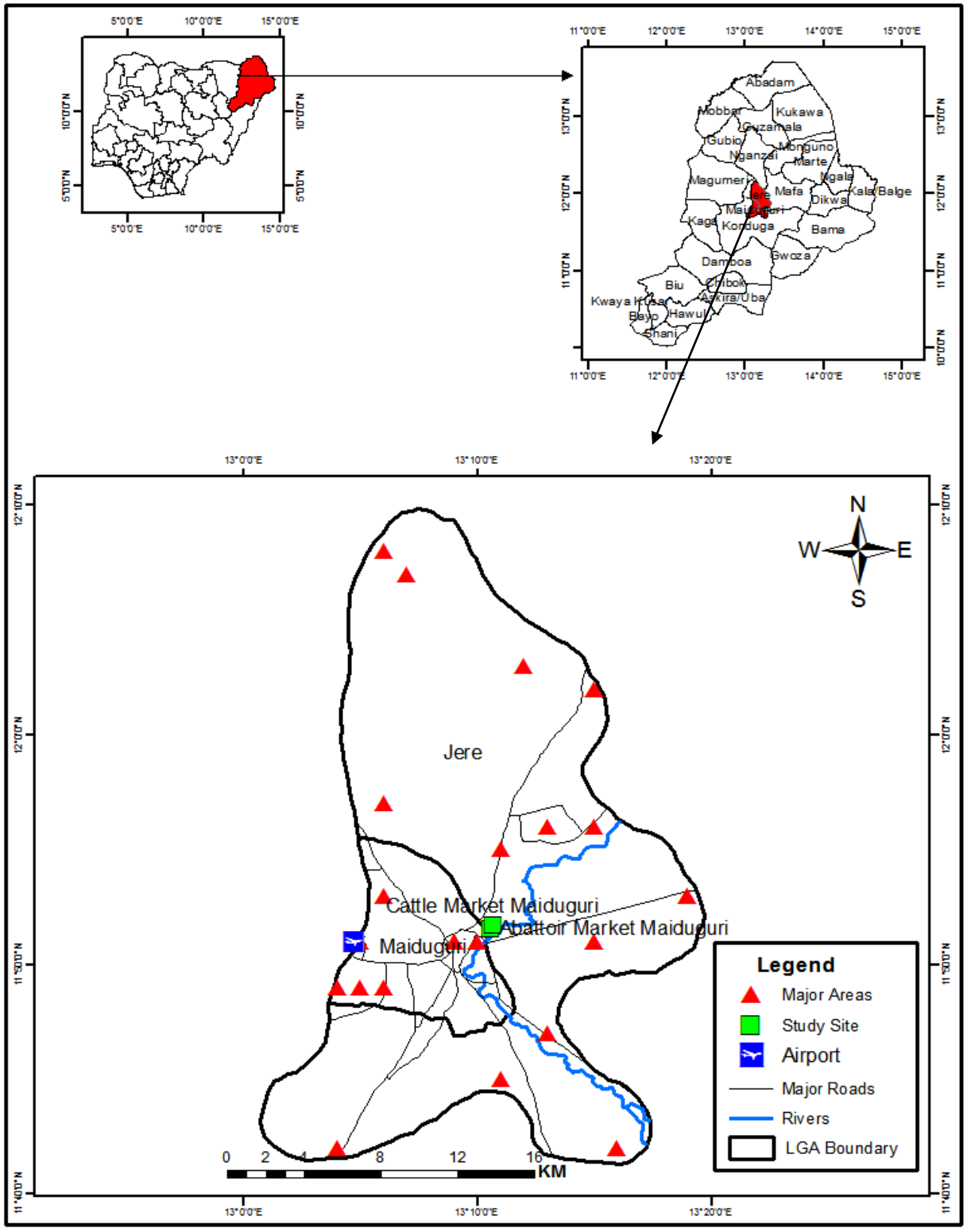


Figure 3: Map of Maiduguri (sampling site)
Source: Adopted and modified from the administrative map of Borno State, 2017

stray dogs (some of which are hunting dogs belonging to hunters at the kasuwan shanu) were seen scavenging on the waste. When cattle from neighbouring villages and camels mainly from Chad republic and Niger are brought for slaughter, they are taken to the kasuwan shanu where they are sold before they are brought into the abattoir (Plate 1).

Gashua is in Bade Local Government Area of Yobe State on latitude 12^{o} 52'5"N and longitude 11^{o}2'47"E (Fig 4). It is one of the largest and most developed towns in Yobe State (Gashua Sunday Tribune, 13, Sept. 2009). It is on the Yobe River a few miles below the convergence of the Hadeja River and the Jama'are River. The population in 2006 was about 125,000. The hottest months are March and April with temperature ranges of 38-40^{o}C. In the rainy season June to September, temperature falls to 23-28^{o}C with rainfall of 500-1000mm *(www.northernnigeriatourism.com).*

The Gashua abattoir is fenced with two slaughter halls one used for cattle and camels and the second one for small ruminants. There is also a fence hall behind the abattoir where wastes from offals are emptied, skin and hide are treated and bones burned. The abattoir is not close to the animal market so there is another hall outside the abattoir where camels and cattle are kept when bought before taking them into the abattoir. The abattoir is situated near the state veterinary clinic and the state veterinary office so it does not have offices for the veterinarians. The cattle are brought for slaughter from the neighbouring villages and camels are from Niger Republic.

3.2 Study Population

The study population were camels and cattle presented for slaughter in Maiduguri and Gashua abattoirs.

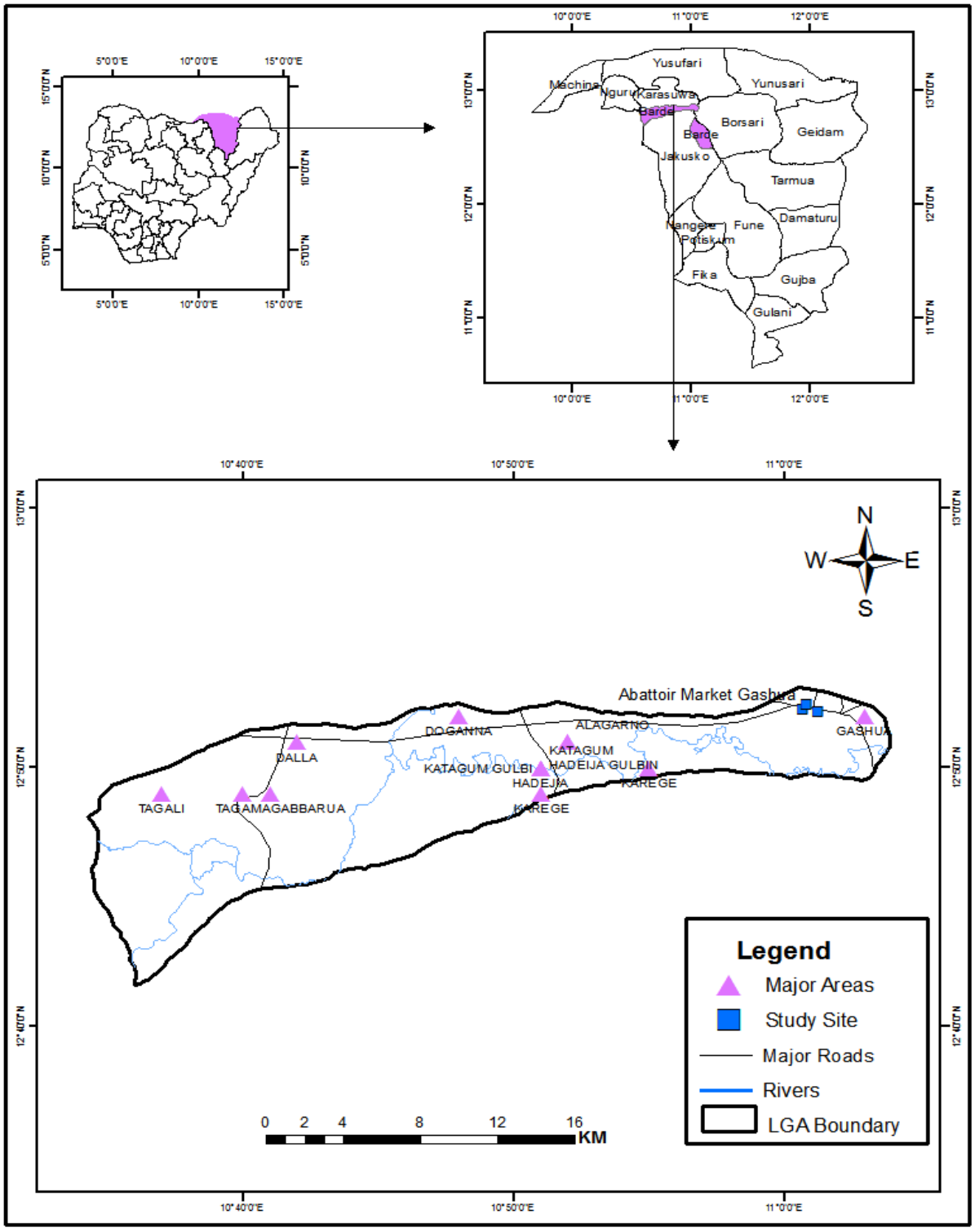


Figure 4: Map of Gashua (sampling site)
Source: Adopted and modified from the administrative map of Yobe State, 2017

Plate I: Camels being herded to the abattoir for slaughter from the Cattle market at Maiduguri

3.3 Sample Size

Sample size was calculated using the formula:-

$N = \frac{Z^2 pq}{L^2}$ (Kreycie and Morgan, 1970; Sarmukaddan and Gerald, 2006)

Where N=sample size required

Z=Standard Normal Distribution at 95% confidence interval = 1.96

P=prevalence = 22.65% (0.23) for camels from Abubakar *et al.* (2009) in Sokoto and 23.1% (0.23) from Luka *et al.* (2010) in Kano.

q=1-p, substituting; q= 1-0.23=0.77

L=allowable error = 5% or 0.05

The prevalence from Abubakar *et al.* (2009) in Sokoto and Luka *et al.* (2010) in Kano were used due to lack of data on cattle and camel in the study area.

Substituting the values $n = \frac{(1.96)^2 x 0.23 x 0.77}{(0.05)^2}$

$= \frac{3.84 x 0.18}{0.0025}$

$= 272.14$

$= 272$ (For camels)

$n = \frac{(1.96)^2 x 0.23 x 0.77}{(0.05)^2}$

$= \frac{3.84 x 0.18}{0.0025}$

$= 272.14$

$= 272$ for cattle

Total number of samples/state = 272+272 = 544

Total number of samples estimated for the study was 544 x 2 = 1088 samples (544) camels and 544 cattle.

But a total of 805 comprising of 160 camels and 85 cattle from Gashua and 304 camels and 256 cattle from Maiduguri were collected due to unavailability and access of animals for sampling in Gashua.

3.4 Study Design

Permission for the study was obtained from the veterinary doctors in charge of the abattoir in Maiduguri and Gashua in Borno and Yobe States respectively. Random sampling method was used for the collection of the samples. Information on the source of animals, the estimated age and sex of the animals (based on information from veterinary doctors and other abattoir staff: camels $\geq$ 8 years considered as adult $<$ 8 years young, cattle $>$ 2 years, adults $\leq$ 2 years young), presence or absence of cyst, location of cyst and the number of cyst recovered per organ were recorded.

In Maiduguri abattoir, sampling begins as early as 6am during which an average number of 40 camels and 50 cattle were slaughtered daily. A maximum of 30 samples were randomly collected. Tacky labels were numbered serially and placed randomly on the pillars where camels are tied for slaughter before the camels are brought in. For the cattle, the random numbers were placed on the walls of the hall at each slaughter point.

In Gashua, sampling starts between 7.00am-7:30am and an average of 7 camels and 5 cattles were slaughtered daily and all the slaughtered animals were sample.

3.5 Collection of Samples

3.5.1 Collection of hydatid cyst

Gross examination of the lungs, liver, heart and kidneys, by palpation, was done at slaughter to determine positive cases for hydatidosis. Cysts detected were carefully removed from the infected organs, labelled and kept in clean plastic containers, which were covered and transported on ice to the Parasitology Laboratory, Department of Zoology, Ahmadu Bello University for processing (Plate II A & B).

3.5.2 Collection of blood samples

Blood was collected from cattle and camels at slaughter into 10mls plain vacutainers, tubes, placed in a slanting position and taken to the virology laboratory, at University of Maiduguri and the Parasitology laboratory in the Teaching Hospital where the blood samples were spined in a centrifuge and the serum simples were transferred into labelled cryogenic tubes and stored in a deep freezer at -20^{o}C until required. In Gashua, the blood samples were taken to the laboratory in the veterinary office and treated as stated above. Sampling was done between 6 -9am each day during the months of September – November 2012 in Maiduguri and April – July, 2013 in Gashua (Plate IIC).

3.6 Hydatid Cysts Characterization

In the Parasitology laboratory, Department of Zoology, Ahmadu Bello University, Zaria, the cysts were weighed using a digital weighing balance and measured with a pair of Vanier calliper to determine the weights and the sizes. Cysts were classified into 3 groups: diameter less than 5cm were recorded as small, between 5-10cm medium and above 10cm large (Oosburg *et al.,* 2000; Ogunsan *et al*., 2000).

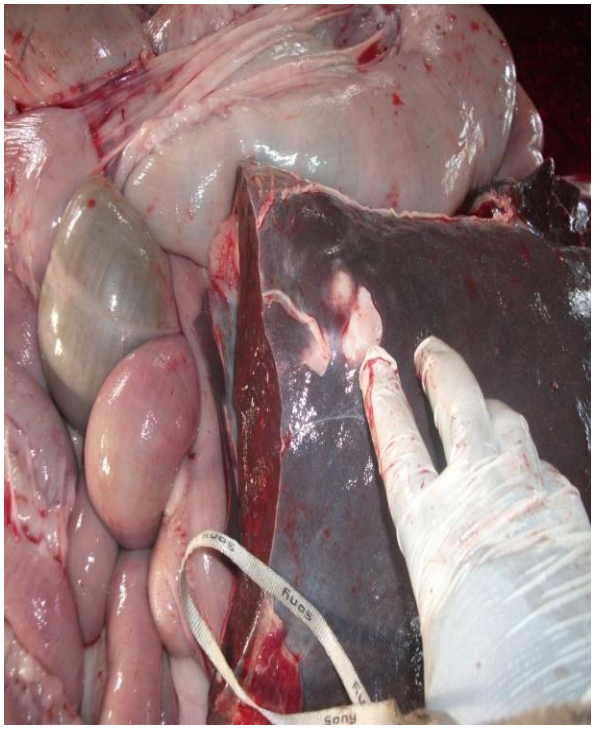
The hydatid cyst fluid was aseptically aspirated using 5ml syringe and transferred into 50ml measuring cylinder and the volume recorded. The cysts were carefully incised to examine if they were fertile (characterized by presence of daughter cyst or protoscolices which are whitish dots on the germinal epithelium) or infertile (which was either sterile characterized by smooth inner lining or calcified characterized by a gritty sound feeling upon incision) (Soulsby, 1986; Kebede *et al.,* 2009).

3.7 Immulogical Study

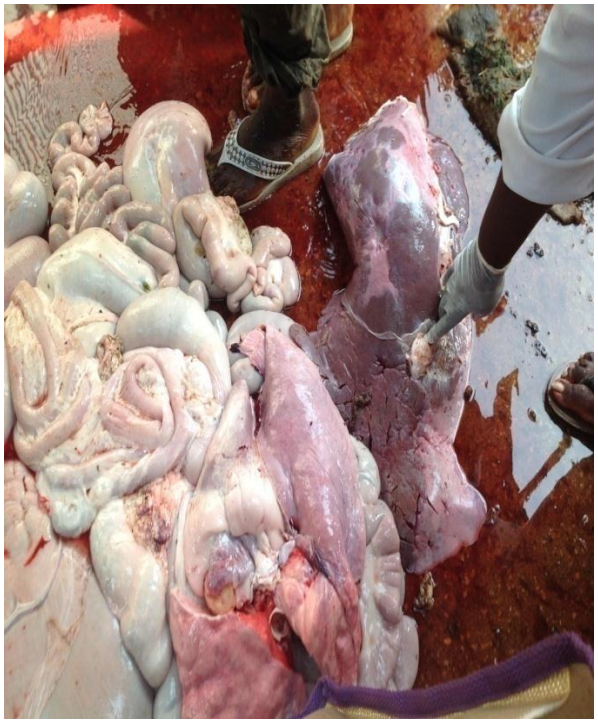
3.7.1 Antigen purification

Hydatid cyst fluid (HCF) antigen was processed according to the methods of Oriol *et al.* (1971) and Gasser *et al.* (1989), in order to obtain fractions with the subunits of the main antigen. The HCF was aspirated aseptically using 5ml syringe from the cysts, pooled and centrifuged at 1,500 rpm for 15 minutes at 4^{o}C using the labofuge 300 Heraeus Centrifuge at the molecular parasitology laboratory at National Veterinary Research Institute (NVRI) Vom., the supernatant was dispensed into universal bottles and stored at -20^{o}c until required.

200ml of the supernatant was dialysed over night at 4^{o}C over distilled water using a dialysis membrane (Sigma Lot106H0874 which was washed in running tap water for 4 hours and treated with sodium sulphide for 1min. It was washed in hot water at 60^{o}C for 2 mins, acidified with 0.2% sulphuric acid and rinsed in hot water to removed acid). 4ml of the dialysed HCF was dispensed into vials, frozen, and freeze-dried using the freeze drying machine at the Viral Vaccine Production Laboratory at NVRI, Vom, to concentrate the HCF antigen. The freeze- dried HCF was re-dissolved in Tris-buffered saline (TBS-pH 7.5) and centrifuged at 15000rpm for 30mins at 4^{o}C. The deposits were



A



B

C

Plate II: A and B – Visceral examination and collection of cyst; C - Blood collection for serum

collected and dissolved in 0.2m phosphate buffer pH 8.0 and centrifuged at 20000rpm for 30min. The clear supernatant containing the antigen was collected into sterile 1.5ml eppendorf tubes and stored at -20^{o} C until used, (Oriol *et al.,* 1971; Gasser *et al.,* 1989).

3.7.2 Sodium Dodecyl Sulphate Polyacrylamide Gel Electrophoresis (SDS-PAGE)

3.7.2.1 Sample preparation

Only the HCF from camels were used as only 4 of the cattle cyst were collected and only 1 had little fluid which was used up during preparation, while the remaining cysts were calcified.

Therefore, three set of samples were prepared for SDS-PAGE

i. Crude HCF pooled from various cysts
ii. Partially purified HCF (lyophilised HCF)
iii. Partially purified not lyophilised HCF

About 50µl of each sample was treated with 5µl sample buffer containing 12.5mM Tris HCL, 4% SDS, 29% β mecaptor ethanol 20% w/v Glycerol and heated in fish kettle for 5 min. The solutions were centrifuged at 14,000rpm for 10 min. 50µl of the treated samples were transferred into fresh eppendorf tubes, 50µl of sample buffer (Laemmli, 1970) consisting of 2% SDS, 4% β mecaptor ethanol, 10% w/v Glycerol and 50µl of 0.1% bromophenol blue dissolved in 0.62mm Tris HCL pH 6.8 were added as whole cell protein.

3.7.2.2 Electrophoreses

The samples were electrophoresed using a discontinuous gel system consisting of 4% stacking gel and 12% resolving gel. The resolving gel was cast and allowed to polymerise

for 1 hour. The gel was then over laid with saturated n-Butanol to remove the n-Butanol layer. The stacking gel was then cast on the resolving gel and the comb inserted and allowed to polymerise for 1hour. The comb was then removed and the wells were rinsed with distilled water.

Samples from the preparations were loaded, 30µl each into separate wells (approximately 10mg/ml as determined by protein assay per lane and separated in 0.75mm thick gel slabs in mini protein II dual slab gel (Biorad laboratories Rockville NY). Pre-stained molecular weight markers (invitrogen Inc) containing myosin 200kDa, B-galactosidase 120kDa, BSA 91kDa, glutamate 62kDa, albumin 46kDa, Carbonic anhydrase 38kDa, lysozyme 19kDa, apotinin 6kDa, insulin B3.5kDa and insulin A2.5kDa were included as reference proteins. The gels were loaded into the electrophoresis tank filled with buffer (Tris-HCL pH 8.3) and set up was connected to a power source.

The electrophoresis was carried out at constant voltage of 200 volts for 45 min until the tracking dye was approximately 1cm to the bottom of the gel. The set up was discontinued and the gel was fixed and stained in Coomassie blue R250 (Biorad laboratories) in 50% methanol and 10% acetic acid for 1hr. The gels were then destained in solution containing 50% methanol and 7% acetic acid to make the bands visible. Apparent molecular weight reference protein standards ran alongside the isolates and photographs were taken.

3.7.3 Enzyme Linked Immunosorbent Assay (ELISA)

The purified HCF antigen from camels was used as source of *Echinococcus* antigen in ELISA for the detection of IgG antibodies in sera of cattle and camels.

Microtitre plates were coated with the prepared antigen (HCF). Negative and positive control sera, sample buffer, wash buffer and stop solution were obtained from Diagnostic Automation, USA manufacturers of *Echinococcus* ELISA kit. The anti bovine IgG was obtained from Sigma and the anti camel IgG from Triple J Farms, USA.

The purified HCF antigen was removed from 20^{o}C, allowed to thaw and were diluted 1:100 in 0.05m phosphate buffer (pH 7.5). The microtitre plates (96 wells Limbro/Titerlek) were coated by adding 150µl per well of the diluted 1:100 HCF and incubated at 4^{o}C in a moist chamber over night. The plates were washed five times with deionized distilled water and frozen at -20^{o}C until used.

Plates were removed from -20^{o}C and allowed to thaw. Sera samples were then removed and allowed to thaw. The sera were diluted 1:64 with the sample buffer containing (phosphate buffer saline (PBS) and 1% bovine serum albumin (BSA) at pH 7.4 and loaded into the wells. The negative and positive control were loaded into well A1 and A2 respectively in each plates for both camel and cattle and 100µl of the diluted samples were loaded into the remaining 94 wells of each plates accordingly (Gasser *et al.* (1989). After loading, the plates were incubated for 10 minutes at room temperature. The wells were washed 3 times with PBS – Tween 20 and plates slapped face down vigorously on hand towels to removed air bubbles.

100µl of enzyme conjugate (anti camel IgG for camels sera and antibovine IgG for cattle) diluted 1:1000 in the sample buffer was added into the wells and incubated at room temperature for 5 minutes. The plates were again washed 3 times as earlier described to removed excess conjugates.

100µl of substrate (chromogen) was added into the wells and incubated at room temperature for 5 min for colour development. The reaction was then stopped using the stop solution from Diagnostic Automation. The absorbance was read using an ELISA reader at 450nm and the cut off was determined based on the manufacturers of negative and positive control. The optical density (OD) values less than 0.3 were considered negative while OD's greater or equal to 0.30 were considered positive.

3.8 Data Analysis

Data were entered into a Microsoft Excel spreadsheet. Odd ratios and Chi-square test were calculated to compare prevalence of hydatidosis across age and sex of the animal.

CHAPTER FOUR

4.0 RESULTS

4.1 Summary of cystic hydatidosis in Maiduguri and Gashua

Table 1 shows the summary of cystic hydatidosis in Maiduguri and Gashua abattoirs. Out of the total of 805 animals sampled 14% (111/805) were cystic positive. Maiduguri had an overall prevalence of 14.1% (79/560) while Gashua recorded an overall prevalence of 13.1%. The association between locality and infection of hydatidosis was not significant (OR = 1.42, 95% CI =0.92, 2.2, χ^2 = 2.20, P>0.05).

4.2 Prevalence of cystic hydatidosis with respect to age and location

Table 2 depicts the prevalence of cystic hydatidosis in respect to age according to location. In both Maiduguri and Gashua younger animals had lower prevalence of 5.7 % (6/106) and 6.9% (6/87) respectively. Adults had highest prevalence. Animals in Maiduguri had 16.1% (73/454) and that of Gashua had 16.5% (26/158) prevalence. The result showed an overall prevalence of 6.5% (12/193) for young animals and 16.2% (99/612) for adults. The association between age and infection according to location was significant (OR=3.38, 95% CI= 1.35, 7.60 χ^2= 6.90, P<0.05) and (OR= 2.7, 95% CI=1.1, 6.9, χ^2=3.71, P<0.05) for Maiduguri and Gashua respectively. Considering Maiduguri and Gashua together, OR value showed an association that was highly significant between age and infection (OR=2.9, 95% C.I=1.56, 5.4, χ^2=11.42, P=0.001).

Table 1: Overall prevalence of hydatid cyst in camels and cattle in Maiduguri and Gashua abattoirs

Location	Number examined	Number positive	Prevalence (%)	OR	CI	χ^2	P=value
Maiduguri	560	79	14.1				
				1.42	0.92,2.20	2.20	0.14^{ns}
Gashua	245	32	13.1				
Total	805	111	14				

Key: OR=Odd ratio

C.I= Confidence Interval at 95%

χ^2= Chisquare

ns = not significant association

Table 2: Prevalence of cystic hydatidosis in cattle and camels (combined) with respect to age and location

Location	Number examined	Number positive	Prevalence (%)	OR	CI	χ^2	P=value
Maiduguri							
Adult	454	73	16.1	3.4	1.35,7.60	6.90	P = 0.01[s]
Young	106	6	5.7				
Gashua							
Adult	158	26	16.5	2.7	1.0, 6.7	3.7	P = 0.03 [s]
Young	87	6	6.9				
Total							
Adult	612	99	16.2	2.9	1.5,5.4	11.4	P = 0.001 [ss]
Young	193	12	6.2				

ss = significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

4.2.1 Prevalence in respect to age and animal species in Maiduguri and Gashua abbatoirs

The prevalence of hydatid cyst in respect to age according to animal's species in Maiduguri and Gashua abattoirs is shown in Tables 3 and 4. The result shows that adult camels had 27.3% (69/253) prevalence and younger camels had 11.8 (6/51) while adult cattle had 1.9% (4/201) and younger ones recorded 0% (0/55) prevalence in Maiduguri. Odds ratio value showed association which was significant between age and infection in camels (OR=2.8, 95% C.I= 1.1, 6.9 χ^2 = 54.7, P<0.05) but there was no association between age and infection in cattle. The odds ratio value could not be determined due to the zero prevalence in young cattle (χ^2=0.19, P>0.05). In Gashua, adult camels recorded a prevalence of 22.5% (25/111) and young camels recorded 12.4% (6/49) while adult cattle had 2.1% (1/47) and younger cattle recorded 0% (0/38). Odds ratio value revealed association between infection and age in camels but the association was not significant (OR=2.1, 95%, C.I= 0.8, 3.5, χ^2 =1.69, P>0.05) while in cattle there was no association between age and infection. The odds ratio value could not be determined due to the zero prevalence in young cattle (χ^2= 0, P>0.05).

4.3 Prevalence of cystic hydatidosis with respect to sex and location

The prevalence of cystic hydatidosis in respect to sex according to location is presented in Table 5.The result shows that males in Maiduguri had prevalence of 17.8% (37/208) compared to males in Gashua which had 11.2% (11/98) while females in Gashua had prevalence slightly higher than females in Maiduguri 14.3% (21/147) and 12% (42/147). The overall prevalence showed that males had prevalence 15.7% (48/306) while females had a prevalence of 12.7% (63/498). The association between cystic hydatidosis with sex was statistically not significant for Maiduguri (OR=1.59, 95%C.I= 0.985, 2.573, χ^2=3.18, P=0.>05) and Gashua (OR=1.31, 95% C.I=0.61, 2.90, χ^2=0.25, P>0.05) with Maiduguri and Gashua combined, OR value showed association which was also not significant (OR=1.28, 95% C.I=.0.90, 1.93, χ^2=1.22, P>0.05).

Table 3: Prevalence of hydatidosis with respect to age of camels and cattle in Maiduguri abattoir

Animal Species	Number examined	Number positive	Prevalence (%)	OR	CI	χ^2	P- value
Camels							
Adult	253	69	27.3	2.81	1.15, 6.90	4.70	P = 0.03[s]
Young	51	6	11.8				
Cattle							
Adult	201	4	1.9				
Young	55	0	0.0	NA	NA	0.19	P = 0.66[ns]
Total	560	79	14.1				

NA = computation of odds ratio is not applicable

s = significant association

ns = not significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

Table 4: Prevalence of cystic hydatidosis in respect to age of camels and cattle in Gashua abattoir

Animal Species	Number examined	Number positive	Prevalence (%)	OR	CI	χ^2	P- value
Camels							
Adult	111	25	22.5	2.1	0.80, 5.50	1.69	$P = 0.19^{ns}$
Young	49	6	12.4				
Cattle							
Adult	47	1	2.1				
Young	38	0	0.0	NA	NA	0.0	$P = 1^{ns}$
Total	245	32	13.1				

NA = computation of odds ratio is not applicable

ns = not significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

Table 5: Prevalence of cystic hydatidosis in camels and cattle (combined) with respect to sex and location

Location	Number examined	Number positive	Prevalence (%)	OR	CI	χ^2	P-Value
Maiduguri							
Male	208	37	17.8	1.59	0.98,2.60	3.18	$P = 0.07^{ns}$
Female	351	42	12.0				
Gashua							
Female	147	21	14.3	1.31	0.61, 2.9	0.25	$P = 0.61^{ns}$
Male	98	11	11.2				
Total							
Male	306	48	15.7	1.3	0.9, 1.93	1.22	$P = 0.27^{ns}$
Female	498	63	12.7				

ns = not significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

4.3.1 Prevalence in respect to sex and animal species in Maiduguri and Gashua abbatoirs

The prevalence of cystic hydatidosis in respect to sex of camels and cattle is recorded in Table 6 and 7. In Maiduguri, male camels recorded a prevalence of 28% (37/133) and females recorded 22.4% (38/170) prevalence while male cattle had 0% (0/75) prevalence and females had 2.2% (4/181). Odd ratio values showed association between sex and infection which were not significant for camels (OR=1.3, 95% C.I = 0.80, 2.30, χ^2 = 0.92, P>0.05) and no association with cattle. The odds ratio value for male cattle could not be computed due to zero prevalence (χ^2 = 0.60, P>0.05). In Gashua, females recorded higher prevalence in camels 21.3% (20/94) and cattle 1.9% (1/53) while the males recorded 16.7% (11/66) in camels and 0% (0/53) in cattle. There was association between sex and infection in camels which was not significant (OR = 0.7, 95%, C.I= 0.3, 1.7, χ^2 = 0.3, P>0.05) while in cattle there was no association between sex and infection which was not significant (χ^2 = 0.7, P>0.05).

4.4 The prevalence of cyst in liver with respect to age and location

The prevalence of cyst in the liver in respect to age according to location is presented in Table 8. The result shows that young animals harboured less number of cysts 3.1% (6/193) in their liver compared to adults which had 8.2% (52/612). In Maiduguri, 5.7% (6/106) young and 10.2% (36/354) adults had cyst in their liver while in Gashua, 4.6% (4/87) young and 10.2% (16/157) had cyst. Odd ratio values showed association between adult and presence of cyst in liver which was significant in Maiduguri (OR=5.89, 95% C.I= 1.40, 24.80, χ^2= 6.33, P<0.05) and not significant in Gashua (OR=2.35, 95% C.I=.761, 7.28, χ^2=1.64, P>0.05). Considering the two location, OR value showed a significant association between adult and presence of cyst in liver (OR=2.89, 95% C.I=1.22, 6.84, χ^2=5.59, P<0.05).

Table 6: Prevalence of hydotidosis with respect to sex of camels and cattle in Maiduguri abattoir

Animal Species	Number examined	Number positive	Prevalence (%)	OR	CI	χ^2	P- value
Camels							
Male	133	37	28.0	1.3	0.80, 2.30	0.92	$P = 0.33^{ns}$
Female	170	38	22.4				
Cattle							
Female	181	4	2.2	NA	NA	0.60	$P= 0.46^{ns}$
Male	75	0	0.0				
Total	559	79	14.1				

NA = computation of odds ratio is not applicable

ns = not significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

Table 7: Prevalence of hydotidosis with respect to sex of camels and cattle in Gashua abattoir

Animal Species	Number examined	Number positive	Prevalence (%)	OR	CI	χ^2	P- value
Camels							
Female	94	20	21.3	1.4	0.60, 3.10	0.30	P =0.60^{ns}
Male	66	11	16.7				
Cattle							
Male	32	0	0.0				
Female	53	1	1.9	NA	NA	0	P = 1^{ns}
Total	245	32	13.1				

NA = computation of odds ratio is not applicable

ns = not significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

Table 8: Prevalence of hydatid cyst in liver of camels and cattle with respect to age and location

Location	Number examined	Number positive	Prevalence (%)	OR	CI	χ^2	P-value
Maiduguri							
Adult	354	36	10.2	5.89	1.4,24.80	6.33	$P = 0.012^s$
Young	106	2	1.9				
Gashua							
Adult	157	16	10.2	2.4	0.8, 7.2	1.64	$P = 0.19^{ns}$
Young	87	4	4.6				
Total							
Adult	612	52	8.5	2.9	1.2, 6.8	5.6	$P<0.05^s$
Young	193	6	3.1				
Overall total	805	58	7.2				

s = significant association

ns = not significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

4.4.1 The prevalence of cyst in liver with respect to age and animal species in Maiduguri

The presence of hydatid cyst in liver in respect to age according to animal species in Maiduguri is presented in Tables 9 and 10. The result shows that 12.7% (32/253) adult camels and 4% (2/51) camels had cysts in their liver, while only 2% (4/201) of adult cattle and 0% (0/55) of young cattle had cysts in their liver. Odds ratio values showed an association that was not significant between age and presence of cysts in liver of camels (OR=3.5, 95% C.I= .70, 12.9, χ^2= 1.2, P>0.05) and no association between age and presence of cysts in liver of cattle. The computation of odds ratio was not applicable due to zero prevalence for young cattle in Maiduguri (χ^2 = 0 P>0.05). In Gashua, 13.5% (5/111) of adult and 3.2% (4/49) of young camels had cysts in their liver and only 2.1% (1/49) of adult cattle and 0% (0/38) of young cattle had cyst on their liver. Odds ratio values show association between age according to animal species and presence of cyst on liver in camels but the association was not significant (OR= 1.7, 95% C.I= 0.6, 5.6, χ^2 = 0.30, P>0.05) but there was no association for cattle. The computation of odds ratio was not applicable due to zero prevalence for young cattle in Gashua (OR= –, 95% C.I= –, χ^2 = 0 P> 0.05).

4.5 Prevalence of cysts in liver with respect to sex and location

The prevalence of cysts in liver with respect to sex according to location is presented in Table 11. The result shows that cysts were recovered in the liver of 8.8% (27/306) males and 6.3% (31/498) females in the study population. In Maiduguri, 9.3% (19/208) males and 5.4% (19/351) females had cysts in the liver while in Gashua, 8.2% (8/89) males and 8.2% (12/147) females had cysts.

Table 9: Prevalence of hydatid cyst in liver of camels and cattle with respect to age in Maiduguri abattoir

Animal Species	Number examined	Number positive	Prevalence (%)	OR	CI	χ^2	P- value
Camels							
Adult	253	32	12.7	3.5	0.70, 12.90	1.20	$P = 0.207^{ns}$
Young	51	2	4				
Cattle							
Adult	201	4	2				
Young	55	0	0	NA	NA	0	$P = 1^{ns}$
Total	560	38	6.8				

NA = computation of odds ratio is not applicable

ns = not significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

Table 10: Prevalence of hydatid cyst in liver of camels and cattle with respect to age in Gashua

Animal Species	Number examined	Number positive	Prevalence (%)	OR	CI	χ^2	P- value
Camels							
Adult	111	15	13.5	1.7	0.6, 5.6	0.30	$P = 0.59^{ns}$
Young	49	4	3.2				
Cattle							
Adult	47	1	2.1				
Young	38	0	0.0	NA	NA	0	$P = 1^{ns}$
Total	245	20	8.2				

NA = computation of odds ratio is not applicable

ns = not significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

Table 11: Prevalence of hydatid cyst in liver in camels and cattle (combined) with respect to sex and location

Location	Number examined	Number positive	Prevalence (%)	OR	CI	χ^2	P-Value
Maiduguri							
Male	208	19	9.3	1.75	0.9,3.4	2.3	$P = 0.13^{ns}$
Female	351	19	5.4				
Gashua							
Male	98	8	8.2	1.0	0.4, 2.5	0	$P = 1^{ns}$
Female	147	12	8.2				
Total							
Male	306	27	8.8	1.36	0.8, 2.3	1.53	$P = 0.21^{ns}$
Female	498	31	6.3				

ns = not significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

Odds ratio value shows association between sex in Maiduguri with presence of cysts in liver but the association was not significant. (OR=1.75, 95% C.I=0.91, 3.40, χ^2= 2.3, P>0.05) similarly, in Gashua, there was association between presence of cyst in liver and sex of the animals although it was not significant (OR=1, 95% CI=.393, 2.54, χ^2=0.0, P>0.05) and also with the two locations combined together. (OR=1.36, 95% CI=0.80, 2.34, χ^2=1.5, P>0.05).

4.5.1 Prevalence of cyst in liver with respect to sex and animal species in Maiduguri and Gashua abattoirs

The prevalence of hydatid cyst in liver with respect to sex according to animal species in Maiduguri and Gashua is presented on Tables 12 and 13. In Maiduguri, 14.3% (19/133) males and 8.8% (15/170) female camels harboured cysts in their liver while only 2.2% (4/181) female cattle had cyst and no male cattle 0% (0/75) had. There was association between sex and presence of cyst in liver according to animal species in camels which was not significant (OR= 1.7, 95% C.I= 0.8, 3.5, χ^2 = 1.7 P>0.05) but not in cattle. The computation of odds ratio was not applicable due to zero prevalence for young cattle in Maiduguri (χ^2 = 0 P> 0.05). In Gashua, 12.1% (8/66) male camels and 11.7% (11/94) female camels had cysts in their liver while 0% (0/32) male and 1.9% (1/53) female cattle have cysts in their liver. Odds ratio values showed association between sex and presence of cysts in liver which was not significant in camels (OR= 1.0, 95% C.I= 0.4, 2.7, χ^2 = 0.6, 4.7, χ^2 = 0.03 P>0.05) but none in cattle. The computation of odds ratio was not applicable due to zero prevalence for young cattle in Gashua (χ^2 = 0, P>0.05).

Table 12: Prevalence of hydatid cyst in liver of camels and cattle with respect to sex in Maiduguri

Animal Species	Number examined	Number positive	Prevalence (%)	OR	CI	X^2	P- value
Camels							
Male	133	19	14.3	1.7	0.8, 3.5	1.72	$P = 0.19^{ns}$
Female	170	15	8.8				
Cattle							
Female	181	4	2.2	NA	NA	0.60	$P=0.46^{ns}$
Male	75	0	0.0				
Total	559	38	6.8				

NA = computation of odds ratio is not applicable

ns = not significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

Table 13: Prevalence of hydatid cyst in liver of camels and cattle with respect to sex in Gashua

Animal Species	Number examined	Number positive	Prevalence (%)	OR	CI	X^2	P- value
Camels							
Male	66	8	12.1	1.0	0.4, 2.7	0	$P = 1^{ns}$
Female	94	11	11.7				
Cattle							
Female	53	1	1.9	NA	NA	0	$P = 1^{ns}$
Male	32	0	0.0				
Total	245	20	8.2				

NA = computation of odds ratio is not applicable

ns = not significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

4.6 Prevalence of cyst in lungs with respect to age and location

The prevalence of cyst in lungs in respect to age according to location is shown in Table 14. The result shows that younger animals had fewer cysts in their lungs 1.6% (2/193 while 4.9% (30/612) had cyst in lungs. In Maiduguri, 5.1% (23/454) adult and 1.9 (2/106) young animals has cyst in their lungs. Only 4.4 (7/111) adults and 1.1% (1/87) young animals had cyst in Gashua. The association between adult and presence of cyst in lungs is not significant in Maiduguri (OR= 2.77, 95% CI=1.7, 4.0, χ^2=19.76, P=0), in Gashua (OR=4, 95% C.I=.5, 32.9) and when the two locations were combined together (OR=3.7, 95% CI= 2.2, 4.8 χ^2=40.9, P=0).

4.6.1 Prevalence of hydatid cyst in lungs with respect to age and animal species in Maiduguri and Gashua abattoirs

The presence of hydatid cysts in lungs with respect to age according to animal species in Maiduguri and Gashua is presented in Table 15 and 16. The result depicts that 9.1% (23/253) adult and 3.9% (2/51) young camels and 0% (0/201) adult and 0% (0/55) young cattle in Maiduguri had cyst on their lungs but there was no association between age and presence of cyst on lungs for camels (OR = 2.4, 95% C.I = 1.5, 3.9, χ^2 = 14.3, P<0.05) and in cattle, OR and χ^2could not be computed due to zero prevalence In Gashua 6.3% (7/111) adults camels and 2.04 (1/49) young camels had cysts in their lungs while no cattle sampled had cyst in their lungs 0% (0/47) adult and 0% (0/38) young. Odds ratio values showed association between age and presence of cyst in lungs for camels (OR = 3.2, 95% C.I = 1.65, 6.3, χ^2 = 12.1, P<0.05) in cattle OR and χ^2 could not be computed due to zero prevalence.

Table 14: Prevalence of cyst in lungs of camels and cattle (combined) with respect to age and location

Location	Number examined	Number positive	Prevalence (%)	OR	CI	χ^2	P-value
Maiduguri							
Adult	454	23*	5.1	2.77	1.7, 4.0	19.6	P=0[s]
Young	106	2*	1.9				
Gashua							
Adult	158	7*	4.4	3.98	2.0, 7.7	18.0	P=0[s]
Young	87	1*	1.1				
Total							
Adult	612	30*	4.9	3.26	2.2,4.7	40.9	P=0[s]
Young	193	3*	1.6				
Overall total	**805**	**33**	**4.1**				

***Data transformed (n x 10)**

s = significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

Table 15: Prevalence of hydatid cyst in lungs of camels and cattle with respect to age in Maiduguri abattoir

Animal Species	Number examined	Number Positive	Prevalence (%)	OR	CI	χ^2	P- value
Camels							
Adult	253	23*	9.1	2.4	1.54,3.90	14.3	P=0.000[s]
Young	51	2*	3.9				
Cattle							
Adult	201	0	0.0				
Young	55	0	0.0	NA	NA	NA	NA
Total	560	25	4.5				

*** Data transformed (n x 10)**

NA = computation of odds ratio is not applicable

s = significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

Table 16: Prevalence of hydatid cyst in lungs of camels and cattle with respect to age in Gashua

Animal Species	Number examined	Number positive	Prevalence (%)	OR	CI	χ^2	P- value
Camels							
Adult	111	7*	6.3	3.2	1.65,6.3	12.1	P = 0.000[s]
Young	49	1*	2.04				
Cattle							
Adult	47	0	0.0				
Young	38	0	0.0	NA	NA	NA	NA
Total	245	8	3.3				

***Data transformed (n x 10)**

NA = computation of odds ratio is not applicable

s = significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

4.7 Prevalence of cyst in lungs with respect to sex and location

Prevalence of cyst in lungs with respect to sex according to location is shown on Table 17. The result depicts that males in Maiduguri had prevalence of 5.2% (11/208) and females had 4% (14/351) while Gashua females had a higher prevalence 4.8% (7/47) than males 1% (1/98). When Maiduguri and Gashua were combined, 4.2% (21/498) females had cyst in lungs and 3.9 (12/306) males. The association between sex and presence of cyst in lungs according to location was not significant in Maiduguri (OR=1.4, 95% CI=.608, 3.066, χ^2=0.3, P>0.5), Gashua (OR= 4.8, 95% CI=.2.5 9.5, χ^2= 24.8, P=05) and when the two location were considered together (OR = 1.08, 95% C.I= 0.5, 1.9, χ^2= 0, P>0.05).

4.7.1 Prevalence of cyst in lungs with respect to sex and animal species in Maiduguri and Gashua abattoirs

The prevalence of hydatid cysts in lungs in respect to sex and animal species in Maiduguri and Gashua is recorded in Table 18 and 19. The result showed that in Maiduguri, 8.3% (11/133) males and 8.2% (14/170) female camels had cysts in their lungs and no male 0% (0/75) and female 0% (0/181) cattle had cyst on lungs. Odds ratio values showed non significant association for camels (χ^2 = 0, P>0.05) but in cattle there was zero prevalence so OR could not be computed. In Gashua, 1.5% (1/66) male and 7.4% (7/94) female camels had cysts in their lungs, while no male 0% (0/32) or female 0% (0/53) cattle had cyst on lungs. There was no association between cyst on lungs with respect to sex and infection in camels (OR= 5.23, 95%, C.I = 2.6, 10.2, χ^2 = 27.5, P = 0).

Table 17: Prevalence of cyst in lungs of camels and cattle with respect to sex and location

Location	Number examined	Number positive	Prevalence (%)	OR	CI	χ^2	P-Value
Maiduguri							
Male	208	11	5.2	1.4	0.6, 3.0	0.3	P=0.621^{ns}
Female	351	14	4.0				
Gashua							
Female	147	7*	4.8	4.8	2.50, 9.45	24.5	P = 0^{s}
Male	98	1*	1.0				
Total							
Female	498	21	4.2	1.08	0.53, 2.2	0.0	P= 0.982^{ns}
Male	306	12	3.9				

- **Data transformed (n x 10)**

s = significant association

ns = not significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

Table 18: Prevalence of hydatid cyst in lungs of camels and cattle with respect to sex in Maiduguri

Animal Species	Number examined	Number Positive	Prevalence (%)	OR	CI	χ^2	P- value
Camels							
Male	133	11	8.3	1.0	0.4, 2.3	0	$P=1^{ns}$
Female	170	14	8.2				
Cattle							
Male	75	0	0.0				
Female	181	0	0.0	NA	NA	NA	NA
Total	559	25	4.5				

NA = computation of odds ratio is not applicable

ns = not significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

Table 19: Prevalence of hydatid cyst in lungs of camels and cattle with respect to sex in Gashua

Animal Species	Number examined	Number positive	Prevalence (%)	OR	CI	χ^2	P- value
Camels							
Female	94	7*	7.4	5.23	2.6,10.2	27.50	$P=0^s$
Male	66	1*	1.5				
Cattle							
Male	32	0	0.0				
Female	53	0	0.0	NA	NA	NA	NA
Total	245	8	3.3				

*** Data transformed (n x10)**

NA = computation of odds ratio is not applicable

s = significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

4.8 Prevalence of cyst in both lungs and liver with respect to age and location

Prevalence of cysts in both lungs and liver with respect to age according to location is presented in Table 20. The result shows that younger animals had lower prevalence of cyst in both lungs and liver 1.9% (2/106) in Maiduguri and 1.9% (1/87) in Gashua than adult 3.1% (14/454) in Maiduguri and 1.9% (3/158) in Gashua with an overall prevalence of 1.6% (3/193) in young and 2.8% (17/612) in adults. The Odds ratio value shows no association between age and presence of cysts inn both lungs and liver in Maiduguri (OR= 1.6, 95% C.I= 1.5, 2.70, χ^2= 4.3, P<0.05) and Gashua (OR= 1.6, 95% C.I= 0.81, 3.4, χ^2= 1.52, P>0.05). Considering the two locations together, the association was also not significant (OR=1.8, 95% C.I=1.3, 2.69, χ^2= 8.72, P<0.05).

4.8.1 Prevalence of cyst in both lungs and liver with respect to age and animal species in Maiduguri and Gashua abattoirs

The prevalence of hydatid cyst in both lung and liver with respect to age according to animal species in Maiduguri and Gashua is presented in Table 21 and 22. In Maiduguri, 5.5% (14/253) of adult and 4% (2/51) of young camels had cysts inn both lungs and liver. While no adult 0 (0/201) or young 0 (0/55) cattle had cyst in both lungs and liver. Odds ratio values showed no association between age and presence of cyst in both lungs and liver for camels (OR = 1.4, 95% C.I = 0.89, 2.31, χ^2= 1.9, P>0.05) and cattle had zero prevalence so odds ratio could not be computed. In Gashua, 2.7% (3/111) of adult camels and 2% (1/49) of young camels had cyst in both lungs and liver. No adult 0% (0/47) or young 0% (0/38) of cattle had cyst on both lungs and liver. Odds ratio values showed no association between age and presence of cyst on both lungs and liver for camels (OR = 1.3, 95% C.I = 064, 2.74, χ^2 = .36, P>0.05) and cattle had zero prevalence so odds ratio could not be computed.

Table 20: Prevalence of cyst in lungs and liver of camels and cattle with respect to age and location

Location	Number examined	Number positive	Prevalence (%)	OR	CI	χ^2	P-value
Maiduguri							
Adult	454	14*	3.1	1.6	1.05, 2.70	4.35	P =0.037^{s}
Young	106	2*	1.9				
Gashua							
Adult	158	3*	1.9	1.8	0.81, 3.42	1.52	P=0.217^{ns}
Young	87	1*	1.1				
Total							
Adult	612	17*	2.8	1.8	1.30, 2.69	8.72	P=0.003^{s}
Young	193	3*	1.6				
Overall total	**805**	**20**	**2.5**				

*** Data transformed (n x 10)**

s = significant association

ns = not significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

Table 21: Prevalence of hydatid cysts in lungs and liver of camels and cattle with respect to age in Maiduguri

Animal Species	Number examined	Number positive	Prevalence (%)	OR	CI	χ^2	P- value
Camels							
Adult	253	14*	5.5	1.4	0.89, 2.31	1.90	$P=0.168^{ns}$
Young	51	2*	4.0				
Cattle							
Adult	201	0	0.0				
Young	55	0	0.0	NA	NA	NA	NA
Total	560	16	3				

*** Data transformed (n x 10)**

NA = computation of odds ratio is not applicable

ns = not significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

Table 22: Prevalence of hydatid cysts in lungs and liver of camels and cattle with respect to age in Gashua

Animal Species	Number examined	Number positive	Prevalence (%)	OR	CI	χ^2	P- value
Camels							
Adult	111	3*****	2.7	1.3	0.64, 2.70	0.36	$P=0.54^{ns}$
Young	49	1*****	2.0				
Cattle							
Adult	47	0	0.0				
Young	38	0	0.0	NA	NA	NA	NA
Total	245	4	1.63				

*** Data transformed (n x 10)**

NA = computation of odds ratio is not applicable

ns = not significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

4.9 Prevalence of cyst in both lungs and liver with respect to sex location

The prevalence of cysts in both lungs and liver in respect to sex according to location is shown in Table 23. The result shows that the presence of cyst in both liver and lungs was 3.8% (8/208) and 2.3% (8/351) in males and females in Maiduguri respectively. Also, in Gashua, 2% (2/98) of males and 1.4 (2/147) had cysts in both lungs and liver. Combining Maiduguri and Gashua together, 3.3% (10/306) males and 2% (10/498) had cyst on both lungs and liver. The Odds ratio values showed association between sex and presence of cyst in both lungs and liver with location but the associations were not significant. Maiduguri (OR=1.7, 95%CI= 0.63, 4.6, χ^2 =0.6, P>0.05); Gashua (OR=1.5, 95% CI=0.81, 2.8, X^2=1.2, P>0.05) and Maiduguri and Gashua combined, (OR=1.64, 95%CI=0.7, 4.0, χ^2=0.78, P>0.05).

4.9.1 Prevalence of cyst in both lungs and liver with respect to sex and animal species in Maiduguri and Gashua abattoirs

The prevalence of hydatid cysts in both lungs and liver with respect to sex according to animal species in Maiduguri and Gashua is presented in Table 24 and 25. The result shows that 6% (8/133) of male camels, 4.7% (8/170) female camels, 0% (0/75) male cattle and 0% (0/181) female cattle in Maiduguri had cyst on both lungs and liver. Odds ratio values show association between sex and presence cyst in both lungs and liver but the association was not significant for both camels (OR = 1.3, 95% C.I = 0.47, 3.5, χ^2 = 0.06, P>0.05), while in Gashua 3% (2/66) male camels, 2.1% (2/94) female camels, 0% (0/53) and 0% (0/53) female cattle had cyst in both lungs and liver. The association between sex and presence of cyst in both lungs and liver was not significant for camels (OR = 2.0, 95% C.I = 1.1, 3.9, χ^2= 4.71, P>0.05) and cattle had zero prevalence so odds ratio could not be computed.

Table 23: Prevalence of cyst in lungs and liver of camels and cattle with respect to sex and location

Location	Number examined	Number positive	Prevalence	OR	CI	χ^2	P-Value
Maiduguri							
Male	208	8	3.8	1.7	0.63, 4.6	0.6	$P=0.417^{ns}$
Female	351	8	2.3				
Gashua							
Male	98	2*	2.0	1.51	0.80, 2.8	1.2	$P=0.25^{ns}$
Female	147	2*	1.4				
Total							
Male	306	10	3.3	1.64	0.6,4.0	0.78	$P=0.38^{ns}$
Female	498	10	2.0				

*** Data transformed (n x 10)**

ns = not significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

Table 24: Prevalence of hydatid cyst in lungs and liver of camels and cattle with respect to sex in Maiduguri

Animal Species	Number examined	Number positive	Prevalence	OR	CI	χ^2	P- value
Camels							
Male	133	8	6.0	1.3	0.47,3.5	0.06	$P=0.80^{ns}$
Female	170	8	4.7				
Cattle							
Male	75	0	0.0				
Female	181	0	0.0	NA	NA	NA	NA
Total	559	16	3.0				

NA = computation of odds ratio is not applicable

ns = not significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

Table 25: Prevalence of hydatid cysts in lungs and liver of camels and cattle with respect to sex in Gashua

Animal Species	Number examined	Number positive	Prevalence	OR	CI	χ^2	P- value
Camels							
Male	66	2*	3.0	2.0	1.11,3.9	4.71	P=0.029[s]
Female	94	2*	2.1				
Cattle							
Male	32	0	0.0				
Female	53	0	0.0	NA	NA	NA	NA
Total	245	4	1.6				

*** Data transformed (n x 10)**

NA = computation of odds ratio is not applicable

s = significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

4.10 Hydatid cyst characteristics

Fiffy (50) cysts were collected, 46 were from camels and 4 from cattle. Out of the 46 from camel 23(50%) were classified as small (<5cm) of which 4(17.4%) were fertile, 16(69.6%) were infertile and 3(13%) were calcified. The small cysts had an average length, weight and volume of 3.60cm, 7.8g and 2.9ml respectively. The other 50% were classified as medium (5-10cm) of which 14(60.8%) were fertile, 3(13%) were infertile and 6(26.1%) were calcified. The medium cysts had an average length, weight and volume of 6.62cm, 49.4g and 28.2ml respectively. The 4 cysts from cattle were all small of which 3(75%) were calcified and 1(25%) was infertile. No fertile cyst was collected from cattle. The cyst had an average length, weight and volume of 3.1cm, 9.0g and 1.07ml as shown in Table 26 and Plate III and IV.

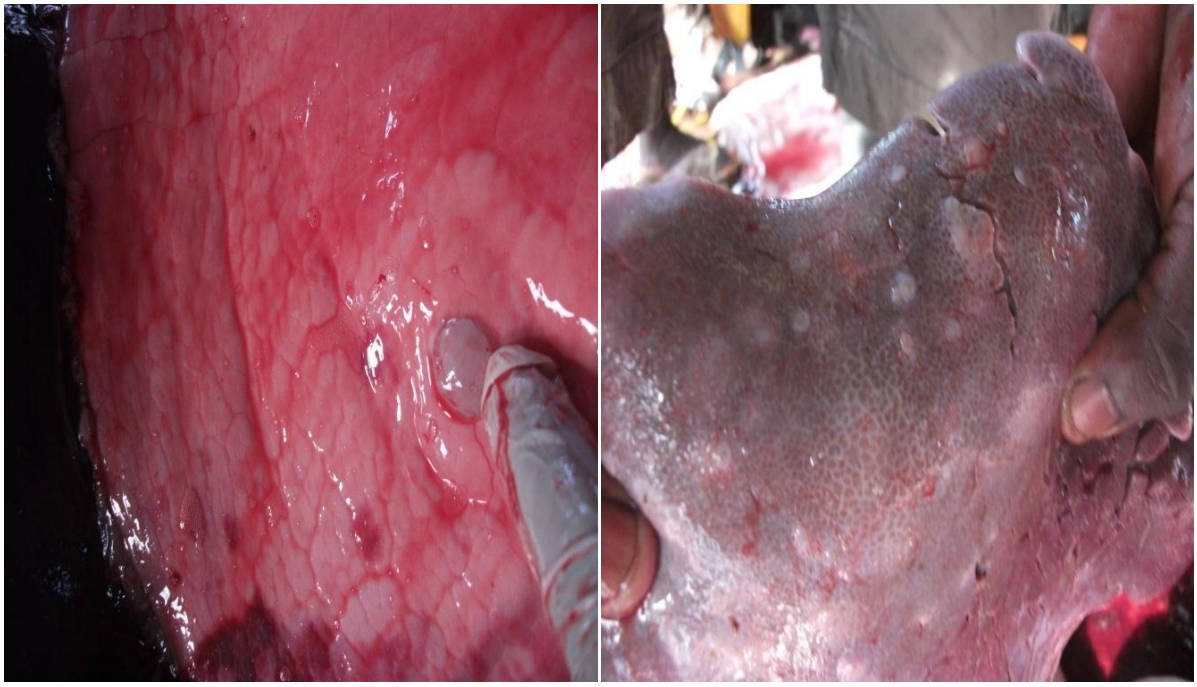
4.11 SDS- PAGE protein profiles

The SDS-PAGE protein analysis of crude, purified hydatid cyst fluid of camel is shown in Plate V. The analysis of crude HCF showed bands of molecular weight of 64kDa, 91kDa, 160kDa, and 200kDa while partially purified fluid showed 5 distinct bands at 200kDa, 160kDa, 120kDa, 91kDa and 64kDa.

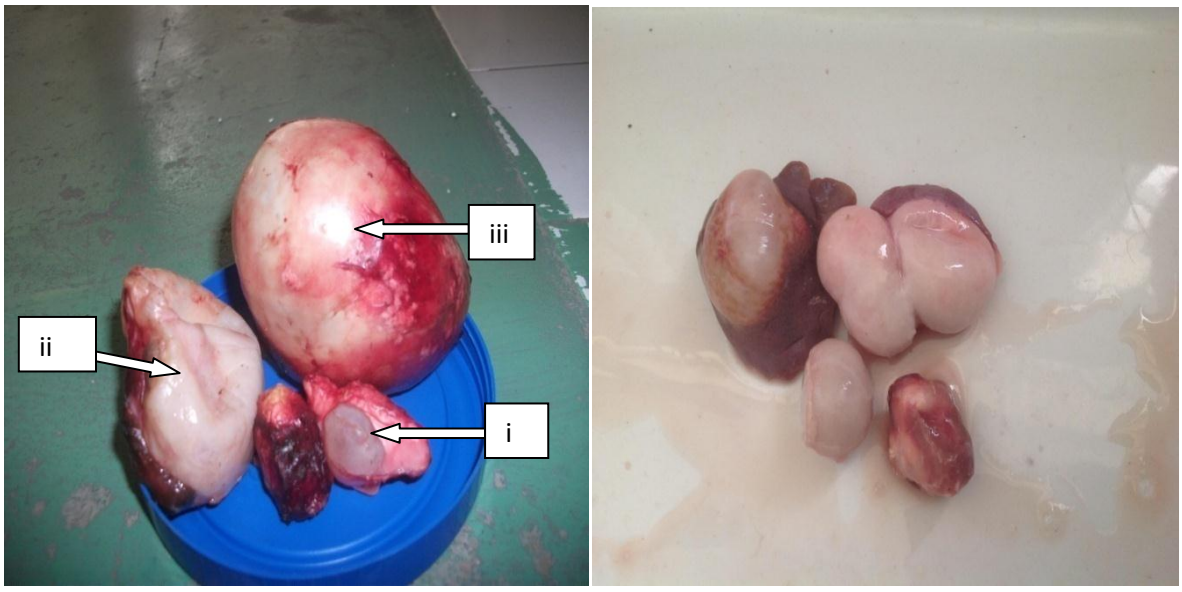
Table 26: Characteristics of hydatid cyst in camels and cattle in Maiduguri and Gashua

Animal species	Cyst size	Average Length (cm)	Average Weight (g)	Average Volume (ml)	Cyst Condition			Total
					Fertile	Infertile	Calcified	
Camel	Small	3.60	7.80	2.90	4(17.4%)	16(69.6%)	3(13%)	23
	Medium	6.62	49.4	28.20	14(39.1%)	3(13%)	6(26.1%)	23
	Large	-	-	-	-	-	-	-
Cattle	Small	3.10	9.00	1.07	0(0%)	1(25%)	3(75%)	4
	Medium	-	-	-	-	-	-	-
	Large	-	-	-	-	-	-	-
Total					18	20	12	50

Small<5cm, Medium=5-10cm, Large >10cm

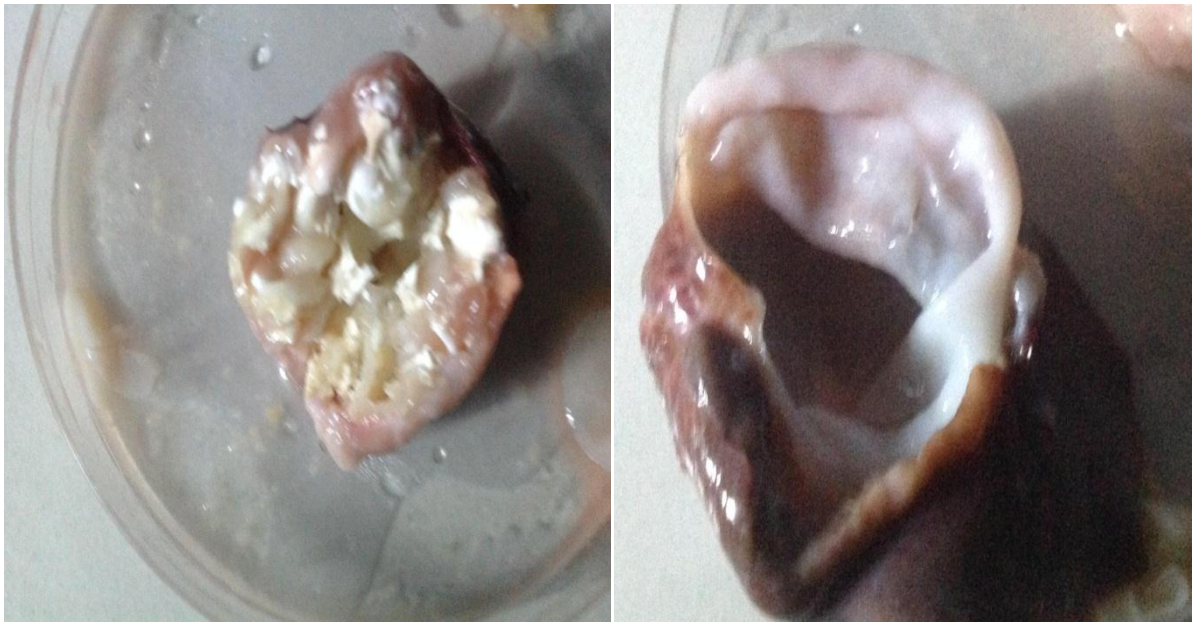


A **B**

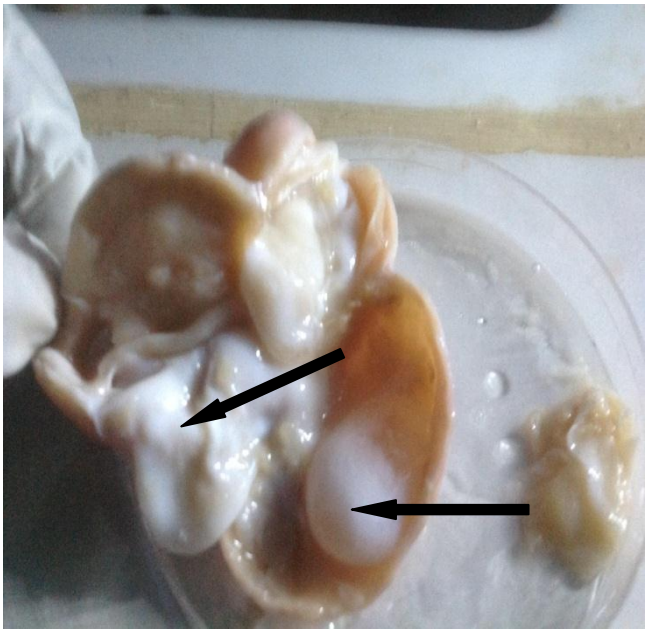


C **D**

Plate III: A – cyst on lungs, B – cyst on liver, C and D – cysts collected: i and iii from lungs then ii and others from liver



A **B**



C

Plate IV

Plate IV: a - calcified cyst,
Plate IV:b - infertile cyst,
Plate IV c– Fertile cyst; arrows pointing at daughter cyst budding off from parent cyst

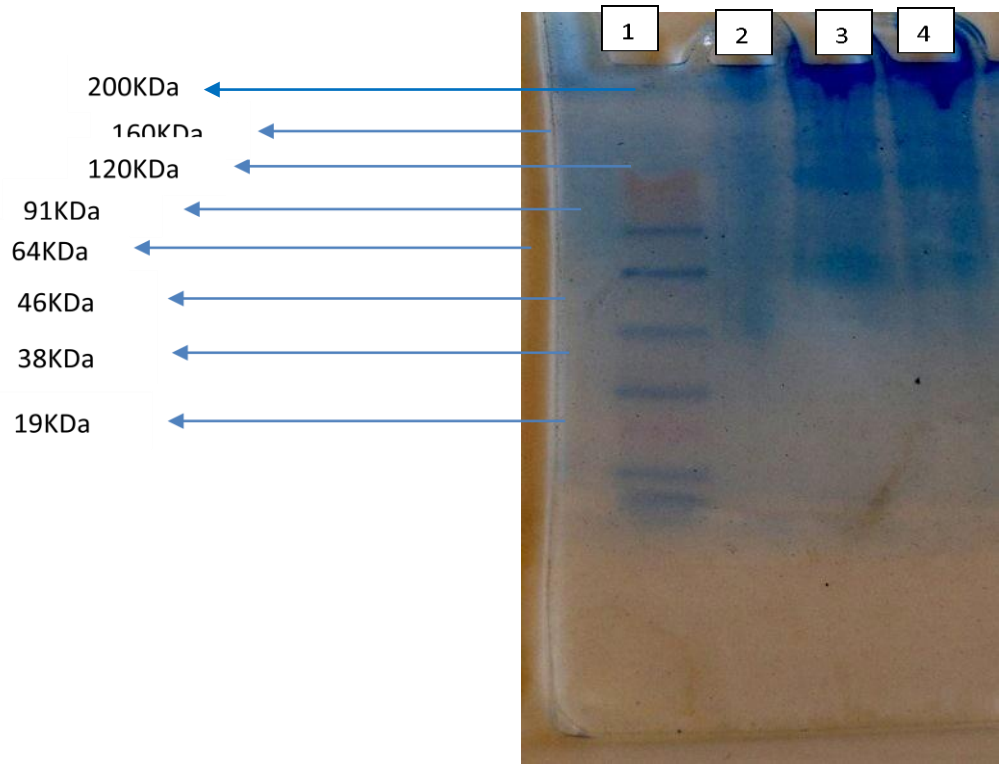


Plate V: SDS- PAGE Protein Profiles Analysis

Lane 1 contain MW, lane 2 crude HCF, lane 3 purified HCF (camel) lane 4 lyophilized HCF

4.12 Seroprevalence of hydatidosis in camels and cattle and location

The sero prevalence of hydatidosis in respect to location is shown in Table 27. Out of the 805 samples examined 326/805 (40.5%) were sero positive for hydatidosis. Maiduguri recorded the highest prevalence 251/805 (44.8%) compared to Gashua 75/245 (30.6%). The association between locality and infection was highly significant (OR=1.8, 95% C.I=1.3- 2.5, χ^2=13.70, P<0.0001).

4.13 Seroprevalence of hydatidosis with respect to age and location

Seroprevalence of hydatidosis in respect to age and location is presented in Table 28. The result shows that younger animals had lower prevalence 28.3% (30/106) in Maiduguri and 8% (7/87) in Gashua than adults 48.7% (221/454) in Maiduguri and 43% in Gashua. An overall seroprevalence of 47.2% (289/612) was recorded for adults and 17.2% (37/193). There was strong association between age according to location and seroprevalence which was highly significant in Maiduguri (OR=2.24. 0 95%C.I=1.41-3.57, χ^2=11.26, P=0.0001), Gashua (OR=8.63, 95%C.I=3.75-19.89, χ^2=30.72, P<0.0001) and also when the two locations were considered together (OR=3.05, 95%C.I=1.39-3.01, χ^2= 13.24, P=.00027).

Table 27: Seroprevalence of hydatidosis in camels and cattle Maiduguri and Gashua

Location	Number examined	Number positive	Prevalence (%)	OR	CI	χ^2	P-Value
Maiduguri	560	251	44.8	1.8	1.3,2.5	13.7	P=0.0001[s]
Gashua	245	75	30.6				
Overall Total	**805**	**326**	**40.5**				

s = significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

Table 28: Seroprevalence of hydatidosis in camels and cattle with respect to age in Maiduguri and Gashua

Location	Number examined	Number positive	Prevalence (%)	OR	CI	χ^2	P-value
Maiduguri							
Adult	454	221	48.7	2.2	1.4,3.5	11.26	P = 0.001[s]
Young	106	30	28.3				
Gashua							
Adult	158	68	43.0	8.6	3.7,19.8	30.72	P<.0001[s]
Young	87	7	8.0				
Total							
Adult	612	289	47.7	3.0	1.3,3.0	13.24	P = .0001[s]
Young	193	37	17.2				

s = significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

4.13.1 Sero prevalence of hydatidosis with respect to age and animal species in Maiduguri and Gashua abattoirs

The sero-prevalence of hydatidosis in respect to age and animal species in Maiduguri and Gashua is presented on Table 29 and 30. The result shows that 55.7% (141/253) of adult camels, 37.3% (19/51) of young camels, 39.6% (80/201) of adult cattle and 20% (11/55) of young cattle were sero-positive for hydatidosis in Maiduguri. Odd ratio values showed association between age according to animal species with infection in both camels (OR = 2.1, 95% C.I =1.1, 3.9, χ^2 =5.1, P<0.05) and cattle (OR =2.6, 95% C.I=1.3, 5.4, χ^2=6.6, P<0.05) and the association were significant. In Gashua, adult camels had a seroprevalence of 45% (50/111) and young camels had 38.3% (7/49) while adult cattle had a sero-prevalence of 14.3% (18/47) and young cattle had 0% (0/38). Odd ratio values showed association between seroprevalence and age in camels (OR=4.5, 95% C.I=1.88, 10.9, χ^2=11.4, P<0.000) and cattle (χ^2=17.1, P<0.05). The association was significant for cattle and camels.

Table 29: The seroprevalence of hydatidosis in camels and cattle with respect to age in Maiduguri

Animal Species	Number examined	Number positive	Prevalence (%)	OR	CI	χ^2	P- value
Camels							
Adult	253	141	55.7	2.1	1.1,3.9	5.1	P=0.024[s]
Young	51	19	37.3				
Cattle							
Adult	201	80	39.6				
Young	55	11	20.0	2.6	1.3,5.4	6.6	P=0.010[s]
Total	560	251	44.8				

s = significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

Table 30: The seroprevalence of hydatidosis of camels and cattle with respect to age in Gashua

Animal Species	Number examined	Number positive	Prevalence (%)	OR	CI	χ^2	P- value
Camels							
Adult	111	50	45.0	4.5	1.88,10.9	11.4	P=0.0007[s]
Young	49	7	38.3				
Cattle							
Adult	47	18	14.3				
Young	38	0	0.00	NA	NA	17.1	P = 0[s]
Total	245	75	30.6				

NA = computation of odds ratio is not applicable

s = significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

4.14 Seroprevalence of hydatidosis in respect to sex and location

The seroprevalence of hydatidosis in respect to sex according to location is presented in Table 31. The result depicts that males had a higher seroprevalence 50% (104/208) in Maiduguri, 36.7% (36/98) in Gashua and an overall seroprevalence of 44.7% (137/306) than female comprising 39% (137/351) in Maiduguri, 28.6% (42/147) in Gashua and an overall of 37.9% (189/498). Odds ratio values showed association between sex and seroprevalence in Maiduguri (OR=1.4, 95% CI=.1.05, 2.1, χ^2=4.6, P<0.05), Gashua (OR=1.4, 95% C.I= 0.8, 2.5, χ^2=1.44, P>0.05) and with Maiduguri and Gashua combined (OR=1.33, 95%C.I=.992-1.77, χ^2=3.38, P>0.05). However, the associations were not significant.

4.14.1 Seroprevalence of hydatidosis in respect to sex and animal species in Maiduguri and Gashua abattoirs

The seroprevalence of hydatidosis in respect to sex according to animal species in Maiduguri and Gashua is recorded in Table 32 and 33. In Maiduguri, male camels had 54.1% (72/133) seroprevalence, and female camels had 51.8% (78/170) while male cattle had a sero-prevalence of 42.7% (32/75) and female had 39.6% (59/180). Odds ratio values showed association between sex and seroprevalence in camels (OR=1.5, 95% C.I=0.9, 2.2, χ^2 =1.7, P>0.05) and cattle (OR=1.4, 95% C.I = 0.9, 2.7, χ^2 = 1.9, P>0.05) but the associations were not significant. In Gashua, male camels had a seroprevalence of 39.4% (26/66), female camels had 33% (31/94), male cattles had 21.9% (7/32) and female cattle had 20.8% (11/53). Odds ratio values show association between sex and sero-prevalence for camels (OR = 1.3, 95% C.I = 0.7, 2.5, χ^2 = 0.4, P> 0.05) and cattle (OR = 1.1, 95% C.I = 0.4, 3.1, χ^2 = 0, P>0.05). However, the associations were not significant.

Table 31: Seroprevalence of hydatidosis in camels and cattle with respect to sex in Maiduguri and Gashua

Location	Number examined	Number positive	Prevalence (%)	OR	CI	χ^2	P-Value
Maiduguri							
Male	208	104	50.0	1.4	1.0,2.10	4.6	P=0.03[s]
Female	341	137	39.0				
Gashua							
Male	98	36	36.7	1.4	0.8,2.5	1.44	P=0.228[ns]
Female	147	42	28.7				
Total							
Male	306	137	44.7	1.3	0.9,1.7	3.38	P=0.06[ns]
Female	498	189	37.9				

s = significant association

ns = not significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

Table 32: The seroprevalence of hydatidosis in camels and cattle with respect to sex in Maiduguri

Animal Species	Number examined	Number positive	Prevalence (%)	OR	CI	χ^2	P- value
Camels							
Male	133	72	54.1	1.4	0.9, 2.2	1.7	$P=0.190^{ns}$
Female	170	78	51.8				
Cattle							
Male	75	32	42.7				
Female	180	59	39.6	1.5	0.9, 2.7	1.9	$P=0.174^{ns}$
Total	559	251	44.9				

ns = not significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

Table 33: The sero-prevalence of hydatidosis in camels and cattle with respect to sex in Gashua

Animal Species	Number examined	Number positive	Prevalence (%)	OR	CI	X^2	P- value
Camels							
Male	66	26	39.4	1.3	0.7,2.5	0.4	$P=0.505^{ns}$
Female	94	31	33.0				
Cattle							
Male	32	7	21.9				
Female	53	11	20.8	1.1	0.4, 3.1	0	$P= 1^{ns}$
Total	245	75	30.61				

ns = not significant association

OR = Odds ratio

CI = confidence internal at 95%

χ^2= chi-square

4.15 Comparison between palpable hydatidosis and ELISA test result in cattle and camels

The result of the comparison between palpable hydatidosis and ELISA test result in cattle and camels is presented in Tables 34 and 35 respectively. A total of 5 (1.5%) cattle out of the 341 sampled had cyst of which 20% (1/5) was both sero and cystic positive (TP) and 80% were seronegative (FN) but cystic positive indicating a sensitivity of 20%. Out of the 331 that had no cyst 32.6% (108/331) were seropositive (FP) and 70.1% (232/331) were seronegative (TN) showing a specificity of 60.3%.

Out of the 464 camels sampled, 106 had cyst of which 70.8% (75/106) were both seropositive and cystic positive indicating a sensitivity of 70.8% in camels and out of the 358 that had no cyst, 39.7% (142/358) were seropositive (FP) and 60.3% (216/358) were seronegative and cystic negative (TN) showing a specificity of 60.3%.

4.16 Comparison of palpable hydatidosis and ELISA test result in cattle in Maiduguri

The result of the comparison between actual hydatidosis and ELISA test result in cattle in Maiduguri is presented in Table 36. 4(1.6%) cattle out of the 256 sampled were confirmed to have hydatid cyst in Maiduguri of which 1 (0.4%) was both seropositive and cystic (True Positive) and 3(1.2%) were seronegative but cystic positive (False Negative) indicating a sensitivity of 25%. Out of the 252 (98.4%) that had no cyst, 90 (35.2%) were seropositive but cystic negative (False Positive) and 162 (63.3%) were seronegative and cystic negative (True Negative) showing a specificity of 64.3%

Table 34: Comparison of palpable hydatidosis and ELISA test result in cattle

	Sero positive		**Total**	
Presence of cyst	Yes	No		
Yes	1 (TP)	4 (FN)	5	20% (sensitivity)
No	108 (FP)	228 (TN)	336	68% (specificity)
Total	109	232	341	

TP = True Positive; TN =True Negative; FP= False Negative and FP = False Positive

Table 35: Comparison of palpable hydatidosis and ELISA test result in camels

	Sero positive		**Total**	
Presence of cyst	Yes	No		
Yes	75 (TP)	31 (FN)	106	70.8% (sensitivity)
No	142 (FP)	216 (TN)	358	53.3% (specificity)
Total	217	247	341	

TP = True Positive; TN =True Negative; FP= False Negative and FP = False Positive

Table 36: Comparism of palpable hydatidosis and ELISA test result of cattle in Maiduguri

	Sero positive		**Total**	
Presence of cyst	Yes	No		
Yes	1 (TP)	3 (FN)	4	25% (sensitivity)
No	90 (FP)	162 (TN)	256	64.3% (specificity)
Total	91	165	256	

TP = True Positive; TN =True Negative; FP= False Negative and FP = False Positive

4.17 Comparison of palpable hydatidosis and ELISA test result in cattle in Maiduguri

The result of the comparison between actual hydatidosis and Elisa test result in cattle in Maiduguri is presented in Table 37. 75 (24.7%) camels out of the 304 sampled were confirmed to have hydatid cyst in Maiduguri of which 54 (17.8%) were both seropositive and cystic (True Positive) and 21(6.7%) were seronegative but cystic positive (False Negative) indicating sensitivity of 72%. Out of the 229 (75.3%) that had no cyst, 106 (34.9%) were seropositive but cystic negative (False Positive) and 123 (40.5%) were seronegative and cystic negative (True Negative) showing specificity of 53.7%.

4.18 Comparison of palpable hydatidosis and ELISA test result in cattle in Gashua

The result of the comparison between actual hydatidosis and ELISA test result in cattle in Gashua is presented in Table 38. Only 1(1.2%) out of the 85 cattle sampled in Gashua had hydatid cyst but was not seropositive (FT) thus no TP case occur in cattle in Gashua sensitivity of 0%. Out of the 84(98.8%) that had no cyst, 18 (21.2%) were seropositive but cystic negative (False Positive) and 66 (77.6%) were seronegative and cystic negative (True Negative) showing specificity of 78.5%.

4.19 Comparison of palpable hydatidosis and ELISA test result in camels in Gashua

The result of the comparison between actual hydatidosis and ELISA test result in camels in Gashua is presented in Table 39. 31(19.4%) out of the 160 cattle sampled in Gashua had hydatid cyst out of which 21(13.1%) were cystic positive and seropositive (TP) and 10 (6.3%) were cystic positive but were not seropositive (FT) indicating a sensitivity of 67.7%. Out of the 129 (80.6%) that had no cyst, 36 (22.5%) were seropositive but cystic negative (False Positive) and 93 (58.1%) were seronegative and cystic negative (True Negative) specificity of 72.0%.

Table 37: Comparison of palpable hydatidosis and ELISA test result of camels in Maiduguri

	Sero positive		**Total**	
Presence of cyst	Yes	No		
Yes	54 (TP)	21 (FN)	75	72% (sensitivity)
No	106 (FP)	123 (TN)	229	53.7% (specificity)
Total	160	144	304	

TP = True Positive; TN =True Negative; FP= False Negative and FP = False Positive

Table 38: Comparison of palpable hydatidosis and ELISA test result of cattle in Gashua

	Sero positive		**Total**	
Presence of cyst	Yes	No		
Yes	0 (TP)	1 (FN)	1	0% (sensitivity)
No	18 (FP)	66 (TN)	84	78.5% (specificity)
Total	18	67	85	

TP = True Positive; TN =True Negative; FP= False Negative and FP = False Positive

Table 39: Comparison of palpable hydatidosis and ELISA test result of camels in Gashua

	Sero positive		**Total**	
Presence of cyst	Yes	No		
Yes	21 (TP)	10 (FN)	31	67.7% (sensitivity)
No	36 (FP)	93 (TN)	129	72.0% (specificity)
Total	57	103	160	

TP = True Positive; TN =True Negative; FP= False Negative and FP = False Positive

4.20 Results of a 10 years retrospective study of hospital records for hydatidosis

No record of hydatidosis was found from hospital records in Maiduguri (Appendix V).

Similarly, there was no hospital record of diagnosis for feacal analysis at the period of the study in Gashua.

CHAPTER FIVE

5.0 DISCUSSION

The overall cystic prevalence of 13.8% (14.1% in Maiduguri and 13.1% in Gashua) and seroprevalence of 40.5% (44.8% in Maiduguri and 30.6 % in Gashua) signifies high prevalence of hydatidosis in the study area. Maiduguri had a cystic prevalence of 25% in camels while Gashua had 19%. In cattle, the cystic prevalence in Maiduguri and Gashua were 2 % and 1 % respectively. The results showed association between location of animals and cystic hydatidosis. In this study, the highest prevalence for both camel and cattle was in Maiduguri; this could be attributed to the presence of stray dogs in the Kasuwan shanu (Cattle market) which is very close to the abattoir and the dogs move freely in and out of the abattoir. The poor sanitary condition of the abattoir in Maiduguri could also be a contributory factor as waste from offals and contaminated organs were emptied close to slaughter slabs. Dogs from the cattle market feed on the waste thus maintaining the life cycle of the parasite and are potential source of infection to intermediate hosts. The animals are mostly purchased from Chad and neighbouring villages, while in Gashua, the cattle market was in Gaidam with only a few cattle coming from within and camels come from the neighbouring Niger Republic. Gashua had better sanitary condition in the abattoir as compared to Maiduguri abattoir, contaminated offals and wastes are dumped in an enclosure away from the slaughter slab and later burnt.

The difference in cystic prevalence might also be due to the difference in agroecology of the study area, the source and grazing system of the animals. Okolugbo *et al*. (2014) and Elsair *et al*. (2016) also made similar conclusions adding that on a general note, lifestock infection may differ from one country to another and the difference in prevalence among

different geographical locations could be attributed to the strain difference of *Echinococcus* that exists in different geographical locations and the transmission of the different strains of *Echinococcus* which might be due to the variation in feeding behaviours of the animals and animal husbandry practices (Soulsby, 1986; Mcmanus, 2006; Abunna *et al*., 2012; Elsair *et al*., 2016).

The difference in the prevalence in camel and cattle could be attributed to difference in strains of *Echinococcus* infecting different species of animals. Soulsby (1986) found evidences which indicate the existence of a number of strains of *Echinococcus* which differ morphologically and biochemically. These include the Sheep/Dog strain, Camel/Dog strain and cattle/dog strain. Okolugbo *et al*. (2014) and Gusbi *et al.* (1990) concluded that the higher prevalence recorded in Camels might be due to the fact that owners allow them to grow to maturity before they are slaughtered and this enables the hydatid cyst to be fully developed and become fertile. Generally, camels are unlikely to be slaughtered before 8 or 10 years and so the risk of acquiring and sustaining infections is relatively higher than in cattle (Ibrahem and Craig, 1998; Kebede *et al*., 2009).

The cystic prevalence of 25% in Maiduguri Camels and 19% in Gashua Camels are similar to others studies by Ogunsan *et al*. (2000) in camels in Sokoto (a prevalence of 26.2%) and 20.5% was reported by Rabiu and Jegede (2010) in Kano. The prevalence rate of cystic hydatidosis in Camel in a study by Okolugbo *et al.* (2013) was 44.4% which is higher than the one in this study. Also, higher prevalence rate of 55.5% was recorded by Dada and Belino (1979) in Kano, and in a study carried out in Kaduna and Zaria representing the northern guinea zone, Dada (1980) reported a cystic prevalence of 50%. Lower prevalence of 8.9% and 6.3% in Camels were reported by Abdullahi *et al*. (2011)

in a study of the incidence of hydatic cyst in food animals slaughtered in central abattoir in Sokoto and by Tijjani *et al*. (2010) respectively.

In cattle, the cystic prevalence in Maiduguri and Gashua were 2% and 1% respectively. Okolugbo *et al*. (2013), a prevalence of 1.8% in cattle of Sokoto while lower prevalences of 0.07%, 0.4% and 0.66% were recorded by Abdullahi *et al*. (2010), Tijjani *et al.* (2010) as well as Rabiu and Jegede (2010) in Kano. Higher prevalence was recorded in Kano (14.7%) and Niger-Delta (32%) by Dada and Belino (1979) and Arene (1985) respectively. Studies conducted from other regions and countries also show high prevalence for cystic hydatidosis in cattle for example, 28.09% in Northern Ethiopia (Dawit *et al*., 2013), 5.7% in Khartoum, Sudan (Elsair *et al*., 2012) and 61.4% in northern Turkana, Kenya (Njoroge *et al*., 2002).

The seroprevalence of 53% and 36% in Camels of Maiduguri and Gashua respectively is in agreement with 59.3% reported by Okolugbo *et al*. (2014) in Camels of Sokoto and 38.9 % reported by Luka *et al.* (2009) in Camels of Kano abattoir. Also, the seroprevalence of 36% and 21% in Cattle in Maiduguri and Gashua is in agreement with 31.2% and 24.3% by the same authors. The difference in prevalence between the cystic and seroprevalence recorded in camels and cattle from the same study areas (Maiduguri and Gashua) is as a result of difference in the diagnostic methods used. The cystic prevalence was based on Post mortem inspection of visceral organs of animals by palpation to detect the presence of cysts. This has a limitation that most often, small cysts are not detected during palpations and at times large cysts are ruptured during palpations and/or by the butchers before inspection takes place, and such animals are recorded as negative (Mcpherson *et al*., 2003). Another limitation for this method is that early

infections are missed because cysts will be too tiny to be detected by palpation. However, the ELISA used for the seroprevalence is more sensitive to detect antibody response in infected animals even in early infection, thus giving a more dependable result. The Chi-square result showed high significant association in prevalence between location of animals and seroprevalence as in the case of cystic prevalence which is attributed to the same reason as environmental conditions, hygienic status of slaughter house, climate condition, contamination rate in the intermediate hosts, presence of dogs as guards on herds, home slaughter of animals, feeding habits of animals and also livestock movement from endemic to less endemic areas.

This study showed highly significant association between cystic and seroprevalence of hydatidosis and age. The prevalence of infection recorded showed that adult animals were highly infected that had (16%) for cystic and (47%) for seroprevalence than the younger animals (6%) for cystic prevalence and (19%) for seroprevalence. Elisair *et al.* (2016) reported that adult camels and cattle have longer to hydatidosis infection and low immunity to it. The chances of locating cysts at post mortem inspection is higher in adults since the disease is chronic, cysts grow bigger in size as animals advance in age (Omer, 2013). Also, Ibrahem and Craig (1998) and Daryari *et al.* (2009) reported that the eggs of *Echinococcus* require 6-12 months before the onchosphere becomes infective to the intermediate host. Another reason for high infection rates in adults may be due to the fact that IgG antibodies to *Echinococcus* can remain for many years in the host even after cure. Rigano *et al*. (2002) in their study of long term serological evaluation of patients with cystic *Echinococcus* treated with Benzemedazole carbamates reported that IgG isotopes remain practically unchanged after 8 years follow up and records have shown

that camels are not taken for slaughter before 8 years except otherwise (Ibrahem and Craig, 1998; Kebede *et al.,* 2009). This implies that when an animal is infected with hydatidosis at younger age and treated, when serologically tested at an adult age, the result will be positive. Okolugbo *et al*. (2014) reported a seroprevalence of 56.3% for adult camels, 29.7% for adult cattle and 27.5% in young camel and 13.7 % in young camels in Sokoto abattoir. Elisair *et al.* (2016) recorded a prevalence of 9.4% in adults and 1.9% in young animals. Though slight variations exist in percentage prevalence, the result of this study is in agreement with previous studies which recorded that adult animals have higher rates of infection than younger ones (Kebede *et al*., 2010; Regassa *et al.,* 2010).

There was no significant association between presence of hydatid cyst among males and females (P>0.05), though the infection within females was 13% and 38% and males was 16% and 45% for cystic and seroprevalence respectively. Although males are more affected compared to females the insignificant association observed between sex and infection could be attributed to the fact that both gender graze together on the same pasture and are exposed to the same risk factors for example presence of dogs as guards in herds (Garba and Maigandi, 1995). The result of this study differs from that of Elsair *et al.* (2016) who reported cystic prevalence of 37.5% in female and 4.5% in males with a significant association at P=0.000 in females attributing it to the fewer number of females slaughtered as compared to males. Okolugbo *et al.* (2014) reported a seroprevalence of 75.8% and 24% for females and 30.4% and 47% for males in camels and cattle respectively attributing it to the fewer number of males to females in camels and fewer numbers of females to males in cattle. The two studies also attributed their findings to

immunological factors which may be inherent in females and in the male defensive mechanism.

The result of the present study showed that the only organs of cattle and camels that were affected with hydatid cysts in Maiduguri and Gashua were the Liver and the Lungs. Other organs such as spleen, heart and kidneys examined by meat inspection had no cysts. This could be attributed to the fact that the lungs and liver are the first capillary sites the migrating *Echinococcus* oncospheres encounter through the portal veins getting over the sequential floatation that occurs in the liver and lungs before any other peripheral involvement (Okolugbo *et al.,* 2013; and Banda, 2013). The larger capillary sites in the lungs than other organs have been reported as a reason for higher prevalence in lungs of cattle (Getaw *et al.,* 2010). This study revealed an overall higher prevalence in liver (9.6%) than in lungs (6.4%). This could be attributed to the fact that most cysts in the lungs are embedded inside the soft tissue of the lungs and if not palpated carefully, the cysts could be missed while that of the liver were seen on the liver when fully matured or seen as small white dots on the surface of the liver. As regards to location, age and sex of animals, the difference in prevalence of cysts on lungs and liver could be attributed to the lack of cooperation from the butchers who did not want the quality of their organ's meat reduced so they quickly carried the organs away for sale as buyers are all over the place.

The results of comparison of cystic (14%) and seroprevalence (40.5%) could be attributed to the uncooperative attitude of butchers and the inability to locate small cyst during meat inspection. Ahmad *et al*. (2017) attributed it to the difficulty in standardization of antigen preparations. Ibrahem and Craig, (1998) reported that it takes 6-12 months before the eggs of *Echinococcus* develop into the onchosphere to become

infective to the intermediate host. It is therefore possible that the host elicit antibody response before the eggs mature into a visible cyst. Banda (2013), also reported that not all strains of *Echinococcus* elicit immune response in the host, thus some infection are missed. Antibodies of *Echinococcus* have been reported to linger in the body for 8years even after treatment which can lead to false positive result in serology (Elsair *et al.*, 2016).

Hydatic cysts characteristics show that only small and medium sized cysts were found this study with small size being the highest in number 27/50 (54%). This could be attributed to the fact that the infected animals were slaughtered before the cysts become larger in size. Soulsby (1986), reported that hydatid cysts are fluid-filled cysts which grow slowly over several months, and large cysts are often found in older animals. The result though slightly higher, agrees with Tefera *et al.* (2012) who reported higher number of small cysts (41.56%) in Addis-ababa. Dawit (2013) recorded a high proportion of small cysts in Mekelle municipal abattoir and attributed it to the immunological response of the host which may prevent growth of cyst size.

The fertility of the cysts in this study was 36% which was observed only in camel which had medium sized cysts and none was found in cattle, thus suggesting that the camel acts as a major intermediate host perpetuating the life cycle of *E. granulosus* in the area. Ibrahim (2009) who found 47.8% fertility in sheep and 24% in goats while Banda (2013), found 43.5% in cattle. The result was different from Berhe (2009), who found lower fertility rates of 10.7% in cattle in Ethiopia and Rinaldi *et al.* (2008) who didn't observe any fertility in their research on the role of cattle in the epidemiology of *Echinococcus granulosus* in an endemic area of southern Italy. Daryari *et al.* (2009) attributed the

differences in infertility rates of cysts to the differences in the immunological responses of different individual hosts and/or the deworming of the animals by use of antihelminthic drugs.

The SDS-PAGE analysis of crude, purified and lyophilized HCF of Camel origin revealed two major antigens 5 and B. Antigen 5 is contained in the 38-150 KDa while antigen B is a thermostable lipoprotein with a molecular weight of 160KDa which dissociates into three bands 8-12, 16 and 24 KDa and it is one of the most abundant parasite antigens in hydatic cyst fluids (Gihan *et al.*, 2009; Person et al., 2002). In this study, no low molecular band was observed which is an indication that antigen B remained thermostable at 160KDa and didn't dissociate, this might be due to the method of processing of HCF before electrophporesis. Antigen purification method that removes higher percentage of impurities reduces the chances of serological cross reactions between bands of *E.granulosus* and other cestodes thus fewer bands are obtained which are specific to *E.granulosus* bands (Oriol *et al*., 1971., Olga *et al.,* 2001). Five polypeptide bands observed in this study differ from that obtained by Derbala (1998) who performed polypeptide analysis of camel HCF and observed seven bands and also differ with that of Latif *et al*. (2013) who observed only three polypeptide bands in Camel HCF. The difference in polypeptide bands of camel in this study and others only agrees with a conclusion of Latif *et al*. (2013); Simsik and Koroglu, (2004); Cuesta-Bandera, (1996) and Shambesh *et al*. (1995) that HCF proteins differ from one geographical region to the other.

The result of this study shows that no record of *Echinococcus* eggs was found at the parasitology unit of the University of Maiduguri Teaching Hospital while at the general

hospital in Gashua no record was found for any stool microscopic examination as at the time of sample collection. This could be as a result of the improper documentation of results from faecal examination in the two hospitals visited, lack of awareness of the nature of the disease, poor diagnostic facilities and recording system observed in this study. Dada, (1980) recorded one case of human hydatidosis in the Southern zone when he carried out a retrospective analysis of hospital records in three ecological zones of Nigeria to ascertain the prevalence of human taeniasis, cysticercosis and hydatidosis in Nigeria and attributed the low prevalence to non-documentation of the disease due to poor diagnostic facilities and inefficient recording system. Onuh *et al*. (1989) reported that only one case of hydatidosis was recorded at the main specialist hospital in Anambra state. They also reported that information from health centres and hospitals in rural and urban areas in the state revealed insufficient awareness of the nature and importance of the disease in man which resulted to lack of evidence even of suspected cases. The result of the present study agrees with that of Luka (2006) who reported that no ova of *Echinococcus* was recorded during a retrospective study of hospital records of three hospitals in Kano State which was attributed to simple inaccurate diagnostic methods which could distinguish *Echinococcus* eggs from other *taeniid* eggs, lack of man power and lack of facilities for serology amongst others. Luka (2006) also reported that the head of Surgery Department of Aminu Kano Hospital said that only one accidental case of unilocular cyst was found in the lungs of a 30 year old male patient during surgery.

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary

The study revealed an overall 13.8% prevalence of cystic hydatidosis and seroprevalence of 40.5% in the study area (Maiduguri and Gashua). The cystic prevalence for camels and cattle in Maiduguri were 25% and 2% respectively while the seroprevalence were 53% and 31.2% respectively. In Gashua, the cystic prevalence for camel and cattle were 19% and 1% while the seroprevalence were 36% and 24.3% for camel and cattle respectively. The result shows that the disease is more prevalent in Maiduguri than Gashua and also in older animals than younger ones. The association between location and age of animals with the disease was statistically significant while that of sex and the disease was not. There was no record of human hydatidosis from the 10years restrospective study of hospital records in the study area. The protein profile, from the analysis of HCF of camel origin by SDS-PAGE revealed that antigens 5 and B were the immunodorminant antigens of HCF in the study area.

A total of 50 cysts were collected during the study; 46 were from camels and 4 from cattle. The camel cysts were medium and small while all the cysts from cattle were small. 18 out of the 46 cysts of camels were fertile, 16 cysts were infertile and 3 were calcified. None of the cysts from cattle was fertile, 3 were calcified and 1 was infertile.

6.2 Conclusion

The study indicates that hydatidosis is prevalent in the study area (25% and 53% for Maiduguri; 19% and 31.2% for Gashua).

There is significant association (P<0.05) between the prevalence of hydatidosis with location and age of animals but not with sex (P>0.05).

Only the lungs and liver of the animals were infected with hydatidosis and the liver had higher prevalence (9.6%) than lungs (6.4%).

The antigenic profile of hydatid cysts fluid from camel slaughtered in Maiduguri abattoir is diverse (200KD, 160KD, 120KD, 91KD and 64KD).

There is no record of hydatidosis in selected hospitals in the study area.

6.3 Recommendations

The following recommendations are made based on the findings of this study.

- Serological studies should be carried out more frequently alongside post mortem findings in other states and in different species of farm animals to give comprehensive status of the disease in the country.
- Public health measures such as the provision and strengthening of meat inspection services at abattoir be encouraged by Government. Home slaughter of animals should be discouraged.
- Fencing abattoirs to prevent stray dogs from entering the abattoir and sanitary conditions of the abattoir be improved through creation of proper drainage and proper means of waste disposal.

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APPENDIX I: SDS-PAGE

Resolving Gel	
Distilled water	3.5ml
1.5 m tris (PH 8.0)	2.5ml
Acrylamide mix (30%)	0.4 ml
10% sodium dodecyl sulphate	0.1ml
10% Ammonium per sulphate	0.1ml
TEMED	0.004ml

Stacking Gel	
Distilled water	6.1ml
0.5m tris PH (6.8)	2.2ml
Acrylamide mix (30%)	2.5ml
10% sodium dodecyl sulphate	0.1ml
10% Ammonium per sulphate	0.1ml
TEMED	0.01ml

APPENDIX II: Ten years Retrospective Study of University of Maiduguri Teaching Hospital for Hydatidosis

Parasite species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total	%
Echinococcus	-	-	-	-	-	-	-	-	-	-	-	0
Ascaris	2	3	2	6	8	13	4	7	1	4	50v	6.3
Hookworm	8	7	5	1	-	5	1	2	1	3	33	4.2
S. mansoni	17	7	3	2	1	5	5	6	-	-	46	5.8
E. histolytica	65	67	38	59	36	77	49	30	36	38	495	62.3
H. nana	3	4	2	3	5	9	3	9	1	3	42	5.3
E. coli	-	-	-	-	-	-	-	-	-	-	-	-
Trichenella	2	-	-	-	-	-	1	-	-	-	3	0.4
Teania Species	-	-	-	-	-	1	-	-	-	-	1	0.1
Enterobrus vermicularis	-	-	-	-	-	1	1	-	-	-	2	0.2
Dicrocoelium dentriticum	1	-	-	-	-	-	-	3	2	1	7	0.9
Intestinal gardia	10	10	11	16	10	15	6	1	10	15	103	13.0
Cryptosporidium	-	-	1	-	-	-	-	-	-	-	-	0.1
Strongyloides stercoralis	7	1	-	-	-	-	-	-	-	-	9	1.2
Diphyllobothrium latum	-	-	-	-	-	2	-	-	-	-	2	0.3
Total	115	99	62	87	60	128	73	58	50	62	794	-