

**COENUROSIS IN SLAB-SLAUGHTERED SHEEP AND GOATS IN
NGORONGORO DISTRICT: PREVALENCE AND PREDISPOSING FACTORS
OF THE DISEASE**

MIRAN BUSHELEGI MIRAN

**A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN
PARASITOLOGY OF SOKOINE UNIVERSITY OF AGRICULTURE.
MOROGORO, TANZANIA.**

2013

ABSTRACT

Taenia multiceps is a worldwide in distribution which inhabits the small intestine of dogs, foxes, coyotes and jackals. However, until recently, there were no reports of the occurrence of *Taenia multiceps* associated ill health in Tanzania in livestock. In this study, the prevalence of *Taenia multiceps* metacestode (*Coenurus cerebralis*) as well as other *Taenia* and *Echinococcus* metacestodes particularly *Cysticercus tenuicollis* and hydatid cysts in slab-slaughtered sheep and goats, community knowledge and predisposing factors of coenurosis in Ngorongoro district were determined. The study reports for the first time the occurrence on the one hand and the prevalence on the other hand of coenurosis in slaughtered sheep and goats due to *Taenia multiceps* metacestode (*Coenurus cerebralis*) in Ngorongoro district. Of 180 examined carcasses of sheep and goats, 80 (44.4%), 93 (51.7%) and 35 (19.4%) were found to be infected with *C. cerebralis*, *C. tenuicollis* and Hydatid cysts respectively whereas some had concurrent infections. Widespread dog keeping for herding purposes, large dog population, close contact between small ruminants (sheep and goats) and dogs, lack of knowledge in the community on how coenurosis occurs, free access of dogs to carcasses/offal including brains of small ruminants sometimes containing viable *C. cerebralis* cysts and inadequate animal health services for dogs especially worm control are major factors which contribute to persisting coenurosis. Thus, knowledge of epidemiology of the disease is critical for the effective disease management and control (health protection and disease prevention). To address these, the development of a control strategy (programme) is required. Therefore, much remains to be done in research to pave the way for coenurosis control and the findings of this study can be used to guide future research programmes.

DECLARATION

I, Miran Bushelegi Miran, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

Miran Bushelegi Miran,
(MSc candidate)

Date

The above declaration is confirmed

Prof. Kassuku, A. A.
(Supervisor)

Date

COPYRIGHT

No part of this dissertation may be produced, stored in any retrieval system or transmitted in any form or by any means without prior permission of the author or Sokoine University of Agriculture on that behalf.

ACKNOWLEDGEMENTS

First and foremost I am thankful to my GOD for enabling me to perform this work. As this work is part of my MSc. study, I am grateful to my supervisor Prof. A. A. Kassuku of Microbiology and Parasitology department, Sokoine University of Agriculture for a good guidance, supervision and support I received from him throughout the entire study period. I thank the Ngorongoro District Council authority for granting me a study leave and for monthly salary I received throughout the study period. I also wish to acknowledge the financial contribution made by IPBES project through TAWIRI and my friends; Mr. Jackson Kalelo and Joseph Domell which significantly strengthened my capacity to undertake the necessary fieldwork tasks in time. I am grateful to Dr. Robert Fyumagwa TAWIRI Director Serengeti Centre for his permission to use the facilities of TAWIRI laboratory. Thanks are also due to Mr. Maulid L. Mdaki TAWIRI laboratory Technician, Yuster Lucas, Robert William and Erick Samwel SUA veterinary students for their invaluable assistance in the laboratory work. I highly acknowledge the cooperation, assistance and support I received from both the Carnivore Diseases Project (CDP) - Serengeti and the Ngorongoro District Livestock Department staff during sample collection. Special thanks to my wife Safina, our lovely children and extended family for their patience and prayer. Last but not least, I thank all the people who in one way or another contributed to the success of this work. Thank you all.

DEDICATION

This work is dedicated to ALMIGHTY GOD. Secondly, this work is dedicated to my family for their prayers, moral and material support.

TABLE OF CONTENTS

ABSTRACT	ii
DECLARATION	iii
COPYRIGHT	iv
ACKNOWLEDGEMENTS	v
DEDICATION	vi
TABLE OF CONTENTS	vii
LIST OF TABLES.....	xi
LIST OF FIGURES.....	xiii
LIST OF ABBREVIATIONS AND SYMBOLS.....	xiv
 CHAPTER ONE.....	 1
1.0 INTRODUCTION	1
1.1 Problem Statement	4
1.2 Justification	5
1.3 Objectives.....	6
1.3.1 Main objective	6
1.3.2 Specific objectives.....	6
 CHAPTER TWO.....	 7
2.0 LITERATURE REVIEW.....	7
2.1 Coenuroses	9

2.2 Taenia multiceps.....	9
2.3 Coenurosis (Gid)	9
2.4 Distribution.....	10
2.5 Taenia multiceps Life Cycle.....	10
2.6 Pathogenesis and Clinical Signs.....	11
2.7 Diagnosis	12
2.8 Differential Diagnosis	12
2.8.1 Scrapie	12
2.8.2 Listeriosis	12
2.9 Treatment.....	13
2.10 Control and Prevention.....	13
 CHAPTER THREE	14
3.0 MATERIAL AND METHODS.....	14
3.1 Study Area.....	14
3.2 Study Design	14
3.3 Types of Data and Sample Size.....	16
3.4 Sample Collection, Processing and Cyst Identification	16
3.4.1 Brain samples – Extraction and examination	17
3.4.2 Faecal sample collection and processing.....	17
3.5 Procedure/Protocol	17
3.6 Interviews – Questionnaire Survey	19
3.7 Data Analysis	19

CHAPTER FOUR	20
4.0 RESULTS.....	20
4.1 Prevalence of <i>Coenurus cerebralis</i> Cysts	20
4.1.1 Coenurosis age wise prevalence	21
4.1.2 Number of <i>Coenurus cerebralis</i> cyst	22
4.1.3 Predilection sites of <i>Coenurus cerebralis</i> Cysts	22
4.2 Prevalence of Metacestodes of <i>Taenia</i> and <i>Echinococcus</i> Worms	24
4.2.1 Mixed infections/co-existence rates of metacestodes	25
4.2.2 <i>Taenia hydatigena</i> infection	26
4.2.3 Echinococcosis	27
4.3 Awareness and Knowledge of Livestock Keepers in Relation to Coenurosis	28
4.4 Predisposing Factors of the Disease	28
4.4.1 Disposal of animal offal and infected organs/brain.....	28
4.4.2 Potential predisposing factors associated with the transmission and persistence of <i>T. multiceps</i>	29
4.4.3 Sighting of wild carnivores sharing grazing areas with livestock.....	30
4.5 Impacts of Coenurosis on Livestock Owners	31
4.6 Timeline.....	32
4.7 Taeniid Eggs in Domestic Dogs	33
4.7.1 Prevalence of taeniid eggs in domestic dogs population.....	33
4.7.2 Prevalence of taeniid eggs in different age groups of dogs.....	34
CHAPTER FIVE	35
5.0 DISCUSSION.....	35

CHAPTER SIX.....	44
6.0 CONCLUSIONS AND RECOMMENDATIONS	44
6.1 Conclusions	44
6.2 Recommendations	44
REFERENCES	46
APPENDICES	54

LIST OF TABLES

Table 1:	Prevalence of <i>Coenurus cerebralis</i> cysts in sheep and goats	20
Table 2:	Prevalence's per slaughter slab according to species	21
Table 3:	Prevalence rates of coenurosis by age of sheep and goats per slaughter slab.....	21
Table 4:	Number of <i>Coenurus cerebralis</i> cyst according to species	22
Table 5:	<i>Coenurus cerebralis</i> cysts locations in sheep and goats	22
Table 6:	Prevalences of <i>Taenia</i> and <i>Echinococcus</i> metacestodes in sheep and goats in three slaughter slabs.....	25
Table 7:	Prevalences of <i>Taenia</i> and <i>Echinococcus</i> metacestodes categorised into species and by sex	25
Table 8:	Mixed infection rates of <i>Taenia</i> and <i>Echinococcus</i> metacestodes	26
Table 9:	Prevalence of <i>Cysticercus tenuicollis</i> in slab-slaughtered sheep and goats in Ngorongoro district.....	26
Table 10:	Species wise prevalence of <i>Cysticercus tenuicollis</i> cysts	27
Table 11:	Prevalence of hydatid cyst in slaughtered sheep and goats per slaughter slab	27
Table 12:	Prevalence and distribution pattern of Hydtid cyst in different organs in slab-slaughtered sheep and goats in Ngorongoro district.....	28
Table 13:	Awareness and knowledge of livestock keepers in relation to coenurosis based on questionnaire survey.....	28
Table 14:	Ways of disposal of brain and other infected organs	29
Table 15:	Potential predisposing factors of coenurosis based on questionnaire survey in Ngorongoro district.....	29

Table 16: Sighting frequencies of wild carnivore in the grazing land based on questionnaire survey	30
Table 17: Rank of coenurosis disease by importance in sheep and goats	32
Table 18: Prevalence of taeniid eggs in domestic dogs.....	33
Table 19: Infection rates (prevalence) of taeniid eggs per specific age group	34

LIST OF FIGURES

Figure 1:	The <i>Taenia</i> tapeworm life cycles diagram	8
Figure 2:	Ngorongoro district sketch map showing the study villages.....	15
Figure 3:	Showing four layers; from top, (a) ether (b) debris (c) formalin and (d) sediment	18
Figure 4:	Photographs of <i>Coenurus cerebralis</i> cysts. (A) Large coenurus cyst occupying almost the right hind lobe of brain under the meninges (B) Individual <i>Coenurus</i> cyst coming out the brain cavity	23
Figure 5:	Meninges and cyst capsule adhering to the inner part of the skull of sheep – due to <i>coenurus cerebralis</i> cyst infection	24
Figure 6:	(A) and (B): Dogs surrounding slaughter slab at Waso, Ngorongoro District.	30
Figure 7:	Wild animals sharing grazing ground/field during the day with sheep in Piyaya/Malambo plains, Ngorongoro district.	31
Figure 8:	Percentage of respondents in relation to coenurosis time occurrence per village	33
Figure 9:	Photographs: A: Taeniid eggs B: single taeniid egg	34

LIST OF ABBREVIATIONS AND SYMBOLS

BCT	Bovine Cerebral Theileriosis
CBPP	Contagious Bovine Pleuropneumonia
CCPP	Contagious Caprine Pleuropneumonia
CDP	Carnivore Disease Project
cm	Centimetre
CNS	Central Nervous System
FAO	World Food and Agriculture Organisation
IPBES	Intergovernmental Platform on Biodiversity and Ecosystem Service
KM	Kilometre
ml	Millilitre
MPVM	Masters in Preventive Veterinary Medicine
NCA	Ngorongoro Conservation Area
NDC	Ngorongoro District Council
OIE	Office International des Epizooties
Ormilo	A Maasai term describing a condition characterized by nervous signs
RVF	Rift Valley Fever
SNP	Serengeti National Park
SUA	Sokoine University of Agriculture
TADs	Trans-boundary Animal Diseases
TAWIRI	Tanzania Wildlife Research Institute

CHAPTER ONE

1.0 INTRODUCTION

Ngorongoro District with an area of 14 036 square kilometres is one of the six districts of Arusha region, Tanzania and an integral part of the Serengeti ecosystem. It is characterized by remoteness and poor communication in most parts; sparsely populated and seasonal mobility of livestock meant to exploit temporal and spatial variation in range resources largely influenced by rainfall and altitude and to minimize disease risk (Ole-Neselle *et al.*, 2008). The world famous: Ngorongoro Conservation Area (NCA) is a significant part of Ngorongoro District constituting 59% of the district land with an area of 8292 square kilometres. The district is administratively divided into three divisions, 21 wards and 56 villages. About 60.3% of the district human population are subsistence pastoralists, 34.7% are agro-pastoralists and 4.8% others including business men and workers (NDC, 2011). Livestock play a central role in the community livelihoods providing food, cash, insurance and a measure of social status (Cleaveland *et al.*, 2001). Virtually almost all the animals kept are indigenous breeds whose main attribute is physiological adaptation to harsh environment of climate variability, seasonal shortage of feed and high disease challenge. The vast majority of livestock keepers practice transhumance for two main reasons. First is to make full utilization of range resources which varies with season and place and secondly to minimize disease risk (Ole-Neselle *et al.*, 2008). It is estimated that, the district has about 383 000 heads of cattle, 629 000 sheep, 632 000 goats, 22 000 donkeys, 6566 pigs, 48 camels and 12 000 dogs (NDC, 2010).

Several factors have been implicated for the growing poverty in the district. Among them, two have particularly been surfaced out as the most important cause of impoverishment among the livestock keepers in the district, namely livestock diseases and drought. The district in general has a very complex livestock disease situation, which is perhaps unique in the country. This is a result of the diverse eco-climatic conditions found in the district, the close interaction between humans-livestock and wildlife, semi nomadic system of livestock husbandry and cross border livestock movements (Ole Neselle *et al.*, 2008).

From an historical perspective, it is also important to note here that the pastoral ecosystem, and Ngorongoro district in particular, has for many years acted as a gateway for most of the Trans-boundary Animal Diseases (TADs) into Tanzania. All the incidences of major TADs outbreaks documented in the past 40 years for example started in Ngorongoro district. These include the last three outbreaks of Rinderpest in 1965, 1981/82 and 1997; the first incidence of the current panzootic of Contagious Bovine Pleuropneumonia (CBPP) in 1990; and the Rift Valley Fever (RVF) outbreaks of 1998 and 2007. As a result, Ngorongoro district has sometimes been described as the “Natural home “of some of these TADs especially CBPP. For example, Loliondo was the last focus of CBPP in the country before it was eradicated in 1965. The same area became the first focus again when the same disease re-emerged in the country in 1990 after an absence of about 25 years (Loomu, 2010).

Other economically important diseases closely associated with Ngorongoro district include Bovine Cerebral Theileriosis (BCT) or ‘ormilo’, which started in Loliondo in the early 1980s, and Contagious Caprine Pleuropneumonia (CCPP) of which the first confirmed case in the country in 1998 came from Ngorongoro district (Ole-Neselle, 2008).

Among the most important animal diseases affecting livestock in the district, helminthosis cannot be left out. At the same time, extensive livestock herding is commonly associated with keeping of a number of dogs which are used for herding purposes including the protection of the domestic animals against predators. The practice results in close contact between livestock and domestic carnivores which are definitive hosts for several parasites or parasitic helminthes that affect domestic animals and humans as well.

Presence of a disease complex situation notwithstanding, very little research and/or attention has been done especially on small ruminants' ill health in the district. For example, Contagious Caprine Pleuropneumonia (CCPP), a killer disease of goats was only officially confirmed in the country in 1998 although empirical evidence shows that it was prevalent in Ngorongoro district since the early 1980s. Again, although epidemiological and serological evidence suggests that *Peste des Petitis Ruminants* (PPR) incursion in the country might have occurred around 1995, its presence was only officially confirmed in 2008. In addition there are 'new' and emerging diseases like coenurosis for which there is no serious effort to diagnose and investigate thoroughly (Loomu, 2010). The study survey carried out in 2010 in Ngorongoro district indicated that, the cause of a Central Nervous System (CNS) disorder ("ormilo" syndrome) in sheep and goats in the district is due to coenurosis: a condition caused by the larval forms of *Taenia multiceps*. This was after a long period of time of assumptions from among professionals and livestock keepers that the cause (aetiology) of "ormilo" in small ruminants is due to *Theileria taurotragi* infection: a protozoan causing disease in cattle. Generally, apart from Ngorongoro, the distribution of coenurosis elsewhere in Tanzania is also not known though unconfirmed reports suggest that it could also be present in Iringa Pawaga division, Monduli and Hai districts. In order to gain insight into the magnitude and losses the disease is causing, this

study was undertaken where the prevalence of *Taenia multiceps* metacestode (*Coenurus cerebralis*) as well as other metacestodes of *Taenia* and *Echinococcus* particularly *Cysticercus tenuicollis* and hydatid cysts in slab-slaughtered sheep and goats in Ngorongoro district were determined.

1.1 Problem Statement

The basic problem facing the livestock keepers of Ngorongoro District is increasing food insecurity and impoverishment because of a growing threat of livestock diseases. Generally, these threats (livestock diseases) have several impacts. Some of them include; diminished herd size due to increased mortality, direct financial losses from low market value, destabilization of the traditional setup resulting from the migration of labour force, poor health status especially in children (Bakuname *et al.*, 2002) and other direct losses due to death, emergency sales and slaughter, and lost milk production. In short, poor livestock production has resulted in families becoming trapped in a cycle of poverty, with many people now facing destitution (Cleaveland *et al.*, 2001).

Although there has been some broad intervention strategies in reducing livestock mortalities from diseases through improved disease preventive measures in the district, these have largely focused on cattle while the small ruminants have been sidelined. As a result, small ruminants have been suffering more from almost natural calamities especially diseases, despite their food security value and economic importance to the community. Among several diseases affecting sheep and goats, helminthosis is considered to be a major cause of mortality and sub-optimal productivity in traditional farming systems (Ibrahim, 1998).

The study survey carried out in the district indicated that the cause of a central nervous system disorder in sheep and goats is due to cerebral coenurosis, an infection by the larval form of *Taenia multiceps* (canids tape worm) with about 12% mean flock morbidity and 100% case fatality (Miran, 2010. unpublished). The impact of coenurosis ('ormilo' in Maasai language) in the district is now alarming and has become one of the major threats to both local food security and poverty alleviation although its status in Tanzania is not known and/or documented.

1.2 Justification

Small ruminants' production is sometimes and in most cases the only livelihood asset for the poor and women-headed households. Disease poses the most serious threat to livestock survival and healthy animals are central to the livelihoods. A study in 2010 has shown that coenurosis is one of the major small ruminants' health problems; a new threat to small ruminants' production and productivity in the district; of high economic importance and claiming about 12% of the flock annually. Therefore, there is a need to evaluate and document the magnitude of this ill health due to the fact that, there is scanty information on the existence and/or the prevalence of coenurosis (gid) in this particular area and in the country (Tanzania) as a whole. Apart from being a demand driven and problem-solving, the output of this study will also give highlights on the magnitude on health problems and form the basis for further research on the parasite's socio-economic impact and its epidemiology (host spectra) aiming at suggesting the appropriate control measures and ultimately its control, if not elimination in the domestic populations.

1.3 Objectives

1.3.1 Main objective

The main objective was to determine the prevalence of coenurosis in slab-slaughtered sheep and goats and explore the predisposing factors of the disease in Ngorongoro district with a view of suggesting the appropriate control measures.

1.3.2 Specific objectives

- i. To establish the prevalence of coenurosis in slab-slaughtered sheep and goats
- ii. To assess the community/livestock keeper's awareness and knowledge on the epidemiology of coenurosis and determine the predisposing factors
- iii. To determine the prevalence of metacestodes of *Taenia* and *Echinococcus* in sheep and goats
- iv. To determine the prevalence of taeniid (tapeworms) in domestic dogs.

CHAPTER TWO

2.0 LITERATURE REVIEW

Different species of tapeworms occur in different vertebrates and they cycle through three stages i.e. eggs, larvae, and adults. They all require definitive and intermediate hosts in order to complete their life cycle. Domestic livestock may, depending on the species of tapeworm, be involved as either the definitive hosts, or as the intermediate hosts. *Taenia* species are long, segmented, parasitic tapeworms. Cestodes of Taeniidae family which infect dog (definitive host) are transmitted to a range of intermediate host species where they cause echinococcosis, cysticercosis or coenurosis (Radfar *et al.*, 2005). As with other tapeworms, these parasites have an indirect life cycle, cycling between a definitive and an intermediate host. Most of the adult tapeworms live in the intestines of the definitive hosts. Species of *Taenia* cause significant health problems and considerable socio-economic losses when infecting humans and livestock (Murell, 2005). In general, the more significant problems from cestodes in livestock are caused when they are involved as intermediate hosts (Anas *et al.*, 2011; Achenef *et al.*, 1999; Soulsby, 1982).

copyright O'Meara -
Pet Informed 2009

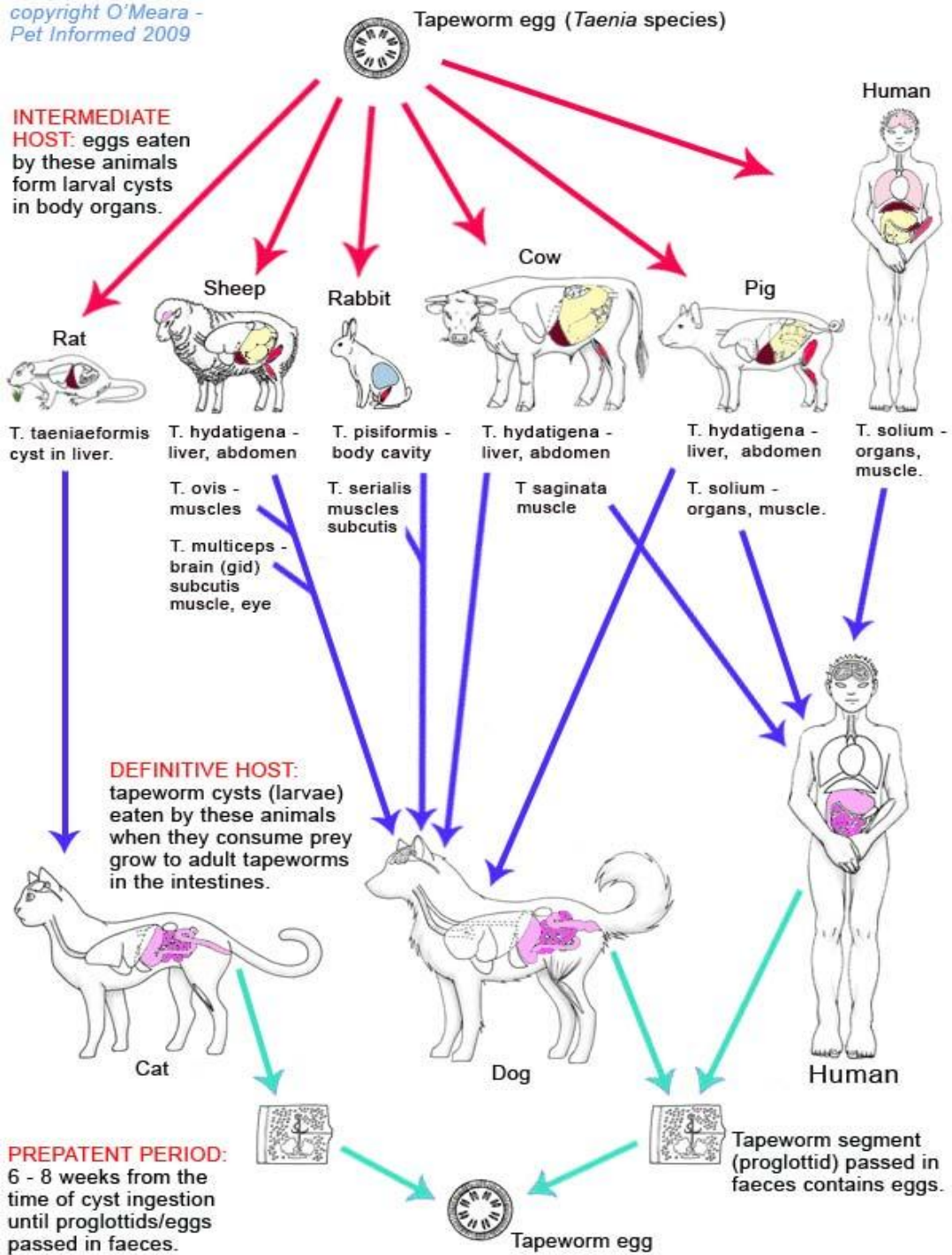


Figure 1: The *Taenia* tapeworm life cycles diagram

Source: <http://www.pet-informed-veterinary-advice-online.com/Taenia.html>

2.1 Coenuroses

Infection with the larval forms of *Taenia multiceps*, *T. serialis* and *T. brauni* is called coenurosis. The larval stage is called a *coenurus* (plural: coenuri). The larval stages of these tapeworms are also known as *Coenurus cerebralis*, *C. serialis* and *C. brauni* respectively. Humans can be infected with the metacestodes of *T. multiceps*, *T. serialis* and *T. brauni*. Animals can also be intermediate hosts for these three species. In the case of *T. multiceps*, coenuri are usually most often found in the CNS of ruminants. However, horses, pigs and human beings can also be infected by this metacestode (Soulsby, 1982). *T. serialis* coenuri are usually found in the subcutaneous tissues, muscles and retroperitoneally of lagamorphs but have also been found in the human brain and *T. brauni* larvae tend to be found in the subcutaneous tissues and the eye and this parasite has only been reported in Africa (Acha and Szyfres, 2003).

2.2 *Taenia multiceps*

Taenia multiceps (Leske, 1780) (syn. *Multiceps multiceps*) is a parasite which inhabits the small intestine of dogs, foxes, coyotes and jackals (Scala *et al.*, 2007). Morphologically the adult worms are whitish, dorsoventrally flattened, segmented and measure up to 50 cm. The larval stages (*Coenurus cerebralis*), are round or oval, large and bladder-like, filled with fluid and have several protoscolices attached to inner side of cyst wall (Desouky *et al.*, 2011).

2.3 Coenurosis (Gid)

Coenurosis is a disease caused by *Coenurus cerebralis*, the larval stage of *Taenia multiceps*, particularly affects sheep and goats (Oge *et al.*, 2012). The clinical signs of the disease develop when the CNS of the sheep/goat is invaded by *Coenurus cerebralis* cyst (Edwards and Herbert, 1982; Avcioglu *et al.*, 2012). Clinical syndrome is based on

location and size of the *Coenurus* cyst in the brain (Avcioglu *et al.*, 2012). It can occur in both acute and chronic disease form. Acute coenurosis occurs during the migratory phase of the larvae, usually about 10 days after the ingestion of large numbers of the tapeworm eggs. Young lambs/kids aged 6-8 weeks are most likely to show signs of acute disease and the signs are associated with an inflammatory and allergic reaction. There is transient pyrexia, and relatively mild neurological signs such as listlessness and a slight head aversion. Occasionally the signs are more severe and the animal may develop encephalitis, convulse and die within 4 - 5 days (Skerritt, 1991).

2.4 Distribution

Is widespread; most of the cases have been reported from Africa. It has been documented in scattered foci throughout the world, including the Americas and parts of Europe and is probably distributed worldwide (Abo-Shehada *et al.*, 2002; Sharma and Chauhan, 2006). In Africa, the disease (coenurosis) has been documented in Ethiopia, Ghana, Mozambique, Uganda, Egypt (Desouky *et al.*, 2011), Democratic Republic of Congo, Senegal, Sudan, Chad, Angola, Kenya and Southern Africa (Afonso *et al.*, 2011).

2.5 Taenia multiceps Life Cycle

Taenia multiceps is a taeniid cestode that in its adult stage, lives in the small intestine of dogs and other canids (Varcasia *et al.*, 2009). Its life cycle can be described as follows; Eggs and gravid proglottids are shed in faeces into the environment by infected definitive hosts (canids). Many animals may serve as intermediate hosts, including rodents, rabbits, cattle, sheep, goats and humans. Intermediate hosts are infected when they ingest the egg(s). Once they are ingested, the eggs hatch in the intestine of the intermediate host releasing oncospheres. These oncospheres circulate in the blood until they lodge in suitable organs (skeletal muscle, eyes, brain/spinal cord, muscles or subcutaneous tissue).

After about three months, the oncospheres develop into cystic like larval balls called coenuri which have many protoscolices. The cycle perpetuates when a canid (definitive host) ingests viable cysts. When this happens, the protoscolices attach on mucosa of the small intestine of the definitive host and develop into adult worms and mature proglottids are fertilized and develop into gravid proglottids which contain gravid uterus with eggs. Gravid proglottids detach from strobila of the worm and are passed out with faeces to the environment (Sousby, 1982).

2.6 Pathogenesis and Clinical Signs

An acute meningoencephalitis may develop if a large number of immature stages migrate in the brain and young lambs/kids aged 6-8 weeks are most likely to show signs of acute disease (Özkan *et al.*, 2011, Giadinis *et al.*, 2012). The signs are associated with an inflammatory and allergic reaction. Usually there is transient pyrexia, and relatively mild neurological signs such as listlessness and a slight head aversion. In rare cases the signs are more severe and the animal may develop encephalitis, convulse and die within 4 - 5 days (Skerritt, 1991).

Chronic coenurosis typically occurs in sheep of 16-18 months of age. The time taken for the larvae to hatch, migrate and grow large enough to present nervous dysfunction varies from 2 to 6 months (Giadinis *et al.*, 2012). The earliest signs are often behavioural, with the affected animal tending to stand apart from the flock and react slowly to external stimuli. As the cysts grow, the clinical signs progress to depression, pyrexia, unilateral blindness, circling, altered head position (head aversion), incoordination, paralysis (Bussell *et al.*, 1997; Mohi El-Din, 2010) and recumbency. Unless treated surgically, the animal will die after recumbency (Skerritt, 1991).

2.7 Diagnosis

Diagnosis is based on epidemiological, clinical and laboratory findings (Edwards and Herbert, 1982). The disease is more complicated and severe when the oncospheres settle in the CNS tissue. In most cases, major clinical signs are depression, unilateral blindness, circling, altered head position, incoordination, paralysis (Bussell *et al.*, 1997) and recumbency. At postmortem, the presence of whitish specks on the transparent cyst (containing clear fluid and numerous protoscolices) wall and germination membrane representing the protoscolices are seen.

2.8 Differential Diagnosis

2.8.1 Scrapie

This is an infectious transmissible fatal degenerative disease affecting the central nervous system of sheep and goats. The disease is caused by a prion (protein particle similar to a virus but lacking nucleic acid) and is usually observed in animals older than 2 years. Early signs include subtle changes in behavior or temperament. These changes may be followed by scratching and rubbing against fixed objects, loss of coordination, weakness, weight loss despite retention of appetite, biting of feet and limbs, lip smacking, and gait abnormalities, (high-stepping of the forelegs, hopping like a rabbit, and swaying of the back end) and the disease is often accompanied by pruritus.

2.8.2 Listeriosis

Listeriosis is an infection caused by the bacterium *Listeria monocytogenes*. The disease can affect sheep, goats and cattle. Symptoms include depression, decreased appetite, fever, stumbling or moving in one direction only, head pulled to flank with rigid neck, facial paralysis on one side, slack jaw, and abortions. The disease is curable by use of antibiotics such as procaine penicillin.

2.9 Treatment

The most common and widely applied treatment for this disease is surgical removal of the cysts under general anaesthesia of the animal; the approach has a very good success rate, especially when the lesion is accurately located (Scott, 2012). In most cases, the use of Albendazole either alone or combined with praziquantel post surgery to prevent dissemination of parasite cysts/secondary cysts is used as in hydatidosis therapy. Other treatments that have shown positive results are the use of praziquantel and albendazole (Scala and Varcasia, 2006). However, to date, no useful information is available regarding the effectiveness of chemotherapeutic treatment against *T. multiceps* metacestode infection (El-On *et al.*, 2008). Taeniasis can be treated with praziquantel, epsiprantel, mebendazole, febantel and fenbendazole (Scala and Varcasia, 2006).

2.10 Control and Prevention

The best control and prevention method of coenurosis is to prevent dogs from having access to intermediate hosts carcasses and not to feed them uncooked meat (Edwards *et al.*, 1979). In addition, the control and prevention of coenurosis should be based on routine anthelmintic dosing of dogs, preferably every three months with anthelmintic compounds such as bunamidine, niclosamide or praziquantel (Bussell *et al.*, 1997). To date, there are no commercially available vaccines against *T. multiceps*. However, there has been vaccine trial in sheep using recombinant oncosphere antigens formulated with Quil A adjuvant (Tm 16 and Tm 18) (Gauci *et al.*, 2008; Varcasia *et al.*, 2009) in which there was a significant reduction in the number of coenurosis cases in the vaccinated animals.

CHAPTER THREE

3.0 MATERIAL AND METHODS

3.1 Study Area

The research was undertaken in Ngorongoro district (Fig. 2) Northern Tanzania, which is bordered by the Kenya to the North, Serengeti National Park to the west, Longido and Monduli districts to the east and Karatu District to the south. Three villages of Endulen, Malambo and Waso were purposively selected based on the geographical location (one from each of the existing three divisions) and the presence of a slaughter slab where a frequent slaughter of sheep and goats takes place.

3.2 Study Design

This was a cross sectional study. From January 2013 to April 2013, visits were made to slaughter slabs during meat inspection where heads of slaughtered sheep and goats were collected. In each month, an average of fifty animals (25 sheep and 25 goats) of both sexes and of different age ranges slaughtered at three local slaughter slabs (Waso, Malambo and Endulen) were randomly chosen, individually identified, and brain extracted and examined for the presence of *C. cerebralis*, cyst(s).

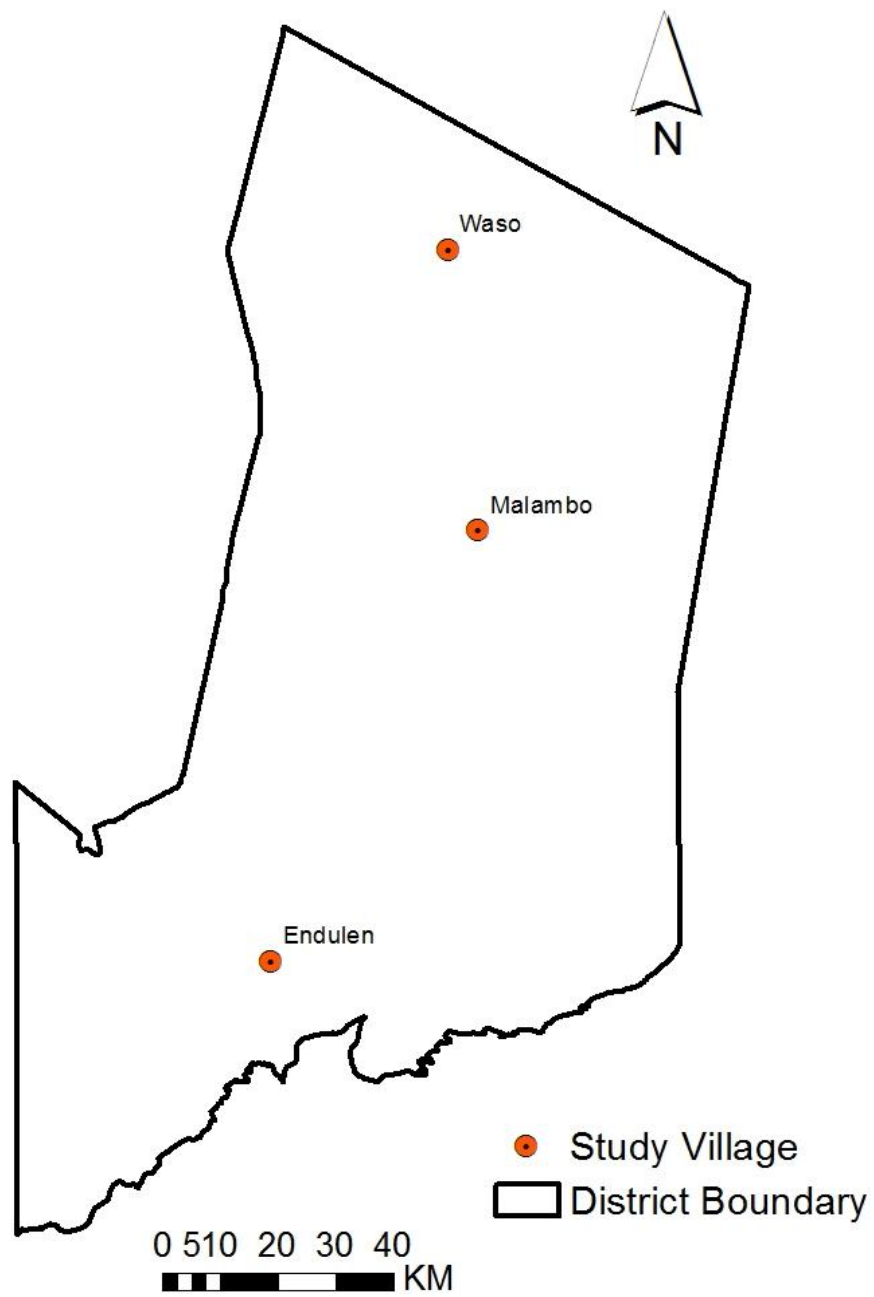


Figure 2: Ngorongoro district sketch map showing the study villages

3.3 Types of Data and Sample Size

Two types of data were collected; primary and secondary data. Questionnaire interviews and biological samples were used to collect/gather the primary data. Secondary data were collected from relevant library and through web browsing. Sample size was calculated using Martin *et al.* (1987) formula: $n = Z^2 PQ / L^2$.

Where; n = required sample size;

Z = Z value for a given confidence level (95% = 1.96);

Q = (1-P); L = allowable error (0.05) and

P = known or estimated prevalence.

The estimated prevalence was 12%. Therefore, the calculated sample size was $1.96^2 \times 0.12 \times 0.88 / 0.05^2 = 162.2$. However, the practical working sample was raised to 180.

3.4 Sample Collection, Processing and Cyst Identification

Biological samples included brain from sheep and goats and dog faeces. Only animals originating from within the village and the surrounding area where a particular slaughter slab is located were examined during the study. To avoid or minimize the inclusion of slaughtered animals originating from outside the study area, animals slaughtered during livestock market days were excluded in the study.

The presence of other tape worm metacestodes (specifically *Cysticercus tenuicollis* and hydatid cyst) in the same carcass and/or their internal organs were also examined and the results/findings were recorded. Age, sex and history/place of origin prior slaughter, number of cysts and site of lodge in the brain at post-mortem were also recorded.

3.4.1 Brain samples – Extraction and examination

The heads of slaughtered sheep and goats were collected, followed by skin removal and careful opening of the skull using a machete without damaging brain. Meninges were incised using a scalpel blade to expose brain tissue. Whole brain of individual animal was collected and examined for the visible cyst (*Coenurus cerebralis*).

3.4.2 Faecal sample collection and processing

Faecal samples of 205 domestic dogs (one sample per animal) from the same villages where slaughter slabs are located (Waso - highland, Endulen - medium and Malambo - lowland) were collected in this study. Faecal samples were collected per rectum using fingers in glove, stored tightly closed in the plastic tubes which were labelled and transported to Tanzania Wildlife Research Institute (TAWIRI) Serengeti laboratory. Faecal samples were screened for the presence of taeniid egg. The age, sex and other health information including general husbandry with regards to a particular dog were also recorded.

Operating procedures regarding the safety of researchers, community and environment were strictly adhered to at all stages of sample collection, storage, transportation and processing. Faecal samples were analysed and interpreted using Formalin-Ether Sedimentation Technique for Fresh Material (Ash, and Orihel, 1987). Results were expressed either as positive or negative after microscopic examination based on the presence or absence of taeniid eggs.

3.5 Procedure/Protocol

An approximate of 1.0 – 1.5 g of fresh faecal material was comminuted in 10 ml 10% formalin in a 50 ml cup. Suspension was strained through two layers of wet gauze directly

into a 15 ml conical centrifuge tube; the tube was filled almost to the rim with 0.85% saline solution and spun at 4000 x g for 2 minutes. In case the supernatant was still cloudy, it was discarded: the sediment resuspended and centrifuged again at 4000 x g using a 0.85% saline solution. The supernatant was then discarded and the sediment resuspended using 10% Formalin by sharply flicking the bottom of the tube and more Formalin was added to bring the total volume of the suspension to 10 ml. Then 3 ml Ether added, and shaken vigorously for about 3 seconds: centrifuged at 5000 x g for three minutes. The outcome formed four layers namely ether, debris that adheres to the wall of the tube, formalin and sediment layers as it is shown in Fig. 3. An applicator stick was inserted to ring and loosen the plug of debris and three top layers were decanted and discarded. By using a glass pipette, a drop of saline was added and mixed with sediment. Unstained wet mounts for examination was prepared for each sample and screened using light microscope.

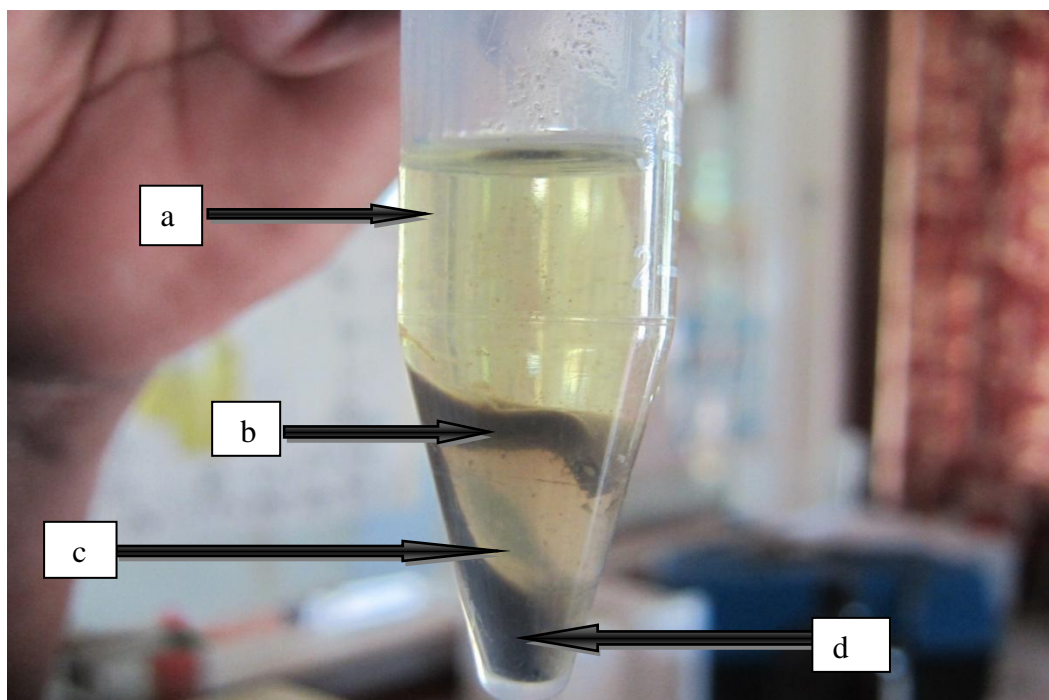


Figure 3: Four layers; from top, (a) ether (b) debris (c) formalin and (d) sediment

3.6 Interviews – Questionnaire Survey

A structured questionnaire was used to assess the community awareness and knowledge on the epidemiology and the predisposing factors of coenurosis. Two main areas of knowledge were assessed, namely the cause of coenurosis and how it is transmitted. Three villages were selected where slaughter slabs exist and at least forty interviews were carried out per village. The selection criteria of an interviewee depended on convenience and/or owning dog(s). A total of 123 livestock keepers/farmers were interviewed individually. The results were expected to generate information on the community awareness and knowledge on the epidemiology and the predisposing factors of coenurosis. The timeline on the presence of the disease in the study area was also established.

3.7 Data Analysis

Data were coded and entered in a Microsoft Office Excel (spread sheet) and analysed using Epi Info 7 software. Descriptive statistics were computed. Prevalence was computed as the proportion of sampled animals which harbour cysts. The Chi-square test was used to assess statistical difference between proportions. In all analyses, a critical probability of $p < 0.05$ was used for statistical significance.

CHAPTER FOUR

4.0 RESULTS

4.1 Prevalence of *Coenurus cerebralis* Cysts

The heads of 180 sheep and goats (90 heads from each species) were grossly examined and eighty (44.4%) of the total heads were found to have *Coenurus cerebralis* cysts in the brain. The overall prevalence of coenurosis in slab-slaughtered sheep and goats was found to be 44.4% (95% CL: 37.05%, 52.02%) while the individual species prevalence's are 45.6% and 43.3% in sheep and goats respectively as indicated in Table 1. The highest species prevalence was recorded in goats (76.7%) at Malambo slaughter slab and 73.3% prevalence in sheep recorded at Waso and the lowest prevalence was 6.7% at Endulen slaughter slab. The detailed findings are summarized in the Tables 2 below. There was no statistical significant difference ($\chi^2 = 0.054$, $p = 0.814$) in the prevalence's of sheep and goats.

Table 1: Prevalence of *Coenurus cerebralis* cysts in sheep and goats

Species	No. examined	+ve cases	Prevalence (%)
Ovine	90	41	45.6
Caprine	90	39	43.3
Total	180	80	44.4

Table 2: Prevalence of *C. cerebralis* per slaughter slab according to species

Slaughter slab	Species	No. examined	+ve cases	Prevalence (%)
Waso	Ovine	30	22	73.3
	Caprine	30	12	40.0
Malambo	Ovine	30	17	56.7
	Caprine	30	23	76.7
Endulen	Ovine	30	2	6.7
	Caprine	30	4	13.3
Total		180	80	44.4

4.1.1 Coenurosis age wise prevalence

Prevalences of coenurosis by age of sheep and goats slaughtered is shown in Table 3 in which the young animals (≤ 1 year) had prevalence of 100% in Malambo and Waso slaughter slabs, followed by the middle age ($>1-2$ years) with 76.5% and 61.5% prevalences in Waso and Malambo respectively. The adults (>2 years) had the lowest prevalences i.e. 35.2%, 25.0% and 11.8% in Waso, Malambo and Endulen respectively.

Table 3: Prevalence rates of coenurosis by age of sheep and goats per slaughter slab

Slaughter slab	Age	Number examined	Infected	Prevalence (%)
Waso	<1 – 1yr	9	9	100
	>1 - 2yr	17	13	76.5
	>2yr	34	12	35.2
Malambo	<1 – 1yr	27	27	100
	>1 -2yr	13	8	61.5
	>2yr	20	5	25.0
Endulen	<1 – 1yr	0	0	0.0
	>1 -2yr	9	0	0.0
	>2yr	51	6	11.8

4.1.2 Number of *Coenurus cerebralis* cyst

In total, one hundred and twenty (n=120) *Coenurus cerebralis* cysts were recovered. Number of cyst(s) per examined head/brain ranged from one to three (1 – 3) and the heads infested by one cyst accounted for 57.5% of the total heads. Thirty five percent and 7.5% were infested by two and three cysts (*C. cerebralis*) respectively as per Table 4. The recovered cysts were thin walled with clear/transparent cyst fluid (Fig. 4B and C) and contained numerous protoscolices. In most cases, the cysts were superficially located (Fig. 4D) and some were big and occupied almost one third of the brain tissue compartment (Fig. 4A).

Table 4: Number of *Coenurus cerebralis* cyst according to species

Species	Number infected	Number of <i>C. cerebralis</i> cyst		
		1	2	3
Ovine	41	26 (63.4)	13 (31.7)	2 (4.9)
Caprine	39	20 (51.3)	15 (38.5)	4 (10.3)
Total	80	46 (57.5)	28 (35.0)	6 (7.5)

4.1.3 Predilection sites of *Coenurus cerebralis* Cysts

The predilection sites (Table 5) were the right hemisphere (51.3%), left hemisphere (43.8%) and cerebellum (5.0%). Most of the cysts were superficially located and bulging (Fig. 5).

Table 5: *Coenurus cerebralis* cysts locations in sheep and goats

Species	Site of lodge (%)		
	Right hemisphere	Left hemisphere	Cerebellum
Ovine	56.1	41.5	2.4
Caprine	46.2	46.2	7.7
Overall	51.3	43.8	5.0

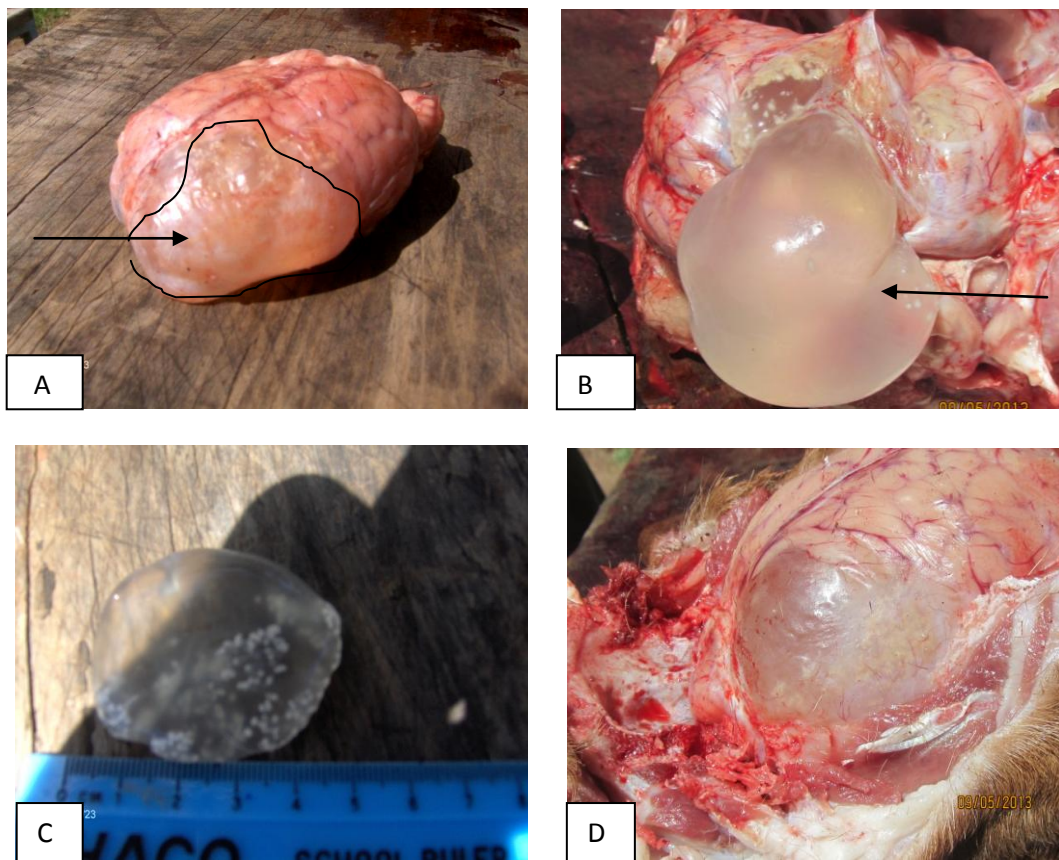


Figure 4: Photographs of *Coenurus cerebralis* cysts. (A) Large *Coenurus cerebralis* cyst occupying almost the right hind lobe of brain under the meninges (B) Individual *coenurus* cyst (arrow) coming out the cranial cavity after capsule rupture (C) *Coenurus cerebralis* cyst containing numerous protoscolices (D) bulging *Coenurus cerebralis* cyst in brain of goat.

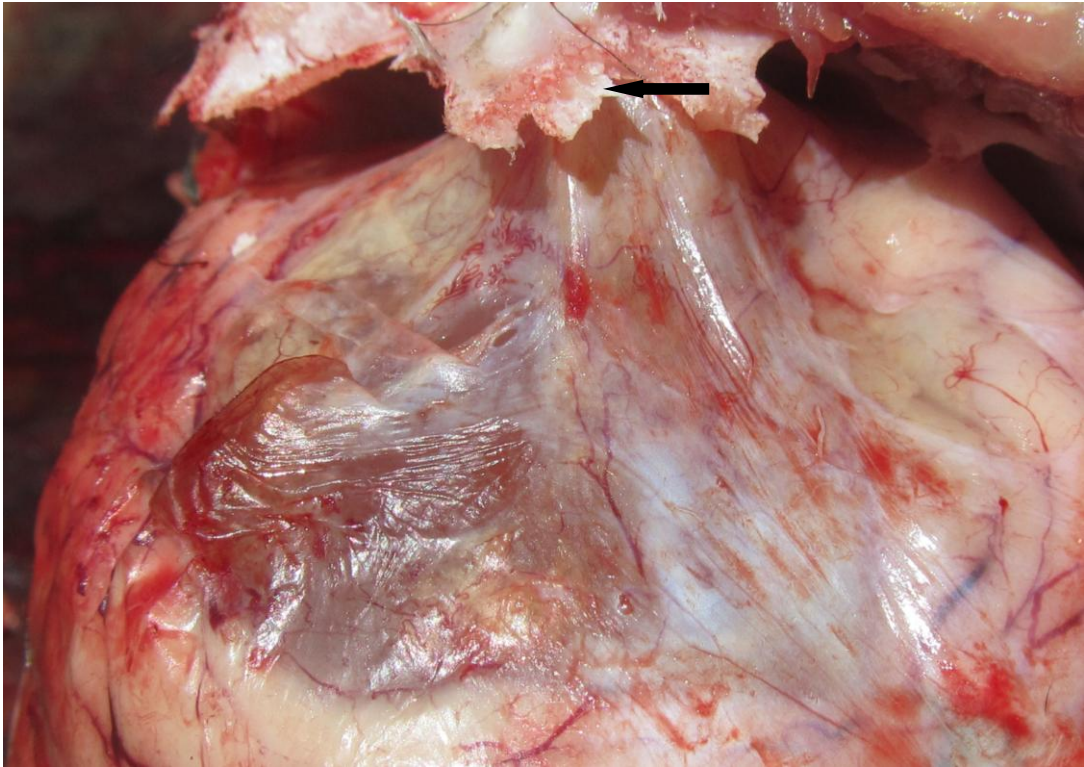


Figure 5: A gross picture of sheep brain showing a complex type meningeal cyst adhering to the dorsum of the skull (arrow). The intact cyst extends ventrolaterally along the cerebrum compressing the brain.

4.2 Prevalence of Metacestodes of *Taenia* and *Echinococcus* Worms

The prevalence's of *Echinococcus granulosus* and *Taenia hydatigena* metacestodes in three slaughter slabs in comparison with the infection rates (prevalence) of *Coenurus cerebralis* are as indicated in Table 6, whereas the prevalence's of the same categorised by species and by sex is detailed in Table 7.

Table 6: Prevalences of *Taenia* and *Echinococcus* metacestodes in sheep and goats in three slaughter slabs

Slaughter slab	Species	<i>C. cerebralis</i>	<i>C. tenuicollis</i>	Hydatid cyst
		(%)	(%)	(%)
Waso	Ovine	73.3	36.7	16.7
	Caprine	40.0	63.3	16.7
Malambo	Ovine	56.7	60.0	30.0
	Caprine	76.7	70.0	40.0
Endulen	Ovine	6.7	30.0	3.3
	Caprine	13.3	50.0	10.0
Total	Sheep & goats	44.4	51.7	19.4

Table 7: Prevalences of *Taenia* and *Echinococcus* metacestodes categorised into species and by sex

Species	Prevalence of metacestode (%)					
	<i>Coenurus</i> cyst		Hydatid cyst		<i>C. tenuicollis</i>	
	Male	Female	Male	Female	Male	Female
Ovine	38.3	60.0	16.7	16.7	40.0	46.7
Caprine	36.6	49.0	19.5	24.5	63.4	59.2
Total	37.6	53.2	17.8	21.5	49.5	54.4

4.2.1 Mixed infections/co-existence rates of metacestodes

A total of 139 (77.2%) carcasses were infected by different metacestodes (64 sheep and 75 goats). Of these, 42.5% (n = 59) were mixed infections (Table 8). The highest and the lowest concurrent infections were 20.9% and 2.2% rates observed between *T. multiceps* and *T. hydatigena*: and *T. multiceps* and *Echinococcus* metacestodes.

Table 8: Mixed infection rates of *Taenia* and *Echinococcus* metacestodes

Species	<i>C. c</i> & <i>C. t</i>	<i>C. c</i> & <i>H. c</i>	<i>C. t</i> & <i>H. c</i>	<i>C. c</i> & <i>C. t</i> & <i>H. c</i>
	(%)	(%)	(%)	(%)
Ovine	20.3	3.1	9.4	7.8
Caprine	21.3	1.3	13.3	8.0
Total	20.9	2.2	11.5	7.9

Key: *C. c* (*Coerurus cerebralis*), *C. t* (*C. tenuicollis*) and *H. c* (hydatid cyst)

4.2.2 *Taenia hydatigena* infection

During postmortem examination, the larval form of this worm (*C. tenuicollis*) was found attached on the mesenteries. The overall prevalence was 51.7% (95% CL: 44.11%, 59.16%) and only 27.3% appeared as a single infection. The species prevalences were 61.1% and 42.2% in goats and sheep respectively as shown in Tables 9 and 10. The prevalences in sheep and goats had statistically significant difference ($\chi^2 = 6.35$, $p = 0.011$).

Table 9: Prevalence of *Cysticercus tenuicollis* in slab-slaughtered sheep and goats in Ngorongoro district

S/slab	Species	# examined	# infected	Prevalence (%)
Waso	Ovine	30	11	36.7
	Caprine	30	19	63.3
Malambo	Ovine	30	18	60.0
	Caprine	30	21	70.0
Endulen	Ovine	30	9	30.0
	Caprine	30	15	50.0
Total	Sheep & goats	180	93	51.7

Key; # = number

Table 10: Species wise prevalence of *Cysticercus tenuicollis* cysts

Species	Number examined	Number infected	Prevalence (%)
Ovine	90	38	42.2
Caprine	90	55	61.1

4.2.3 Echinococcosis

Of 180 examined carcasses, 19.4% (95% CL: 13.93%, 25.99%) were infected by hydatid cyst (Table 11), 16.6% were found in sheep and 22.2% in goats. Forty percent and 22.9% of the cysts were located only in lungs and liver respectively (Table 12). Concurrent infections were 25.7% in the liver and lungs; 2.9% in the lungs together with spleen and 8.6% in three organs (liver, lungs and spleen). No hydatid cyst(s) were found to be located either in the spleen or in liver and spleen concurrently in sheep. The differences in the prevalence in the species and sex were both not statistically significant i.e $\chi^2 = 0.82$ ($p=0.36$) and $\chi^2 = 0.323$ ($p=0.569$) respectively.

Table 11: Prevalence of hydatid cyst in slaughtered sheep and goats per slaughter slab

Slaughter Slab	Species	# examined	# infected	Prevalence (%)
Waso	Ovine	30	5	16.7
	Caprine	30	5	16.7
Malambo	Ovine	30	9	30.0
	Caprine	30	12	40.0
Endulen	Ovine	30	1	3.3
	Caprine	30	3	10.0
Total		180	35	19.4

Key: # = number

Table 12: Prevalence and distribution pattern of Hydtid cyst in different organs in slab-slaughtered sheep and goats in Ngorongoro district

Species	Organ location in percentage				
	Liver	Lungs	Liv&lun	Lun&spl	All
Ovine	20.0	46.7	26.7	0.0	6.7
Caprine	25.0	35.0	25.0	5.0	10.0
Total	22.9	40.0	25.7	2.9	8.6

Key: liv&lun (liver and lungs), Lun&spl (lungs and spleen) and All (liver, lungs and spleen), Total (sheep and goats)

4.3 Awareness and Knowledge of Livestock Keepers in Relation to Coenurosis

In total, 123 responses (11.4% women and 88.6% men) were received. All the respondents (100%) agreed that they have seen clinical case(s) of coenurosis and are likely to diagnose it accurately on the basis of clinical manifestations without further testing. At the same time, all the respondents (100%) were totally ignorant about the cause of coenurosis and the mode of transmission as per Table 13.

Table 13: Awareness and knowledge of livestock keepers in relation to coenurosis based on questionnaire survey

Awareness and knowledge	Number of respondents	Number of +ve responses	% of +ve responses
Ever seen the disease	123	123	100
Know the cause	123	0	0
Know mode of transmission	123	0	0

4.4 Predisposing Factors of the Disease

4.4.1 Disposal of animal offal and infected organs/brain

The study found that, during home slaughters, 40.5% of respondents throw raw brain to dogs; 55.4% throw into bush; 1.7% burn; 0.8% burry and 1.7% feed the brain from the animals that had died or had been slaughtered to their dogs after cooking (Table 14).

Table 14: Ways of disposal of brain and other infected organs

Way of disposal	Number of respondents	Number of +ve responses	% of +ve responses
Thrown raw to dog(s)	121	49	40.5
Thrown raw into bush	121	67	55.4
Burned	121	2	1.7
Fed to dog after cooking	121	2	1.7
Buried	121	1	0.8

4.4.2 Potential predisposing factors associated with the transmission and persistence of *T. multiceps*

The study has also shown that, potential predisposing factors associated with the transmission of *T. multiceps* and of its associated disease are; dogs left free all time and some are shepherd dogs (98.2%), lack of worm control in dog(s) (93.6%), brain thrown raw into bush (55.4%) and brain thrown raw to dog(s) (40.5%) as per Table 15. At the same time, it was found that deworming of domestic dogs was influenced by the farming system, whereby in pastoral areas 100% of the respondents have never dewormed their dogs before while only 17.9% in agro-pastoral areas where veterinary services are available they sometimes deworm their dogs although not routinely.

Table 15: Potential predisposing factors of coenurosis based on questionnaire survey in Ngorongoro district

Predisposing factors	Number of respondents	Number of +ve responses	% of +ve responses
Lack of worm control in dog(s)	110	103	93.6
brain thrown raw to dog(s)	121	49	40.5
Brain thrown raw into bush	121	67	55.4
Domestic dogs scavenging	110	10	9.1
Dogs left free all time and herding	110	108	98.2

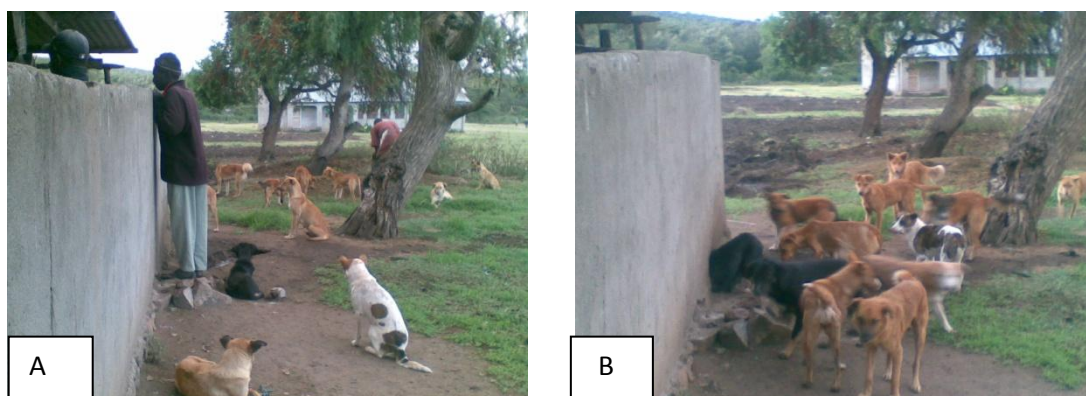


Figure 6: (A) and (B): Dogs surrounding slaughter slab at Waso, Ngorongoro district.

4.4.3 Sighting of wild carnivores sharing grazing areas with livestock

The wild carnivores particularly hyena (*Crocuta crocuta*), jackals (*Canis mesomelas*, *C. aureus*, and *C. adustus*) and wild dogs (*Lycaon pictus*) which might serve as definitive host for the tapeworms were seen in different frequencies in the grazing ground/land by questionnaire respondents. The sighting frequencies of wild carnivores in the grazing land are indicated in Table 16 below where hyenas and jackals were the mostly sighted animals. Domestic wildlife animal interface is a common feature in most parts of the district (Fig. 7).

Table 16: Sighting frequencies of wild carnivore in the grazing land based on questionnaire survey

Wild carnivore	Sighting frequency (%)		
	Often	Occasionally	Never
Hyena	89.4	10.6	0
Jackals	78.0	21.1	0.8
Wild dogs	9.8	61.8	28.5



Figure 7: Wild animals sharing grazing ground/field during the day with sheep in Piyaya/Malambo plains, Ngorongoro district.

4.5 Impacts of Coenurosis on Livestock Owners

Coenurosis was ranked amongst the most important sheep and goats diseases in the study area, where 58.8% and 47.9% of respondents ranked it as the disease of most concern in sheep and goats respectively in terms of mortality and all have felt the effects of the disease. Among the direct losses arising from cerebral coenurosis are emergency sales or slaughter of affected animals once the clinical disease became apparent and sometimes death occur. For example, out of 54 respondents who sold sick goats in the past one year, 66.7% sold goat due to coenurosis.

During the questionnaire survey, there were no reports of any animals (sheep and/goat) having recovered from coenurosis clinical case (the outcome is usually fatal). All young sheep and goats of up to one year old that were slaughtered at Waso and Malambo

slaughter slabs had *C. cerebralis* infection. This indicates that they were slaughtered because they were sick. In coenurosis clinical cases, 23.1% respondents indicated that the animals are slaughtered at home, 4.1% of respondents sell the animals live in market/butcher and 72.7% would sell to butcher/market or slaughter at home at low price depending on the physical condition of the animal.

Table 17: Rank of coenurosis disease by importance in sheep and goats

Species	Rank				
	1	2	3	4	5
Ovine	58.5	27.2	12.3	0.9	0.9
Caprine	47.9	34.7	16.5	0.8	0

Key: 1 = most important followed by 2, 3 and 4 in the descending order. 5 = least important

4.6 Timeline

Respondents had different views on when the disease (coenurosis) occurred for the first time in their flocks or when they had seen the “ormilo” syndrome in sheep and/or goats elsewhere for the first time. The majority of respondents (43.1%) agreed that the disease (coenurosis) has been prevalent in their areas/flocks for the period of less than 10 years while 17.9% in less than five years and 39% in more than 10 years back. The responses in percentage per specific village are detailed in Fig. 8.

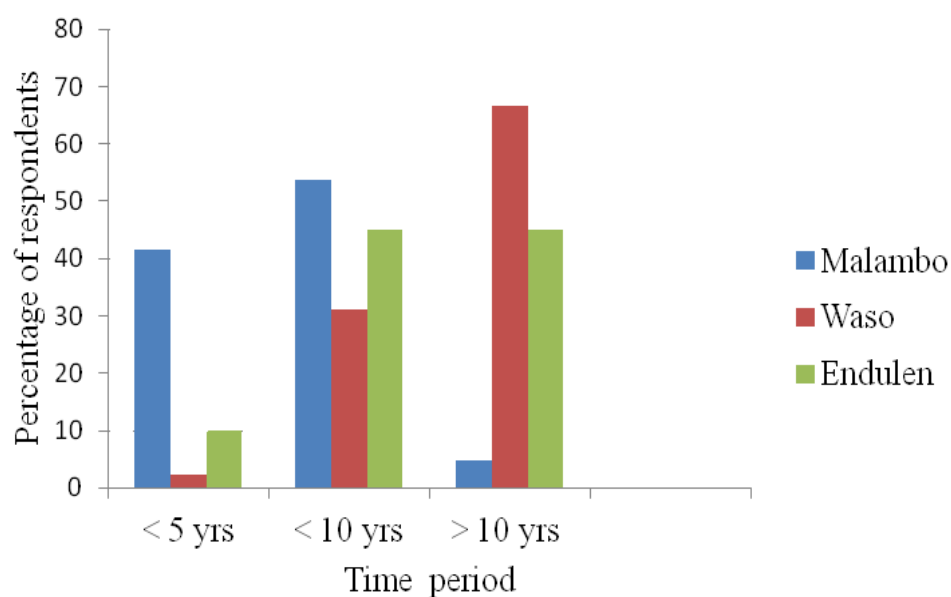


Figure 8: Percentage of respondents in relation to coenurosis time occurrence per village

4.7 Taeniid Eggs in Domestic Dogs

4.7.1 Prevalence of taeniid eggs in domestic dogs population

Two hundred and five domestic dog faecal samples were screened for the presence of taeniid eggs. Out of the total faecal samples, only 26.8% were negative for taeniid infections while 73.2% faecal samples were positive (Fig. 9). Table 18 illustrates prevalence of taeniid eggs in domestic dogs in specific village.

Table 18: Prevalence of taeniid eggs in domestic dogs

Village	Number examined	Number (+ve)	% +ve
Waso	93	75	80.6
Malambo	76	48	63.2
Endulen	36	27	75.0
Total	205	150	73.2

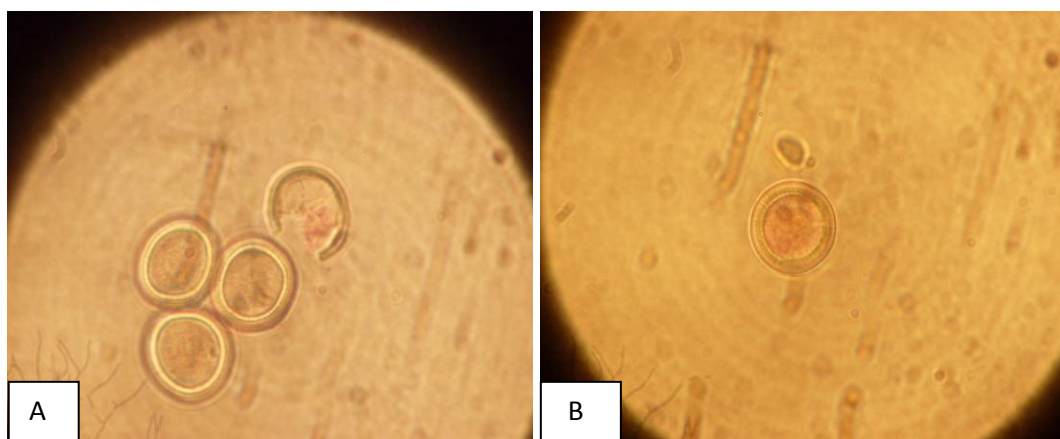


Figure 9: Photographs: A: Four taeniid eggs B: single taeniid egg

4.7.2 Prevalence of taeniid eggs in different age groups of dogs

Table 19 summarises the infestation rates per specific age group. Higher prevalence (80.0%) was observed in young dogs <1 year to 2 years (72.7%) and in adults >3 years (75.3%). Adults aged >2 – 3 years had the lowest prevalence of 58.3%.

Table 19: Infection rates (prevalence) of taeniid eggs per specific age group

Age	Number examined	Number +ve	% +ve
<1 yr	30	24	80.0
1 – 2 yrs	66	48	72.7
>2 – 3 yrs	24	14	58.3
>3 yrs	85	64	75.3

CHAPTER FIVE

5.0 DISCUSSION

To the best of my knowledge, there has been no report to date describing the occurrence of coenurosis in Tanzania. So, results in this study report for the first time the occurrence on one hand and the prevalences on the other hand of coenurosis in slaughtered sheep and goats due to *Taenia multiceps* metacestode (*Coenurus cerebralis*) in Ngorongoro district. Currently, coenurosis is one of the setbacks in sheep and goats production and productivity in the area. For a long period of time wrong assumptions have been made from among professionals and livestock keepers that, the cause of “ormilo” in small ruminants in the area was *Theileria taurotragi* infection, a protozoan of elands, causing disease in cattle. This is because *T. taurotragi* is an important parasite for eland and cattle but is not known to cause clinical disease in sheep and or goats.

There are limited reports on prevalence of coenurosis in Africa especially in slaughter slabs where in most cases slaughter animals originate from within the locality. As shown in the results (Table 1), the overall prevalence of *C. cerebralis* was 44.4% (45.6% in sheep and goats 43.3%) in slab-slaughtered sheep and goats and there was no statistical significant difference ($\chi^2 = 0.054$, $p = 0.814$) in the prevalences of sheep and goats. However, sex prevalences differed significantly ($\chi^2 = 4.271$, $p = 0.0387$). This study has shown that the prevalence of coenurosis is higher (44.4%) in Ngorongoro district, Tanzania, compared to findings of 18.65% obtained by Tavassoli *et al.* (2011) in Uramia abattoir, Iran and 14.8% in Tete municipal abattoir, Mozambique by Afonso *et al.* (2011). Other reported prevalence rates of 5% in Bangladesh (Nooruddin *et al.*, 1996), 10% in Fars province, Iran (Oryan *et al.*, 1994), 15.5% in Kars province, Turkey (Gicik *et al.*, 2007) and 36.8% in Turkey (Uslu and Guclu, 2007). With regards to number and site of

lodge of coenurus cysts, in majority of positive cases (57.5%) the cysts were located in the right hemisphere, 35% in the left hemisphere and 7.5% in the cerebellum. The study findings are contrary to other workers such as Tavassoli *et al.* (2011) who recorded 54.63% in the left and 40.20% in the right hemisphere in sheep in Northwest of Iran. Gicik *et al.* (2007) in Kars province, Turkey also reported 60% and 40% of the cysts localised on the left and right hemispheres respectively. This difference suggests that there are equal chances of the cyst to lodge at any site of the brain. The softening of the skull associated to *C. cerebralis* infections as reported by Soulsby, (1982); Nooruddin *et al.* (1996) was not observed in this study. However, in some cases there was adherence of a complex type meningeal cyst adhering to the dorsum of the skull (Fig. 5) and perhaps in long period of time the pathological effect might lead to the softening of the skull.

The high prevalence of coenurosis in slaughtered animals (sheep and goats) depicts the real disease situation of the flocks in Ngorongoro district. Considering the extensive mode of rearing sheep and/or goats, the situation observed and recorded in this study might be more or less the same in other parts of the country (Tanzania) and such cases are passing without being documented. Therefore, transferring sheep and/or goat(s) from these areas into other places where the disease is unknown to exist or is less prevalent, could pose a considerable risk for the introduction of the disease (coenurosis) into new areas and the disease will likely continue to spread as an important pathogen in other parts of the country if proper and strategic control measures are not put in place as from now. Although selling “ormilo” sick animal to the livestock market and/or butcher is an alternative for the farmers to avoid losing an animal, it was observed during field survey that, different from other two surveyed slabs, at Endulen slaughter slab, there was a restriction to slaughter coenurosis sick animal(s) imposed by meat inspectors. i.e. those sheep and goats which were manifesting obvious clinical signs of coenurosis were rejected

during the antemortem inspection. At these slaughter slabs, animals for slaughter are available by livestock keepers on daily basis. To minimize the inclusion of slaughtered animals originating from outside the study area, animals slaughtered during livestock market days were excluded in the study. However, there is a possibility that few animals were bought on a market day and then kept for few days before being slaughtered and therefore be included in this study. The low prevalence recorded at Endulen slaughter slab is thought to be from those animals which did not manifest obvious clinical signs (non-clinical positive) and thus escape rejection during antemortem inspection.

The study also has shown that, coenurosis (“ormilo”) is a well known sheep and goats’ health problem by livestock keepers where 100% of respondents had seen the disease. However, they lack knowledge on the cause and how it is transmitted. Considering the livestock keeping and husbandry that have persisted for several decades in the area, it is not of doubt that livestock keepers (pastoralists) are aware of livestock diseases that normally prevail within their herds and flocks. For this reason, since majority of respondents (61%) saw the disease for the first time in less than ten years, it is an indication that coenurosis is a new sheep and goats’ health problem in the study area.

The established timeline indicated that majority (43.1%) of respondents agreed that the disease (coenurosis) has been prevalent in their village and within their flocks in less than ten years while 17.9% had seen the disease for the first time in less than five years and 39% in more than ten years. However, there were different perceptions on when the disease was seen for the first time in three study villages. For example, out of 40 respondents in NCA (Endulen village), 90% (n=36) of respondents indicated that the disease (coenurosis) has been prevalent for more than the past 5 years, and only 10% indicated that the disease was seen for the first time in less than the past 5 years. Majority

(66.7%) at Waso said the disease has been prevalent in their area for more the past 10 years whereas in Malambo the situation was different and only 4.9% of respondents indicated the disease has been there for the same period of time (>10 years). Those who indicated the disease has persisted for more than ten years (39%) agreed that the disease is still a new one and its magnitude is getting a steady growth. Majority of respondents perceived an increase on the disease incidences over the past five years. According to their explanations on the disease magnitude, initially coenurosis occurred sporadically and that the disease has changed from its endemicity experienced in the past few years and is now becoming an epidemic.

Knowledge on cause and the mode of transmission is very important in the control of the disease (Loomu, 2010). It has been found that the disease (coenurosis) is maintained by close interactions between the definitive (canids) and intermediate hosts (sheep and goats). This is facilitated by the very limited community awareness and knowledge on the cause and transmission of coenurosis. It is important to note here that during home animal slaughters, brain tissues and other trimmings which are seen as not fit for human consumption are simply thrown away into the bush only when there is no nearby dog(s) to feed. Otherwise, these tissues are normally thrown raw to dogs; the habit that actually cultivates the disease problem when they contain an infective material by increasing the risk of sheep or goat-dogs infection. On the other hand, the habit of feeding dogs with brains which might contain *Taenia multiceps* cyst (*C. cerebralis*) as it was obtained in the questionnaire survey results, improper disposal of infective material - organs/tissues as it is evidenced by throwing of raw brains into the bush and/or direct feeding dogs with raw offal, was seen as an important factor which contributes to the dissemination of viable cysts. These cysts finally develop into adult tapeworms following ingestion by definitive host in case the material is from the infected animal(s). At the same time, most dogs are

free all the time and sometime these are shepherd dogs: the practice that increases the chance of pasture contamination by dog faeces.

For that matter, the *Taenia multiceps* life cycle (egg – cyst – tapeworm) is maintained by the factors namely close contact between small ruminants (sheep and goats) and dogs, lack of knowledge in the community on how coenurosis occurs, free access of dogs to carcasses/offal including brains of small ruminants containing viable *C. cerebralis* cysts and inadequate animal health services for dogs especially worm control. In all three slaughter slabs where the study was conducted, each slab had a condemnation pit for disposal of the unfit offal and/or carcasses. However, it was further observed that these were not adequately used especially during livestock market days as meat inspectors do not ensure proper disposal of condemned organs in such a way that some organs/trims were simply thrown away. These pits are not fenced and their depths are too shallow to restrict accessibility by scavenging animals (both domestic and wild). For example, in Endulen (located in Ngorongoro Conservation Area), domestic dogs and wild carnivores were seen having free access to meat inspection condemnation pit located outside the settlement area. This exacerbates the situation as susceptible definitive hosts (including wild carnivores) are likely to contract the infection.

Based on the current situation of high prevalence of coenurosis in sheep and goats in the district; the lack, on the part of livestock keepers and butchery men, of knowledge on the cause and transmission of the coenurosis, it is apparent that apart from persistence of the disease, the problem will exacerbate in the near future as more definitive hosts (in this case domestic dogs) are directly and continuously being infected and sometimes re-infected on day to day basis. This calls for the parasite zoonosis impact assessment in the study area.

During survey, one scientist from TAWIRI reported having seen wildebeest manifesting CNS clinical signs (circling) at one time in Serengeti National Park (SNP) adjacent to Ngorongoro district (Tom personal communication, 2013). Although the circling signs might be due to several causes, there is every reason to believe that interspecies circulation of *Taenia* parasites between domestic and wildlife populations (domestic and sylvatic cycles) may occur and coenurosis should also be considered among others. Therefore, further research may deem necessary to explore the possibility of infection and transmission dynamics in wildlife as the parasite of this disease can affect a variety of animals including man. i.e. the parasite is a two-host zoonotic cestode (Scala and Varcasia 2006).

Of 180 animals (90 sheep and 90 goats) examined in three slaughter slabs, 19.4% were found infected with hydatid cysts. Goats had the highest infection rate of 22.2% compared to 16.6% of sheep. However, the differences in species and sex wise were not statistically significant i.e $\chi^2 = 0.82$ ($p=0.36$) and $\chi^2 = 0.323$ ($p=0.569$) respectively. The high prevalence in goats recorded in this study are in agreement to the findings by Dalimi *et al.* (2002) who reported a mean prevalence of 8.1% hydatidosis in sheep, 38.3% in goats in Iran and contrary to Oryan *et al.* (2012) observation of 45.52%, and 10.00% in sheep and goats respectively in Fars, southern Iran. The prevalence of hydatid cyst was higher in older sheep and goats (23.8% and 23.1% in >2 and >1 – 2 years respectively) compared to the younger ones and higher in females than males (female 21.5% and 17.8% in males). This is in agreement with the study by Oryan *et al.* (2012) in Fars, southern Iran who found higher prevalence in adults and female than the respective younger and males in sheep and goats.

Forty per cent and 22.9% of the hydatid cysts were located only in one organ namely the lungs and liver respectively. As in other previous studies by Getaw *et al.* (2010) in Central Oromia, Ethiopia and Ibrahim (2010) in Al Baha region, Saudi Arabia, lungs and liver were the organs most commonly affected by hydatid cysts in sheep and goats. The respective concurrent organ infections were 25.7% in the liver and lungs; 2.9% in the lungs together with spleen and 8.6% in three organs (liver, lungs and spleen). Fromsa and Jobre (2011) in Ethiopia abattoirs obtained the prevalence's of 11.78% in sheep, and 4.9% in goats. The prevalence of hydatid cyst from this study was lower than the findings obtained 63.8% in sheep and 34.7% in goat by Ernest *et al.* (2009) from Ngorongoro District. The differences may be attributed to the accuracy in the retrospective records and/or due to variations in the number of animals examined. However, in this study the prevalence was higher than that reported by Nonga and Karimuribo (2009) which was 6.02% in sheep and goats from Arusha. Although the prevalence was lower compared to the findings by Ernest *et al.* (2004), still the prevalence suggests the possibility that hydatidosis is of public health importance in this study area and that some of the taeniid eggs recovered from the faeces of dogs may be eggs of *Echinococcus* species.

Taenia hydatigena metacestode had the highest prevalence compared to those of *Echinococcus* and *Taenia multiceps*. Out of the examined 90 sheep and 90 goats, the overall prevalence of *Cysticercus tenuicollis* was 51.7% and only 27.3% appeared as a single infection. The species prevalences were 61.1% and 42.2% in goats and sheep respectively (refer Table 9). Most of the cysticerci were found attached to the omentum or mesenteries.

The *C. tenuicollis* prevalence differences between sheep and goats were statistically significant ($\chi^2 = 6.35$, $p = 0.011$) the prevalence having been observed to be higher in

goats (61.1%) compared to sheep (42.2%). The reason for higher prevalence of *Taenia hydatigena* cysts in goats than in sheep is not known given the differences in feeding behaviour of these two species i.e. grazers and browsers . However, similar observations were also documented in other studies by Radfar *et al.* (2005) who reported a prevalence of 12.87% in sheep and 18.04% in goats in Iran; Nimbalkar *et al.* (2011) (goats 34.2% and sheep 21.4%) in Maharashtra, India. Oryan *et al.* (2012) recorded the prevalence of 17.52% in sheep and 55.05% in goats in Fars, southern Iran and Singh *et al.* (2013) reported a prevalence of 4.83% in goats compared to 2.23% in sheep. With regards to concurrent infections, the individual prevalence of *T. multiceps*, *Echinococcus* and *T. hydatigena* metacestodes was 26.6%, 3.6% and 27.3%, respectively. The rest coexisted in different organs with the highest and the lowest concurrent infection being 20.9% and 2.2% prevalences, observed between *T. multiceps* and *T. hydatigena*: and *T. multiceps* and *Echinococcus* metacestodes respectively (Table 7).

Out of 205 domestic dogs which were screened, 73.2% were found to harbour taeniid eggs. The high prevalence of taeniid eggs in domestic dogs indicates the level of contamination of pastures/environment with the eggs in addition to contamination from faeces of infected wild carnivores. It was found that, worm control for dogs was not a common practice in the study area although a small proportion (6.4%) of dog owners dewormed although not routinely and the rest, (93.6%) never dewormed dogs. During the study period, many stray dogs were observed scavenging throughout and some had access to slaughter slab premises as evidenced in Fig. 6. As mentioned before, some factors which contribute to the high prevalence of *Taenia* and *Echinococcus* metacestodes in sheep and goats are the same factors which contribute to high prevalence of taeniid eggs in definitive host, in this case domestic dogs. It is a fact that, microscopically the taeniid eggs (*Taenia* and *Echinococcus*) are indistinguishable (Allan *et al.*, 2003). From the

results on the taeniid egg prevalence in domestic dogs, it is here postulated that since the prevalence of *Cysticercus tenuicollis* was the highest in slaughtered sheep and goats, the same (*Taenia hydatigena* egg) have the highest percentage in the contaminated environment and the chances to be picked by grazing animals are also high followed by *Taenia multiceps* and *Echinococcus* eggs respectively. Ernest *et al.* (2009) found that 10% of dogs were infected with *E. granulosus* in Ngorongoro district. There is a need to develop a diagnostic method that would detect *Taenia multiceps* infections in dogs to species level. The higher prevalence of taeniid eggs in young dogs indicates the higher worm burden in the group category. The situation might be due to low immunity against infections in young dogs. Again, it is known that, as the animal ages, the immunity start decreasing. This is supported by these findings in Table 19 where dogs which were older than three years had the higher prevalence (75.3%) than those of middle age.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

First and foremost, it is concluded that this work report for the first time the occurrence of *C. cerebralis* in Ngorongoro district, Tanzania with high prevalence of 44.4% in slab-slaughtered sheep and goats and one of the contributors in young sheep and goats mortalities. Secondly, *Taenia multiceps* metacestode (*Coenurus cerebralis*) infections in small ruminants and its associated disease (coenurosis) are of great importance to the livelihood of the Ngorongoro community, a new threat to small ruminant's production and productivity and therefore effective control measures must be taken. Third, the study has also shown that other tapeworm metacestodes particularly *C. tenuicollis* and hydatid cysts are highly prevalent (51.7% and 19.4% respectively). Fourth, major factor that plays a great role in the persistence of the disease is mainly human factor that is lack of knowledge on the disease including appropriate control measures.

6.2 Recommendations

Knowledge of epidemiology of the disease is critical for the effective disease management and control (health protection and disease prevention). So far, some of the possible predisposing factors to the expression and persistence of cerebral coenurosis have been identified. To address the identified gaps, the development of a control strategy (programme) is necessary and can be amalgamated with other disease control programmes. However, any control/mitigation programme should emphasise on increasing the level of knowledge in the community on the epidemiology of the disease and how it can be prevented; changing practices that facilitate the spread and persistence of the disease as well as treating dogs for taeniasis.

As to next step, information on disease prevalence at flock level and other risk factors are not well understood. It is for this reason that further extensive molecular and epidemiological studies are needed to ascertain among others if there are different species causing coenurosis or if genetic variation of *T. multiceps* exists in different species of host animals; host spectra, other risk factors that perpetuate the disease and the role of wildlife in the persistence of the same in the ecosystem. In order to improve the surveillance and control of the parasite, development of a specific diagnostic method for *T. multiceps* infection in both definitive and intermediate hosts should be investigated. With regards to *Echinococcus* infections, it is recommended that the current status of hydatidosis infection in humans need to be properly investigated in the study area. Therefore, much remains to be done in research to overcome the problem of coenurosis and other tapeworm infection both in humans and animals and the findings from this study can be used to guide future development.

REFERENCES

- Abo-Shehada, M. N., Jabreen, E., Arab, B., Mukbel, R. and Toergerson, P. R. (2002). Prevalence of *Taenia multiceps* in sheep in northern Jordan. *Preventive Veterinary Medicine* 55: 201 – 207.
- Acha, P. N. and Szyfres, B. (Pan American Health Organization [PAHO]). Zoonoses and communicable diseases common to man and animals. Volume 3. Parasitoses. 3rd ed. Washington DC: PAHO; 2003. Scientific and Technical Publication No. 580. Coenurosis; p. 162-165.
- Achenef, M., Markos, T., Feseha, G., Hibret, A. and Tembely, S. (1999). *Coenurus cerebralis* infection in Ethiopian highland sheep: incidence and observations on pathogenesis and clinical signs. *Tropical Animal Health and Production* 31(1): 15 – 24.
- Afonso, S. M. S., Mukaratirwa, S., Hajovska, K., Capece, B. P. S., Crist`ofol, C., Arboix, M., and Neves, L. (2011). Prevalence and morphological characteristics of *Taenia multiceps* Cysts (*Coenurus cerebralis*) from Abattoir-Slaughtered and Experimentally Infected Goats. *Journal of Neuroparasitology* 2: 1 – 5.
- Allan, J. C., Wilkins, P. P., Tsang, V. C. W. and Craig, P. S. (2003). Immunodiagnostic tools for taeniasis. *Acta Tropica* 87: 87 – 93.
- Anas, A. D., Ahmed, I. B. and Refaat, A. R. (2011). Survey on Coenurosis in sheep and goats in Egypt. *Veterinaria Italiana* 47(3): 333 – 340.

- Ash, R. and Orihel, T. C. (1987). Parasite, a guide to laboratory procedures and identification. American society of pathologist pg 23-25
- Avcioglu, H., Terim, K. A. and Yildirim, A. (2012). Clinical, morphological and histopathological features of bovine coenurosis: case reports. *Revue Méd. Vét* 163(6): 295 – 298.
- Bakuname, C., Lynen, G., Shongon, B., Mollel, J. O., Jongejan, F. and Cleaveland, S. (2002). *Bovine Cerebral Theileriosis in Tanzania*. A report of a Participatory Rural Appraisal in Arusha region. 65pp.
- Bussell, K. M., Kinder, A. E. and Scott, P. R. (1997). Posterior paralysis in a lamb caused by a *Coenurus cerebralis* cyst in the lumbar spinal cord. *Veterinary Record* 140: 21 – 560.
- Cleaveland, S., Kusiluka, L., Kuwai, J., Bell, C. and Kazwala, R. (2001). *Assessing the Impact of Malignant Catarrhal Fever in Ngorongoro District, Tanzania*. A study commissioned by the Animal Health Programme, Department for International Development. 68 pp.
- Dalimi, A., Motamedi, G., Hosseini, M., Mohammadian, B., Malaki, H., Ghamari, Z. and Ghaffari-Far, F. (2002). Echinococcosis/hydatidosis in western Iran. *Veterinary Parasitology* 105: 161 – 171.
- Desouky, E. A., Badawy, A. I. and Rafaat, R. A. (2011). Survey on coenurosis in sheep and goats in Egypt. *Veterinaria Italiana* 47(3): 333 – 340.

- Edwards, G. T., Hackett, F. and Herbert, I. V. (1979). *Taenia hydatigena* and *Taenia multiceps* infections in Snowdonia, UK. The role of hunting dogs and foxes as definitive hosts, and of sheep as intermediate hosts. *British Veterinary Journal* 135(5): 433 - 439.
- Edwards, G. T. and Herbert, I. V. (1982). Observations on the course of *Taenia multiceps* infections in sheep: clinical signs and post-mortem findings. *British Veterinary Journal* 138: 489 –500.
- El-On, J., Shelef, I., Cagnano, E. and Benifla, M. (2008). *Taenia multiceps*: a rare human cestode infection in Israel. *Veterinaria Italiana* 44(4): 621 – 631.
- Ernest, E., Kassuku, A. and Kazwala, R. (2004). Studies on the epidemiology of echinococcosis/hydatidosis in Ngorongoro district, Arusha region, Tanzania. *International Arch Hydatid* 35: 43.
- Ernest, E., Nonga, H. E., Kassuku, A. A. and Kazwala, R. R. (2009). Studies on the epidemiology of echinococcosis/hydatidosis in Ngorongoro district, Arusha region, Tanzania. *Tropical Animal Health Production* 41(7): 1179 - 1185.
- Fromsa, A. and Jobre Y. (2011). Infection prevalence of hydatidosis (*Echinococcus granulosus*, Batsch, 1786) in domestic animals in Ethiopia: A synthesis report of previous surveys. *Ethiopia Veterinary Journal* 15(2): 11 – 33.

- Gauci, C., Vural, G., Oncel, T., Varcasia, A., Damian, V., Kyngdon, C. T., Craig, P. S., Anderson, G. A. and Lightowlers, M. W. (2008). Vaccination with recombinant oncosphere antigens reduces the susceptibility of sheep to infection with *Taenia multiceps*. *International Journal for Parasitology*. 38(8-9): 1041-1050
- Getaw, A., Beyene, D., Ayana D., Megersa B. and Abunna, F. (2010). Hydatidosis: Prevalence and its economic importance in ruminants slaughtered at Adama municipal abattoir, Central Oromia, Ethiopia. *Acta Tropica* 113: 221–225.
- Giadinis, N. D., Psychas, V., Polizopoulou, Z., Papadopoulos, E., Papaioannou, N., Komnenou, A. T., Thomas, A. L., Petridou, E. J., Kritsepi-Konstantinou, M., Lafi, S. Q. and Brellou, G. D. (2012). Acute coenurosis of dairy sheep from 11 flocks in Greece. *New Zealand Veterinary Journal* 60(4): 247 – 253.
- Gicik Y., Kara M. and Arslan M. O. (2007). Prevalence of *Coenurus cerebralis* in sheep in Kars prevalence, Turkey. *Bulletin of the Veterinary Institute in Pulawy* 51: 379–382.
- Ibrahim, M.M. (2010). Study of cystic echinococcosis in slaughtered animals in Al Baha region, Saudi Arabia: Interaction between some biotic and abiotic factors. *Acta Tropica* 113: 26 – 33.
- Ibrahim H. (1998). *Small Ruminant Production Techniques*. ILRI Manual 3. ILRI (International Livestock Research Institute), Nairobi, Kenya. 207pp.

- Loomu, M. P. (2010). *Trans-boundary Animal Disease Surveillance in Ngorongoro District: The case of Peste des Petits Ruminants*. Research paper for award of MPVM at Sokoine University of Agriculture, Morogoro, Tanzania. 37pp
- Martin, S. W., Meek, A. H. and Willeberg, P. (1987). *Veterinary Epidemiology, Principles and Methods*. Iowa State University Press, Ames. 343pp.
- Mohi El-Din, M. M. (2010). The significance of subarachnoid cerebrospinal fluids (CSF) in the development of metacystode of *Coenurus cerebralis* in sheep with reference to its pathological effect. *Global Veterinaria* 4(4): 343 – 348.
- Murell, K. D. (2005). *Epidemiology of Taeniosis and Cysticercosis*. Guidelines for the Surveillance, Prevention and Control of Taeniosis/Cysticercosis WHO/FAO/OIE, Paris. 44pp.
- Ngorongoro District Council (2011). *2011–16 Five years development plan*. Ngorongoro District Council, 77pp
- Ngorongoro District Council (2010). *Livestock Mass Deworming Report*. 6pp
- Nimbakar, R. K., Shinde, S. S., Kamtikar, V. N. and Muley, S. P. (2011). Study on *Taenia hydatigena* in the slaughtered sheep (*Ovis bharal*) and goats (*Capra hircus*) in Maharashtra, India. *Global Veterinaria* 6(4): 374 – 377.

- Nonga, H. E. and Karimuribo, E. D. (2009). A retrospective survey of hydatidosis in livestock in Arusha, Tanzania, based on abattoir data during 2005 – 07. *Tropical Animal Health and Production* 41(7): 1253 – 1257.
- Nooruddin, M., Dey A.S., Ali M.M. (1996). Coenuriasis in Bengal goats of Bangladesh. *Small Ruminant Resource* 19: 77-81.
- Oge, H., Oge, S., Gonenc, B., Ozbakis, G. and Asti, C. (2012). Coenurosis in the lumbar region of a goat: a case report. *Veterinari Medicina* 57(6): 308 – 313.
- Ole-Neselle, M. B., Loomu, P. M., Swai, E., Nyakyi, A. and Saruni, J. (2008). *The status of animal health services in Ngorongoro district and options for improvement. Stakeholders consultation report.* 40pp.
- Oryan, A., Goorgipour, S., Moazeni, M. and Shirian, S. (2012). Abattoir prevalence, organ distribution, public health and economic importance of major metacestodes in sheep, goats and cattle in Fars, southern Iran. *Tropical Biomedicine* 29(3): 349 – 359.
- Özkan, C., Yildirim, S. and Kaya, A. (2011). Clinical coenurosis (*Coenurus cerebralis*) and associated pathological findings in a calf. *Pakistan Veterinary Journal* 31(3): 263 – 266.
- Radfar, M. H., Tajalli, S. and Jalalzadeh, M. (2005). Prevalence and morphological characterization of *Cysticercus tenuicollis* (*Taenia hydatigena* cysticerci) from sheep and goats in Iran. *Veterinarski Arhiv* 75(6): 469 – 476.

- Scala, A. and Varcasia, A. (2006). Updates on morphobiology, epidemiology and molecular characterization of coenurosis in sheep. *Parassitologia* 48: 61– 63.
- Scala, A., Cancedda, G .M., Varcasia, A., Ligios, C., Garippa, G. and Genchi, C. (2007). A survey of *Taenia multiceps* Coenurosis in Sardinian sheep. *Veterinary Parasitology* 143(3-4): 294-298.
- Scott, P. R. (2012). Diagnosis and treatment of coenurosis in sheep. *Veterinary Parasitology* 189(1): 75 – 78.
- Sharma, D. K. and Chauhan, P. P. S. (2006). Coenurosis status in Afro-Asian region: A review. *Small Ruminants Research* 64: 197 – 202.
- Singh, B. B., Sharma, R., Gill, I. P. S. and Sharma, J. K. (2013). Prevalence and morphological characterisation of *Cysticercus tenuicollis* (*Taenia hydatigena* cysts) in sheep and goats in north India. *Journal of Parasitic Diseases*. DOI: 10.1007/s12639-013-0284-7.
- Skerritt, G. C. (1991). *Coenurosis*. In: *Diseases of Sheep*. 2nd Edition. Martin, W. B. and Aitken, I. D. Blackwell Scientific Publications, Oxford. 70pp.
- Soulsby, E. J. L. (1982). *Helminths, Arthropods and Protozoa of Domesticated Animals*. Bailliere Tindall, London. 809pp.**
- Tavassoli, M., Malekifard, F. and Tajik, H. (2011). Prevalence of *Coenurus cerebralis* in sheep in Northwest of Iran. *Veterinary Research Forum* 2(4): 274 – 276.

Uslu, U. and Guclu, F. (2007). Prevalence of *Coenurus cerebralis* in sheep in Turkey.

Medycyna Weterynaryjna 63(6): 678 – 680.

Varcasia, A., Tosciri, G., Coccone, G .N., Pipia, A. P., Garippa, G., Scala A., Damien, V.,

Vural, G., Gauci, C. G. and Lightowlers M. W. (2009). Preliminary field trial of a vaccine against coenurosis caused by *Taenia multiceps*. *Veterinary Parasitology*;

162(3-4): 285-289.

APPENDICES

QUESTIONNAIRE

DETERMINATION OF COMMUNITY AWARENESS AND KNOWLEDGE ON THE CAUSE AND MODE OF TRANSMISSION OF CEREBRAL COENUROSIS IN SHEEP AND GOATS

Q. No:

PART A: General information

Village: Ward: Date:

1. The person interviewed is:

- a) ☐ Head of household
- b) ☐ Other member of household

2. Age of the respondent: _____ years old

3. Sex of the respondent:

- a) ☐ Male
- b) ☐ Female

4. Farming system;

- a) Pastoral ☐
- b) Agro-pastoral ☐

5. Place of domicile

- a) ☐ Game Controlled Area (GCA)
- b) ☐ Ngorongoro Conservation Area (NCA)

PART B: Domestic animals (Number).

Cattle: **1** = (1 – 10), **2** = (11 - 50), **3** = (51 – 100), **4** = (>100)

Sheep: **1** = (1 – 10), **2** = (11 - 50), **3** = (51 – 100), **4** = (>100)

Goats: **1** = (1 – 10), **2** = (11 - 50), **3** = (51 – 100), **4** = (>100)

Dog(s): **1** = 0, **2** = (1-3), **3** = (>3)

PART C: Small ruminants' health problems/diseases? - Rank by importance**Sheep****Goats**

1. PPR	<input type="text"/>	1. PPR	<input type="text"/>
2. Coenurosis	<input type="text"/>	2. Coenurosis	<input type="text"/>
3. Helminthosis	<input type="text"/>	3. Helminthosis	<input type="text"/>
4. Mange	<input type="text"/>	4. CCPP	<input type="text"/>
5. Pox	<input type="text"/>	5. Pox	<input type="text"/>

PART D: Livestock sales

1. Did you sell sheep(s) in the last one year period? **1**= Yes, **2**= No

2. Number sold.

3. Reason for selling;

Sick animal **1** = Yes **2** = No **3** = 1&2

If "Yes", what disease? **1** = Coenurosis, **2**= Others **3**= 1&2

4. Did you sell goat(s) in the past 1 year period? 1 = YES, 2 = NO ☐

Number sold

Reason for sale;

Sick animal 1 = Yes 2 = No. 3 = 1&2 ☐

If "YES", what disease? 1 = coenurosis 2 = Others. 3 = 1&2 ☐

PART E: Herders' knowledge on sheep and goats circling syndrome

1. Have you ever seen any 'ormilo' case (sheep and/or goat)?

Yes ☐ No ☐

2. If "Yes", do you know its cause? Yes ☐ No ☐

3. Do you know how "Ormilo" is spread? Yes ☐ No ☐

4. When did you see the disease for the first time?

(1= < 5 yrs), (2= < 10 yrs) or (3= >10 yrs) ☐

5. What do you do with 'ormilo' sick animal(s) - sheep and/or goat?

i. 1 = Sale at the livestock market or Butcher ☐

ii. 2 = Slaughter at home ☐

iii. 3 = 1 & 2 ☐

iv. 4 = Do nothing ☐

6. When sheep/goat is slaughtered or die at home, what do you do with the brain?

- | | |
|--|---|
| i. <input type="checkbox"/> Thrown raw to dog | v. <input type="checkbox"/> Given to dogs after cooking |
| ii. <input type="checkbox"/> Thrown into bush | vi. <input type="checkbox"/> Buried |
| iii. <input type="checkbox"/> Burned | vii. <input type="checkbox"/> Others (specify) |
| iv. <input type="checkbox"/> Eaten by family members | |

PART F: Dog management

1. Reason for keeping dog(s);

2. What is the source of food for your dog(s)?

1 = cooked food, **2** = leftovers or **3** = scavenge

☐

3. Housing:

Is your dog(s), **1** = Full time tied? **2** = Tie at night only? **3**=Tie during the day?

4 = Free all time and herding

☐

4. Dog health services

- i. Vaccination when;
- ii. Deworming ; when;

PART G. Wildlife

1. How frequently do you see the following wildlife species in the grazing grounds?

i) Jackals

a) ☐ often

b) ☐ occasionally

c) ☐ Never

ii) Wild dogs

a) ☐ often

b) ☐ occasionally

c) ☐ Never

iii) Hyena

a) ☐ often

b) ☐ occasionally

c) ☐ Never