SWOLLEN GLAND SYNDROME/ HAEMORRHAGIC SEPTICAEMIA OF CAMELS IN NORTHERN KENYA: INDIGENOUS KNOWLEDGE AND SOCIO-ECONOMIC IMPLICATIONS

BY:

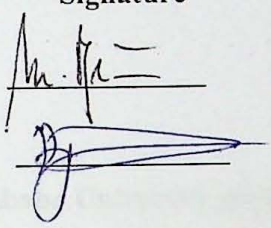
DIBA DIDA WAKO

Academic advisors

Dr. Maximilian Baumann (FU-Berlin, Germany)

Dr Tesfaye Sisay Tessema (AAU, Ethiopia)

Signature



DECEMBER, 2011

DEBRE- ZEIT, ETHIOPIA

SWOLLEN GLAND SYNDROME/ HAEMORRHAGIC SEPTICAEMIA OF CAMELS IN NORTHERN KENYA: INDIGENOUS KNOWLEDGE AND SOCIO-ECONOMIC IMPLICATIONS

BY:

DIBA DIDA WAKO

A thesis submitted to the school of graduate studies of Addis Ababa University and Freie Universität Berlin, department of international animal health, faculty of veterinary medicine, in partial fulfilment of the requirements for the degree of joint Master in Transboundary Animal Disease Management

December 2011,

Debre- Zeit, Ethiopia

SWOLLEN GLAND SYNDROME/ HAEMORRHAGIC SEPTICAEMIA OF CAMELS IN NORTHERN KENYA: INDIGENOUS KNOWLEDGE AND SOCIO-ECONOMIC IMPLICATIONS

BY:

DIBA DIDA WAKO

SUPERVISORS:

Dr Baumann, Maximilian (Dr.med.vet. MPVM, DipECVPH), Faculty of Veterinary Medicine, Freie Universität Berlin

Dr Tessema, Tesfaye Sisay (DVM, Msc, PhD, assistant professor), Addis Ababa, University School Veterinary Medicine

Dr Younan, Mario (DVM, PhD) Kenya Arid and Semi-Arid Lands/Kenya Agricultural Research (KASAL/KARI) Programme,

BOARD OF EXAMINERS

Dr Baumann, Maximilian (Dr.med.vet. MPVM, DipECVPH)
Co-ordinator Postgraduate Studies in International Animal Health, Faculty Panel Veterinary Public Health, Faculty of Veterinary Medicine, Freie Universität- Berlin/Germany.

Signature ..... Date.....

Dr Tessema, Tesfaye Sisay (DVM, Msc, PhD), assistant professor
Head, Department of Microbiology, Immunology, Epidemiology and Public Health, Faculty of Veterinary Medicine, Addis Ababa University,
P. Box 34, Debre Zeit, Ethiopia.

Signature ..... Date.....

Dr Ejobi, Francis (BVM, MVPH, PhD), Associate professor,
Head of Department of Veterinary Public Health and Preventive Medicine,
College of Veterinary Medicine, Animal Resources and Biosecurity, Makerere University,
Kampala, Uganda

Signature ..... Date.....

DEDICATION

I dedicate this work to my brothers Halakhe D. Waqo and Halkano D. Waqo, for because of them I am enjoying the fruit of education; and to my parents.

ACKNOWLEDGEMENTS

I would like to express a sincere gratitude to my supervisors Dr. Maximilian Baumann for requesting Kenya Arid and Semi-Arid Lands/Kenya Agricultural Research Institute (KASAL/KARI) programme to sponsor my field work, providing me with literature on camel haemorrhagic septicaemia/swollen glands syndrome (HS/SGS) and guiding me throughout the study; Dr. Tesfaye Sisay Tessema for guiding me from proposal development to preparation of this manuscript and Dr. Mario Younan for providing me with enormous literature on camel HS/SGS, guiding me in selection of study area, constantly supervising my entire field work and helping me in laboratory processing of the samples.

I remain indebted to my sponsors KASAL/KARI for sponsoring my entire field work, Deutscher Akademischer Austausch Dienst (DAAD) (German Academic Exchange Service) for sponsoring my personal expenses throughout the programme, European Union (EU), the African Caribbean and Pacific group of states (ACP), ACP-EU cooperation for higher education (AEDULINK) and the Programme management Unit (PMU) for paying the tuition fees and travel expenses throughout the study period and for coordinating the programme and VSF-Suisse, Kenya for supporting me with logistics in the field on a number of occasions.

I would like to thank Dr. David Miano, KASAL coordinator who facilitated my field logistics support and the entire KASAL/KARI team. I am particularly grateful to Njogu, KASAL/KARI driver whose cheerful spirit in all circumstances assisted me in criss-crossing the difficult terrain of northern Kenya.

Sincere thanks to Dr. I.V Gluecks of VSF-Suisse for supporting me with literature materials and advising me about the field work, Dr. Douglas Machuchu, of also of VSF-Suisse for training me in Participatory Epidemiology (PE) methods; Anis Hassan, Mohamed Adan, Omar Jacelo and Issa Mohamed for helping me in clinical investigation and data collection.

Many thanks to Lawi, Stella, Kim and Linet, all from Analabs, for their support in laboratory analysis of the samples

Special thanks to Dr. Yilkal the dean of school of veterinary medicine, Addis Ababa University, Dr. Heileleul, Dr. Barsisa and their secretaries for their support in various ways.
I would like to thank Dr. Zerihun Taddesse for his valuable input in data management analysis alongside the entire team of supervisors who contributed to this manuscript by way of comments and criticism during the Data Analysis Workshop.

I acknowledge the contribution of the late Prof. Moses Kyule in the design of this study.
Contributions of Dr. Astrid Bethe of Freie Universität Berlin, Dr. Eric Mungube of KARI, Mr. Adan Wako of CARE Kenya and Dr Abdub Golicha of Practical Action are highly acknowledged.

Many thanks to my translators and local guides: Alexander Diba, Shedo, Rage, Noor, Mapengo and Issack.

This work would have not been possible without the cooperation of the DVOs (Dr. Kiama and Dr. Korir), CAHWs, chiefs, village elders and most of all, the herders (informants) all of whom helped me in organising the meetings and providing information regarding camel HS/SGS. Thank you.

I would also like to thank my classmates and in particular Tariku J, Yassir A, Mohamed E and Batwala S for their help in data analysis and writing of this thesis.

Last but not least, heartfelt thanks to Mrs Kurfa Guyo Huqa for hosting me in North Horr during the study period. Many thanks to all you people who are not mentioned here but contributed to the success of this study in one way or another. Thank you.

TABLE OF CONTENTS **PAGES**

ACKNOWLEDGEMENTS i

TABLE OF CONTENTS iii

LIST OF TABLES vii

LIST OF FIGURES viii

LIST OF APPENDICES ix

LIST OF ABBREVIATIONS x

1 INTRODUCTION 1

2 LITERATURE REVIEW 5

2.1 The Camel 5

2.1.1 Camel population and distribution 5

2.1.2 Importance of camel 5

2.1.3 Camel breeds in Kenya. 6

2.2 Camel Haemorrhagic septicaemia 6

2.2.1 Definition 6

2.2.2 Aetiology 6

2.2.3 Pasteurella multocida 8

2.2.4 Epidemiology 8

2.2.5 Pathogenicity 9

2.2.6 Pathogenesis 10

2.2.7 Immune Response 10

2.2.8 Clinical signs 10

2.2.9 Pathological lesions 11

2.2.10 Economic importance 12

2.2.11 Diagnosis 12

2.2.12 Treatment and control 13
2.3 Participatory Epidemiology (PE) 14
2.3.1 Participatory epidemiology tools 14
2.3.2 Advantages of participatory epidemiology over conventional epidemiology 18
2.3.3 Disadvantages of participatory epidemiology 19
2.4 Importance of indigenous knowledge in epidemiology 19
3 MATERIALS AND METHODS 20
3.1 Study area 20
3.1.1 Selection of the study area 21
3.2 Study population and sampling technique 22
3.3 Study Design 22
3.4 Preliminary activities 22
3.5 Data collection 23
3.5.1 Secondary data review 23
3.5.2 The indigenous knowledge of the pastoralists regarding camel diseases in general and HS/SGS in particular 23
3.5.3 Socioeconomic implications of HS/SGS and other priority diseases 28
3.5.4 Clinical investigation 29
3.5.5 Data Management and Analysis 31
4 RESULTS 32
4.1 Indigenous knowledge regarding camel diseases in general and HS/SGS in particular 32
4.1.1 Disease description 32
4.1.2 Temporal distribution of HS/SGS 35
4.1.3 Spatial distribution of HS/SGS 36
4.1.4 Historical trends of HS/SGS 36
4.1.5 Period prevalence of priority camel diseases between June-August 2010 and June-August 2011 38

4.1.6 Relative frequency of occurrence and response to treatment 39
4.1.7 Clinical course and outbreak length of camel diseases 41
4.1.8 Within-herd characteristics of HS/SGS and the other priority diseases 41
4.1.9 Comparative *qando* versus *qarir/khandich* data of HS/SGS 43
4.2 Socioeconomic implications of HS/SGS 46
4.2.1 Relative importance of livestock species 46
4.2.2 Socioeconomic importance of camels 46
4.2.3 Ranking the benefits derived from camels 48
4.2.4 Benefits derived from different age groups of camels 48
4.2.5 Socioeconomic effects of the priority camel diseases studied 50
4.3 Clinical investigation 54
4.3.1 Observed clinical signs and postmortem lesions of suspected HS/SGS cases 55
4.3.2 The disease HS/SGS 56
4.3.3 Laboratory result from specimen taken during the outbreak 56
5 DISCUSSION 59
5.1 Disease ranking 59
5.2 Clinical signs and postmortem findings of HS/SGS 60
5.3 Temporal and spatial patterns of HS/SGS 60
5.4 Historical trend reported for HS/SGS 61
5.5 Relative frequency of occurrence and response to treatment 62
5.6 Clinical course and outbreak length of HS/SGS 63
5.7 Herd characteristics of HS/SGS 63
5.8 *Qando* (Marsabit North) versus *Qarir/Khandich* (Wajir East/Mandera West) 65
5.9 Socioeconomic implications of HS/SGS 67
5.9.1 Relative importance of livestock 67
5.9.2 Socioeconomic importance of camels 67

5.9.3 Socioeconomic effects of priority camel diseases on the benefits derived from camels 69

6 CONCLUSIONS AND RECOMMENDATIONS 70

6.1 Conclusion 70

6.2 Recommendations 71

7 REFERENCES 72

8 APPENDICES 79

9 CURRICULUM VITAE 95

10 DECLARATION 100

LIST OF TABLES

Table 1: Advantages of participatory epidemiology over conventional epidemiology 18
Table 2: Ten most important camel diseases as scored by 11 herder groups using 50 stones in each group, Northern Kenya, 2011 33
Table 3: Scoring of the clinical signs of camel diseases in the study area as done by 10 herder groups using 20 stones to score clinical signs against the diseases, Northern Kenya, 2011.... 34
Table 4: Past major outbreaks of *qando* (HS/SGS) among Gabra camel herds as narrated by the herders in Marsabit North, Kenya, 2011 37
Table 5: Expected morbidity and case fatality rates of priority camel diseases by age group as done by 8-10 informant groups using 100 stones for each age group and each disease in northern Kenya, 2011 43
Table 6: Comparison of HS/SGS descriptions and epidemiology between the three communities resp. Districts in the study area, Northern Kenya, 2011 44
Table 7: Comparison of age-group specific morbidity rates of HS/SGS as scored by a total of 10 herder groups from three communities in northern Kenya using 100 stones for each age-group, 2011 45
Table 8: Summary of the benefits derived from camels according to different communities (not in a particular order), Northern Kenya, 2011 47
Table 9: Relative effects of priority diseases on socioeconomic benefits derived from camels as scored by 11 informant groups using 25 stones, Northern Kenya, 2011 51
Table 10: Sale prices of different age-groups camels according to the herders in Northern Kenya, 2011 52
Table 11: Losses incurred by a herder due to mortality as a result HS/SGS in a herd in Northern Kenya 53
Table 12: Loss of milk incurred by a camel herder per lactating camel becoming diseased with HS/SGS, Northern Kenya, 2011 54
Table 13: Morbidity and case fatality rates of HS/SGS in 6 herds encountering an outbreak of HS/SGS in Wajir East and Mandera West, Kenya, 2011 55
Table 14: Laboratory results of samples from camels tentatively diagnosed with HS/SGS in Northern Kenya, 2011. 58

LIST OF FIGURES

Figure 1: Map of Kenya showing the three study districts and study locations (in maroon colour) 21
Figure 2: Scoring for seasonal patterns of rain, pasture ticks and 4 disease complexes investigated in Northern Kenya, 2011 36
Figure 3: Period prevalence assessment of priority camel diseases for the preceding 12 months, Northern Kenya, 2011 38
Figure 4: Case fatality rate assessment of priority camel diseases for the preceding 12 months, Northern Kenya, 2011 39
Figure 5: Relative frequency of occurrence of camel diseases as scored by 11 informant groups, Northern Kenya, 2011 40
Figure 6: Relative response of 6 priority camel diseases to treatment according to 11 informant groups in northern Kenya, 2011. 40
Figure 7: Average clinical course and outbreak length of priority camel diseases according to 11 herder informant groups, Northern Kenya, 2011. 41
Figure 8: Expected within herd morbidity (blue colour) and case fatality rates (red colour) of priority camel diseases at 95% confidence level according to 11 informant groups, Northern Kenya, 2011 42
Figure 9: Relative importance of livestock as ranked by pastoral herders in Northern Kenya, 2011 46
Figure 10: Ranking of the benefits derived from camels according to 11 groups of camel herders, Northern Kenya, 2011. 48
Figure 11: Benefits derived from camels according to different age groups among the Gabra pastoral herders, Kenya, 2011 49
Figure 12: Benefits derived from camels according to different age categories among the Garri and Somali pastoral herders, Kenya, 2011. 50
Figure 13: Suspected case of HS/SGS; swollen preparotid lymph node and lachrymation, 10 months old male calf in Mandera West, 2011 57
Figure 14: Enlarged and hemorrhagic lymph nodes, suspected case of HS/SGS in Mandera West, 2011 57

LIST OF APPENDICES

Annex 1: Names of the groups of informants according to their locations, Northern Kenya, 2011 79
Annex 2: Clinical case definitions of camel SGS and camel HS 80
Annex 3: Matrix scoring of clinical signs as done by 10 groups of herders using 20 stones to score each clinical sign against four diseases, Northern Kenya, 2011. 81
Annex 4: Summary of clinical signs of HS/SGS according to 11 informants groups, Northern Kenya, 2011. 85
Annex 5: Summary of Postmortem lesions of HS/SGS according to 11 informants groups, Northern Kenya, 2011. 86
Annex 6: Clinical signs of camel HS/SGS observed in 8 camels in an outbreak, Northern Kenya, 2011. 87
Annex 7: Within herd morbidity and case fatality rates of priority camel diseases in northern Kenya as scored by 10 informant groups, 2011 88
Annex 8: Relative socioeconomic effects of priority camel diseases in Northern Kenya as scored by 11 informant groups using 25 stones per indicator, 2011 89
Annex 9: Participatory map showing the outbreak areas of priority camel diseases as done by the informants in Marsabit north, Kenya, 2011. 93
Annex 10: Participatory map showing the outbreak areas of priority camel diseases as done by the informants in Wajir East, Kenya, 2011. 94

LIST OF ABBREVIATIONS

API 20 NE...Analytical Profile Index for Non-Enteric Gram negative rods

ASAL.....Arid and Semi-Arid Lands

AU/IBAR...African Union Inter-African Bureau of Animal Resources

CAHWs.....Community Animal Health Workers

FAO.....Food and Agricultural Organisation of UN (United Nations)

FGD.....Focus group discussion

HS.....Haemorrhagic Septicaemia

KARI.....Kenya Agricultural Research Institute

KASAL.....Kenya Arid and Semi-Arid Lands

OIE..... Office International des Epizooties.

PE..... participatory epidemiology

PRA.....participatory rural appraisal

RDC 1.....Respiratory disease complex 1

RDC 2.....Respiratory disease complex 2

SGS.....swollen gland syndrome

SPSS.....Statistical Package for Social Sciences

SSI.....Semi-structured interview

VSF-Suisse...Veterinaires sans Frontieres Switzerland

ABSTRACT

This study describes camel hemorrhagic septicaemia/swollen gland syndrome (HS/SGS) in Northern Kenya (Marsabit North, Mandera West and Wajir East Districts), with the objectives of tapping the local knowledge regarding the disease, assessing its socioeconomic implications and attempting to determine its causative agent. The locations of the study and the informants were purposively selected based on concentration of camel herds during June to September 2011 period. The following participatory methods were used in the data collection: focus group discussion (FGD), semi-structured interviews (SSI), matrix scoring, proportional piling, participatory mapping, seasonal calendars, time lines and pair-wise ranking. Clinical examination and sampling of camels suspected to be suffering from HS/SGS were done. Laboratory analysis of whole blood and lymph node swabs, nasal swabs, pharyngeal swabs and tissue swabs was also carried out. Camel HS/SGS was ranked the top most important disease of camels ahead of Respiratory Disease Complex 1 (RDC 1), Camel Pox, Wry Neck and Respiratory Disease Complex 2. Enlarged superficial lymph nodes, lachrymation, fever, recumbency, bad odour and high mortality were heavily associated with HS/SGS. Other clinical signs given by the informants include shivering, little or no urine, slight cough, dyspnoea and extreme weakness. Main postmortem findings are enlarged and hemorrhagic lymph nodes, haemorrhages in the intestines and subcutaneous tissue and swollen lungs. Furthermore, according to the informants, the age group most affected by HS/SGS are young adults (3-5 years) with an expected mean morbidity rate of 67%, followed by older calves (0.5-2 years) at 49%. Adults are less affected with an expected mean morbidity rate of 18%. Expected mean within herd morbidity and mortality rates of HS/SGS were estimated at 49% and 46%, respectively. The disease is said to run a clinical course of about 2 weeks and a prolonged outbreak is estimated to take an average of 3.5 months in a herd before it ceases. There was no significant agreement regarding the seasonality of HS/SGS though most informants gave high scores for the cold and dry period of the year (June-August). HS/SGS, RDC 1 and Pox were ranked as the most frequently occurring camel diseases in that order. HS/SGS and wry neck had the worst relative response to treatment compared to trypanosomosis, RDC 2 and RDC 1, and trypanosomosis having the highest relative response. There was good agreement (W=0.815) between the groups regarding the ranking of the benefits derived from camels in order of importance as follows: milk (21%), transportation (17%), cash/barter (15%), dowry (13%), meat (11%), sacrifice (9%), slaughter

for funeral (8%), skin (4%) and prestige (2%). On estimating the relative effects of priority diseases on these benefits, HS/SGS had the highest relative effects on some of the most important benefits of camels such as milk, transportation, dowry and funeral, while pox had the highest relative effects on skin and sacrifice. The relative effects of both HS/SGS and Pox on the meat and cash/barter were the same. The agreements between groups regarding these effects were moderate to good except for funeral where there was no significant agreement. In the investigation of an outbreak of suspected HS/SGS that occurred in Wajir East and Mandera West, the clinical signs given by the informants were confirmed. The mean morbidity rate of HS/SGS was 20% and the mean case fatality rate was 37% in this outbreak. The majority of camels affected were mainly between 10 months and 5 years of age and the upper age limit was 12 years confirming the information given by the informants. Out of the fourteen samples collected, seven (nasal swabs) were positive for genus Pasteurella when tested by API 20 NE (Analytical Profiling Index for Non-Enteric bacteria). However the test could not determine specific species involved. Based on the result of this study, it was concluded that HS/SGS is an important disease in Northern Kenya exerting high relative socioeconomic pressure on the pastoralists. It was also concluded that the information given by the informants largely agreed with the description of this disease in the available literature and it `leaned´ towards SGS more than the typical camel HS description. However, due to the inability of this study to put clear difference between HS and SGS and find their causative agent (s), it was recommended that more in-depth studies are to be done to ascertain the occurrence of both HS and SGS and clearly differentiate them or conclude beyond doubt that only one of them is present in northern Kenya.

Key words: Haemorrhagic septicaemia (HS), swollen gland syndrome (SGS), camel, Northern Kenya, participatory epidemiology (PE), socioeconomic

1 INTRODUCTION

Livestock production plays a significant role in supporting the livelihoods of the poor throughout the developing world (FAO, 2002). It plays an important role in contributing towards poverty reduction and enhancement of livelihoods (Ahuja, 2004). This is especially true for pastoral communities where livestock production is core to their socioeconomic mainstay and identity (Sandford and Ashley, 2008). Current trends indicate that the proportion of the world's population living in under developed countries is increasing and as a result large food deficit is expected, hence increased production of animal protein would be important in helping fill this deficit (FAO, 1998).

About 30% of the gross value of agricultural production in Africa is from livestock production and 70% of the rural poor in Africa own livestock, including pastoralists who mostly live in arid and semi-arid zones (Seré, 2004). Livestock production is an important part of the economies of the IGAD (Intergovernmental Authority for Development) countries which includes Kenya (Sandford and Ashley, 2008). In Kenya, the agriculture sector is the largest foreign exchange earner besides providing employment and livelihoods for large proportion of the country's population where an estimated 75% of the population depend on it either directly or indirectly (EPZA, 2005). Ten per cent of the Gross Domestic Product (GDP) and thirty per cent of the farm-gate value of agricultural commodities come from livestock subsector (Kiptarus, 2005). Livestock production is not only a major economic activity but also plays an important role in the social aspect of the communities living both in high producing areas and arid and semi-arid lands (Kiptarus, 2005).

According to FAO (2002), animal diseases and veterinary public health problems comprise a major constraint to livestock production and safety of animal products worldwide. In pastoral communities large herd sizes play a crucial role in buffering shocks such as persistent droughts (Sandford and Ashley, 2008). Diseases lower this buffering effect by constantly causing mortality and reducing herd sizes making the herders more vulnerable to poverty and dependency. In a participatory epidemiology study in Turkana district in 2009, livestock diseases, frequent droughts and insecurity due to livestock theft had been identified as the

major constraints limiting livestock production in this area (Bett et *al.*, 2009). In Borana lowland of Southern Ethiopia infectious and parasitic diseases are said to be the major constraints hampering the potential performance of the camels since they are either carriers of, susceptible to or suffering from a vast array of infectious and parasitic diseases (Megersa, 2010).

The one-humped camel (*Camelus dromedarius*) is an essential livestock species distinctively adapted to hot and arid environment (Schwartz and Dioli, 1992). It is a symbol of human survival in the desert forming the core of culture and agriculture of the hot dry areas of northern hemisphere (FAO, 2001). As the world expects increased global warming, the camel would perhaps be the most favoured animal to develop (Ahmad et *al.*, 2010). Kuria et *al.* (2011) describe camel rearing in northern Kenya as a highly rational adaptation of human life to a harsh environment. In the face of increasing human population pressure and declining per capita production of food in Africa, it is prudent to develop previously marginal resources, such as the semi-arid and arid rangelands, and optimise their productivity through appropriate livestock production systems, of which camel production is undoubtedly the most fitting one (Schwartz and Dioli, 1992). Camel produces more milk and for longer period hence playing a central role in providing nutrition for the pastoralists living in the arid zones of East Africa compared to other livestock species (Farah et *al.*, 2007). It is best suited in surviving frequent and prolonged droughts in these arid zones. "The camel not only survived such droughts, but continued producing and reproducing while other animals ceased production or died out" (Cardellino et *al.*, 2005).

In Kenya, northern part of the country is the most important camel producing area constituting 95% of the total population of camels in the country (Kiptarus, 2005). In spite of their enormous ability to thrive in this arid and semi arid lands, there are a number of constraints to the production of camels in this area. According to Dirie and Abdurahman (2003) even though camels are comparatively hardy and less susceptible to common diseases affecting other animals, they do contract many other diseases some of which are still unknown. In Ethiopia which borders Kenya to the north, respiratory disease is considered as an emerging disease in camel and a major threat to camel production (Bekele, 1999; Bekele, 2008; Awol et *al.*, 2011).

Different participatory epidemiology studies done in northern part of Kenya have described a number of diseases affecting the camels. In a study among the Turkana herders on the socio-economic impact of camel diseases in 2006, surra and mange were given high median scores on all the indicators while non-specific diarrhoea, tick infestations, and haemorrhagic septicaemia received moderate median scores (Mochabo et *al.*, 2006). Another study in Lapur Division of Turkana District ranks trypanosomosis, mange, tick infestation, haemorrhagic septicaemia and non-specific diarrhoea as the first five diseases of camels in order of importance according to their annual incidence (Mochabo et *al.*, 2005). Kaufmann (1998), considered diseases as one of the major constraints in camel production in Northern Kenya and Swollen Glands in particular was the top most killer among the Gabra and Rendille camel herds.

Haemorrhagic septicaemia (HS) or septicaemic pasteurellosis is an acute, often fatal epizootic disease of large ruminants and camels, caused by capsular types 6B and 6E of *Pasteurella multocida* (Lane et *al.*, 1992). Haemorrhagic septicaemia in camels has been described by a number of authors. Wilson (1984) described the disease as widespread in camels with usual pulmonary symptoms being observed. Outbreaks in camels have been reported in various African countries, Russia, India and Iran (Wernery and Kaaden, 1995; Higgins, 1986). The disease is quite prevalent in East Africa amongst cattle and camel (Schwartz and Dioli, 1992).

A disease in camels known as Swollen Gland Syndrome (SGS) has been described by Kaufmann (1998) and Koehler-Rollefson et *al.* (2001). The disease is believed to be haemorrhagic septicaemia but the causative agent has not been identified yet.

A participatory epidemiological study of haemorrhagic septicaemia in camels was conducted by VSF-Suisse in five Districts of Northern Kenya in 2007 and 2008 and the disease was ranked from first to forth position in all the areas. In using this approach clinical features of HS in camels and the occurrence of camel HS in different seasons and in different age groups could be described. However, the project was at that time unable to identify the cause of HS in camels and subsequently could not develop a set of disease control measures for camel owners to apply (Gluecks et *al.*, 2010).

Understanding haemorrhagic septicaemia in camel is still far from being clear and comprehensive. "There are discrepancies regarding the clinical presentation as well as the

assignment to a distinct species of Pasteurella" (Wernery and Kaaden, 1995). First attempts to experimentally infect camels with *Pasteurella multocida* type B and E failed to cause the disease (Cross, 1919; Wernery and Kaaden, 1994 unpublished, cited by Wernery and Kaaden, 1995) which led these authors to conclude that a comprehensive scientific study is deemed necessary to further clarify the disease complex of pasteurellosis in camels. Higgins (1986) describes three forms of pasteurellosis in camels i.e. the acute form, peracute form and the gastrointestinal form where diarrhea is the main sign. Outbreaks of Pasteurellosis are often mistaken for other diseases presenting similar clinical signs such as anthrax and salmonellosis leading to uncertainty in defining the disease in camels (Fazil and Hofmann, 1981; Mustafa, 1987, cited by Wernery and Kaaden, 1995). For instance, the Rendille term *khanid* which means "lymph node" is used to describe any condition that causes swelling of lymph nodes (Koehler-Rollefson et *al.*, 2001). So far, most of the descriptions done and conclusions drawn have been based on haemorrhagic septicaemia in cattle. Furthermore, its socioeconomic implications in the pastoral communities of northern Kenya have not yet been fully understood.

Thus, the objectives of this study using participatory epidemiology tools are:

1. to tap the indigenous knowledge of the pastoralists regarding HS /SGS of camels in order to generate further epidemiological data and to
   i. identify the camel diseases in the area and rank them in order of importance;
   ii. describe the clinical signs and symptoms of HS /SGS;
   iii. describe herd level characteristics of the disease including mortality and morbidity rates,
   iv. describe seasonal, spatial and temporal trends of the disease
2. to study the socioeconomic implications of HS /SGS by
   i. determining the social and economic values of camels in the society,
   ii. and estimating the relative effect of diseases, HS /SGS in particular on those identified social and economic values,
3. and, eventually, to perform clinical investigations in case an outbreak occurs within the study period.

2 LITERATURE REVIEW

2.1 The Camel

2.1.1 Camel population and distribution

The dromedary camel (*Camelus dromedarius) is* found in the hot desert of Africa, on the Arabian Peninsula and Pakistan and India (Kaufmann, 1998). Camel population worldwide is estimated at 25,893,855 of which 21,853,999 (84.4%) are living on the African continent. In Eastern African region (Sudan not included), their population is estimated at 10,755,784 (FAO, 2009). Though FAO (2009) estimates Kenya's camel population at 947,200, according to Kenyan Population and Housing Census (KPHC) (2010), camel population in Kenya is 2,971,111.

2.1.2 Importance of camel

The camel has enormous socioeconomic importance which supports the survival of millions of people in the semi-arid and arid areas of Asia and Africa. It is an important source of transport, meat, milk and income for pastoralists living the Sahel, East Africa, the Middle East and South Asia (Bekele, 1999; Koehler-Rollefson et *al.*, 2001; Ali, et *al.*, 2009). Other uses include ploughing and levelling of land, working mini-mills for oil extraction, grinding grains, crushing sugarcane, and pulling carts (Ahmad et *al.*, 2010). During the periods of prolonged droughts, camel milk is the sole nourishment for the pastoralists (Cardellino et *al.*, 2005). For example in northern Kenya camel milk constitutes often over 60% of the human diet (Kaufmann, 1998). Schwartz and Dioli (1992) indicate that the pastoralists in Eastern Africa keep camels mainly for subsistence and that sale of live animals as slaughter stock is limited. The importance of camel is most likely higher than its actual or potential contribution to the national economy. In addition to its economic importance, camel has cultural values in many Islamic countries (Kaufmann, 1998). According to Schwartz and Dioli (1992), in Eastern Africa camel production provides significant contributions to national economies, however, this is hard to quantify by more conventional methods since most camel products never reach any market, but are rather consumed locally or traded in kind instead of cash.

2.1.3 Camel breeds in Kenya.

The classification of the camel breeds in Kenya is based on the tribes that keep them such as Somali, Rendille/Gabra, Turkana, Pokot and Samburu. The Somali breed which is largely *benadir* type is the largest with an adult female average weight of 500-600kg and an adult male average weight of 600-800kg and commonly kept in North-Eastern province. A few imported camels from Pakistan and their crossbreeds with the local breeds are found on some ranches (Wilson, 1984; Gluecks, 2007).

2.2 Camel Haemorrhagic septicaemia

2.2.1 Definition

Camel haemorrhagic septicaemia with the reported likely synonyms *garir* (Somali language) *ngarngar* (Samburu language) *Khanid* (Rendille language) *qandich* (Borana language) *qando* (Gabra dialect) *lorarrurei* (Turkana language) is an important disease which is said to appear suddenly and kill animals quickly (Schwartz and Dioli, 1992; Koehler-Rollefson *et al.*, 2001). It occurs in the rainy season and is sometimes linked to drinking water from puddles. It is especially common in areas that get flooded (Schwartz and Dioli, 1992; Koehler-Rollefson *et al.*, 2001). The disease has low morbidity, but it is said that up to 80% of the sick die (Schwartz and Dioli, 1992; Koehler-Rollefson et *al.*, 2001).

2.2.2 Aetiology

According to the Technical Disease Cards of the World Organisation for Animal Health (OIE, 2011) haemorrhagic septicaemia is caused by certain serotypes of *Pasteurella multocida*, a Gram-negative coccobacillus belonging to the Order *Pasteurellales*, Family *Pasteurellaceae*. As in other animals, pasteurellae are also symbionts in camels found on mucous membranes, mainly in the upper respiratory tract becoming pathogenic when the hosts' resistance is lowered due to disturbance of the host-parasite balance, such as mange infestation, trypanosomosis or climatic stress (Higgins, 1986).

The Asian serotype B:2 and the African serotype E:2 (Carter and Heddleston system), corresponding to the newer 6: B and 6: E classification (Namioka-Carter system), are mainly responsible for the disease. The letter denotes the capsular antigen and the number stands for the somatic antigen (OIE, 2011). These organisms cause haemorrhagic septicaemia, mainly in cattle and buffaloes with high mortality rates and economic significance in Asia and Africa (Tabatabaei *et al.*, 2002; Ataei *et al.*, 2009).

However, whether the same serotypes cause the disease in camel is not clear. There are conflicting reports in the literature as to the susceptibility of camels to *Pasteurella multocida.* Different authors have reported on the clinical course following experimental infection of dromedaries with culture of Pasteurella. Fayed (1973) cited by Wernery and Kaaden (1995) isolated 6 *Pasteurella multocida* strains from 100 nasal swabs of healthy dromedaries in Egypt. All of the isolates were pathogenic for rabbits and mice. However, two dromedaries that were infected intra-nasally with these strains recovered following a short period of illness. Cross (1919) (cited by Wernery and Kaaden, 1995) also inoculated two dromedaries with bovine HS culture, observing no systematic disease other than local swellings. In Egypt, Awad et *al.* (1976) experimentally infected two dromedaries with *Pasteurella multocida* type B by intranasal route. The camels showed increase in temperature, lachrymation, and excessive salivation, cessation of rumination, inappetance, tachycardia and tachypnoea. They recovered after five days without treatment. By rabbit inoculation, *Pasteurellae* were recovered from the saliva. However, they could not be detected microscopically in blood smear taken during pyrexic stage (cited by Higgins, 1986).

In an outbreak of pasteurellosis in India 11 out 14 dromedaries died (Momin et *al.,* 1987, cited by Wernery and Kaaden, 1995). The camels presented high fever, cervical edema with acute respiratory problems and sudden death. Blood smear showed presence of bipolar organisms resembling *Pasteurella multocida.* Pasteurella multocida was recently isolated from camels in an outbreak that occurred in Cholistan desert of Pakistan (Khan et *al.*, 2011). The disease ran a clinical course of 5-7 days. On the other hand various authors believe that camels are generally resistant to HS (Leese, 1918: Cross, 1919, cited by Wernery and Kaaden, 1995).

2.2.3 *Pasteurella multocida*

Pasteurella multocida is a heterogeneous species of Gram-negative bacteria. It is nonmotile cocobacilli, non–spore-forming, non-haemolytic, facultative anaerobic, typically catalase, oxidase and indole positive, reduces nitrates and attacks carbohydrates fermentatively (Hirsh, 1999; Alcamo and Warner, 2010; Confer, 1993).

a. Morphology and staining:

Cells measure from 0.2 micrometer up to 2.0 micrometers. Staining of only the tips of the cells (bipolarity) can be demonstrated with polychrome stains (e.g. Wright's stain). The capsules are the basis of the specificity (Hirsh, 1999).

b. Structure and composition:

"Most *P. multocida* strains produce a polysaccharide capsule on their surface" (Gyles et *al.*, 2010). Some strains express adhesins. Cell walls consist mainly of lipopolysaccharides and proteins. Some of the proteins are iron-regulated hence only expressed under iron-poor conditions (Hirsh, 1999).

2.2.4 Epidemiology

a. Geographical distribution

According to Schwartz and Dioli (1992) haemorrhagic septicaemia is prevalent in East Africa among cattle and camels. The disease is reported in Africa, India, Iran and Union of Soviet Socialist Republics (USSR) (Higgins, 1986; Wernery and Kaaden, 1995).

b. Host range

Principally HS occurs in cattle and water buffaloes; the latter are thought to be more susceptible. HS is seen infrequently in swine and even less commonly in sheep and goats. It has been reported in bison, camels, elephants, horses, and donkeys, and there is evidence of its occurrence in yak. An acute pasteurellosis indistinguishable from HS is seen infrequently

in deer, elk, and perhaps other feral ruminants. Laboratory rabbits and mice are highly susceptible to experimental infection. There are no reported cases of human infection. Cattle, water buffalo, and bison appear to be the reservoirs of infection (Merck Veterinary Manual, 2005; OIE, 2011; Alwis, 1992).

c. Mode of transmission

P. multocida is transmitted by direct contact with infected animals and on fomites. Animals become infected when they ingest or inhale the causative organism, which probably originates from the nasopharynx of infected animals. It is carried in contaminated saliva, discharge from the nose, and in faeces. The organism does not survive outside the animal body to any significant degree so as to be a source of infection. Moist conditions prolong its survival (Merck Veterinary Manual, 2005; Shafarin et *al.*, 2009).

The worst epidemics occur during the rainy season. Stresses such as a poor food supply are thought to increase susceptibility to infection, and close herding and wet conditions seem to contribute to the spread of the disease. *P. multocida* can survive for hours and possibly days in damp soil or water; viable organisms are not found in the soil or pastures after 2–3 weeks. Outbreaks of the disease have been closely associated with carrier animals that transmit the organism to susceptible animals during stressful condition (Merck Veterinary Manual, 2005; Koehler-Rollefson et *al.*, 2001; OIE, 2011; Benkirane and Alwis, 2002; Shafarin et *al.*, 2007).

2.2.5 Pathogenicity

Members of this genus have a number of substances that are associated with pathogenecity such as the capsule, lipopolysaccharides, iron-regulated outer membrane, toxic outer membrane proteins, adhesins, leukotoxins, and enzymes (hyaluronidase and neuraminidase). The capsule plays many roles of which the interference with phagocytosis and the protection of the outer membrane attack from complexes generated by activation of complement system are the most important ones. Lipopolysaccharides are directly toxic to respiratory tract endothelial cells. Leukotoxin has cytotoxic effect upon leukocytes, i.e. death of leukocytes by apoptosis and downregulation of major histocompatibility II (MHC II) proteins on the surface of macrophages affecting their ability to present antigens (Hirsh, 1999).

2.2.6 Pathogenesis

It is hypothesized that animals become susceptible to HS as a result of various stresses. The initial site of proliferation is thought to be the tonsillar region. In susceptible animals, a septicaemia develops rapidly, and death due to endotoxemia occurs within 8-24 hours after the first signs develop. Exotoxins have not been demonstrated (Merck Veterinary Manual, 2005). Studies in buffalo infected experimentally with *P. multocida* B:2 showed an association between a severe endotoxemia in the terminal stages of HS and the onset of clinical signs, signifying a major role for endotoxin in the pathogenesis of the disease (Horadagoda et *al.*, 2001; Horadagoda et *al.*, 2002).

2.2.7 Immune Response

Pasteurella multocida has developed mechanisms that enable it to evade innate host defence such as phagocytosis, antimicrobial peptides and complements in naive hosts. Immunity is mainly by circulating antibodies. The type specific capsular antigens are considered as important immunogens in haemorrhagic septicaemia (Hirsh, 1999; Gyles et al., 2010)

2.2.8 Clinical signs

The clinical signs of camel HS include high fever (over 40°C), increased respiratory and pulse rate, depression, oedematous swelling in pharyngeal and prescapular region which is described as hot and painful by Schwartz and Dioli (1992), enlarged superficial lymph nodes (submandibular and/or cervical), abortions and signs of respiratory dyspnoea such as dilated nostrils or open mouth breathing, rapid and shallow breathing and cyanotic mucous membrane. Hemorrhagic enteritis characterised by clinical signs of acute abdominal pain and excretion of tarry faeces and coffee-coloured urine is present in most cases (Higgins, 1986; Schwartz and Dioli, 1992; Gitao, 2006). In addition to the above signs, Koehler-Rollefson et *al.* (2001) describe swollen painful lymph node at angle of the jaw and bottom of the neck, dark red mucous membranes, weak cough, salivation and blood-stained faeces. Affected animals rarely recover; it dies within 24 to 48 hours (Schwartz and Dioli, 1992).

Higgins (1986) describes three clinical forms of camel HS. The peracute form which is associated with sudden death, the acute disease characterized by the signs described above and possibility of a third form which is characterized by diarrhoea, sometimes bloody.

Kaufmann (1998) describes major signs of SGS as swollen superficial lymph nodes (especially of the head and neck region), fever, excessive lachrymation, diarrhea, reduced urine, anorexia and resting on sternal recumbency more than usual which leads to emaciation and reduced milk yield. In addition to the above signs, Koehler-Rollefson et *al.* (2001) describe watery eyes, shivering, diarrhoea, little or no urine, dullness, rough coat, slight cough and difficulty in breathing as major signs of Swollen Glands. Kaufmann (1998) described the course of the disease as short and acute.

2.2.9 Pathological lesions

Generalized internal petechiation especially under serosa of intestines, heart and lymph nodes are the major postmortem findings. Gelatinous fluids around the lymph nodes, hemorrhagic enteritis and lesions of pneumonia may be present (Schwartz and Dioli, 1992; Gitao, 2006). Koehler-Rollefson et *al.* (2001) reported small red or purple spots like flea-bites on the surface of the internal organs and indicated possibility of bleeding spots in the stomach and lungs.

Necropsy findings of SGS include haemorrhages in all body tissues particularly the lymph nodes and petechiae in the intestines (Kaufmann, 1998; Koehler-Rollefson et *al.*, 2001). They also added that the meat is dark red due to blood.

In bovine HS, swellings on the head, neck and brisket region contain a clear or straw-colored serous fluid on incision. The edema in the musculature and the subserous petechial haemorrhages are characteristic findings. Fluids in the pericardial sac, thoracic and abdominal cavities are often blood tinged. Petechial haemorrhages in the pharyngeal and cervical lymph nodes are particularly prominent. Pneumonia is usually not as extensive as it is the case of pneumonic pasteurellosis (Merck Veterinary Manual, 2005).

2.2.10 Economic importance

Economic significance of HS is apparent in Asia and Africa due to its high mortality rates (Tabatabaei et *al.*, 2002). Economic losses caused by HS in general are not only confined to losses to the animal industry, but also crop production on account of its high prevalence among draught animals (Benkirane and Alwis, 2002). "HS is a disease that is most prevalent in situations where husbandry practices are poor and, concurrently, disease surveillance systems are often not well developed. Reported losses, therefore, merely reflect the trend, actual losses generally being considerably higher" (Alwis, 1992).

In regard to camel HS/SGS in particular, the economic losses are likely to be significant when one considers its high proportional mortality against socioeconomic roles of the camel e.g. Kaufmann (1998) considered it as the leading killer among the Gabra and Rendille herds in Marsabit, Kenya. Khan et *al.* (2011) attribute economic losses caused by camel HS to high fatalities, loss of productivity and cost of compulsory medication and vaccination.

2.2.11 Diagnosis

Some characteristic epidemiologic and clinical features help in the diagnosis of HS. History of earlier outbreaks and a recent failure to vaccinate is particularly significant. Epidemiologic features considered in diagnosis include season of the year, rapid course, and high herd incidence. Characteristic clinical signs such as fever and oedematous swellings indicate typical HS. Characteristic necropsy lesions further support the clinical diagnosis.

Isolation of *Pasteurella multocida* from the blood and vital organs of an animal with typical signs is used as tentative diagnosis while definitive diagnosis depends on identifying the serotypes that causes HS. In Asia and Africa the passive mouse protection tests using specific B: 2 and E: 2 immune rabbit sera are used to identify these serotypes. Other tests include indirect hemagglutination, coagglutination, and counterimmunoelectrophoresis and immunodiffusion tests. In case of postmortem decomposition, subcutaneous inoculation of mice or rabbits with small amounts of blood and tissue suspensions facilitates the recovery of the pasteurellae in pure or nearly pure culture and avoids overgrowth of extraneous bacteria. Serologic tests are said to be of no value in diagnosis though indirect hemagglutination procedure and passive mouse protection tests are of value in determining the immune status of

animals (Merck Veterinary Manual, 2005). Tissue impressions and transtracheal aspirates can be stained by polychrome stain (e.g. Giemsa, Wright's and Waysons's stains) and examined for bipolar staining. The presence is suggestive but not definitive diagnosis *pasteurella.* Isolation of the bacteria is made by culturing overnight on bovine or sheep blood agar and identified using differential tests (Hirsh, 1999). Polymerase chain reaction based on random application of polymorphic DNA region is a quite sensitive, specific and valuable technique (Biswas et *al.*, 2004).

2.2.12 Treatment and control

Systemic treatment with high dosages of sulphonamide or sulfamethazine and other antibacterial drugs such as amoxicillin and tetracyclines is recommended. Enteritis should be treated by sulphonamides orally at dosage rate of 110 mg/kg body weight each day for up to 4 days. Supplementary feeding and frequent watering is beneficial. In endemic areas prophylactic vaccination programmes before the rainy season may be helpful (Schwartz and Dioli, 1992; Koehler-Rollefson et *al.*, 2001). However, treatment is constrained by a number of practical considerations. According to Benkirane and Alwis (2002) HS can only be cured if treated at very early stages and effective treatments are usually lacking in less modern husbandry systems.

a. Traditional treatment

According to Koehler-Rollefson et *al.* (2001), camel owners treat the sick as follows: The Samburu and Rendille brand the swollen glands of sick animals. The Turkana boil 1 kg of crushed leaves of *Salvadora persica* in 2.5 litres of water, allow the mixture to cool, and then drench the animal with it. They repeat the treatment every 4 days until the camel recovers. The Gabra herders use *Euphorbia heterochroma* (*harken*) boiled water (an arm's length in 2 litres), then cooled and used the liquid as a drench. Three finger-size roots in 1 litre of water are used for calves. Alcohol and human urine are used for treatment of the sick by Raika and Indian herders feeding the animal with milk and eggs or *gur* (molasses) as supportive treatment. However, it is not known how effective the traditional treatments are.

2.3 Participatory Epidemiology (PE)

This is an emerging branch of veterinary epidemiology based on the principles and methods of Participatory Rural Appraisal (PRA) (Catley, 2005). It is useful in improving the understanding of animal health issues especially in pastoral livestock production system and allows tapping of the indigenous knowledge of the pastoralists regarding human and animal health while encouraging their participation in animal disease control (Catley and Mariner, 2001). Though it mainly generates qualitative data through qualitative enquiry, some activities may yield results that are quantitative or semi-quantitative in nature (FAO, 2000).

Several organisations and programmes in Africa have used and are still using participatory methods in animal health research with enormous success e.g. Rinderpest control in the Afar region of Ethiopia and in southern Sudan was achieved through CAHW programmes which arose from participatory analysis with the communities (Catley and Mariner, 2002b).

In recent years veterinary epidemiologists have adopted these methods and used them to improve the understanding of livestock diseases in resource-poor settings where conventional methods are difficult to use or where virtually there was no information. Thus, the pioneers in this field, Catley and Mariner (2002b) stated: "Three studies in different pastoralist locations and on different diseases were conducted and in all cases, PE methods were found to be reliable and valid".

These PE methods and approaches allow communities and field researchers to jointly study specific disease problems, understand local disease characterization, estimate morbidity, mortality and other variables, and, eventually identify appropriate solutions (Catley, 2005).

2.3.1 Participatory epidemiology tools

Participatory appraisal (PA) tools are used to collect information by means of a "toolkit" comprising diagramming, mapping, scoring, ranking and interviewing methods (Catley, 1997). This toolkit which was applied in this study includes the following methods:

a. Focus group discussion (FGD)

The focus group is made up of 6 -12 persons who are demographically homogenous, and have certain experiences in common, meeting at a traditional meeting site to discuss subjects of interest. Traditional community meeting sites are said to be useful group discussion sites (FAO, 2000). The discussion is facilitated by an interviewer who consults a once in a while to pose questions. FGD was used for identification of important camel diseases and perceived socioeconomic benefits derived from the camels. Use of pastoralists' defined socioeconomic indicators was recommended by Catley and Admassu (2003) because the pastoralists are likely to use indicators that veterinarians may overlook. "When livestock keepers' perceptions of 'benefit' are known, it is then possible to for example use proportional piling to show the impact of different diseases on each of these benefits" (Catley and Admassu, 2003).

b. Semi-Structured interview (SSI)

This is a form of an interview where a checklist of topics to be covered is used as a point of reference rather than a questionnaire (Catley and Mohamed, 1996; Catley et *al.*, 2001). It is useful in providing information on all topics and it is used together with all other methods (Catley and Mariner, 2002b). The questions are usually open-ended and the participants are given the opportunity to introduce topics and issues (Catley and Mariner, 2001). Probing questions are asked in the process in order to obtain more details and check information for internal consistency (Catley and Mariner, 2002a).

c. Matrix Scoring

It is defined as series of proportional piling exercises repeated using different indicators (PENAPH, 2010). Matrix scoring is a useful technique to confirm verbal descriptions provided in interviews and to "delve more deeply into shades of meaning and extent or importance of different characteristics" (AU/IBAR, 2002). A matrix is drawn on the ground, with items or issues to be considered in columns, and local criteria in rows. Seeds or other counters represent values in each box. The scores are then ranked to show which are considered most important. In the process of scoring and ranking, a discussion is generated which is expected to produce valuable information. It is useful in characterising the local

disease terminologies (Catley et *al.*, 2004). Counters are left on the ground as the informants move to next indicator in order to visualize the result after the scoring (Catley, 2005; PENAPH, 2010). When scoring indicators such as clinical signs against diseases, the questions should be clear and consistent in each group (Catley, 2005).

d. Disease impact matrix scoring (DIMS)

DMIS is defined as a complex matrix scoring which is done in two stages; first the benefits derived from the species of interest are determined and ranked in order of importance and then these benefits are used to score against the diseases of interest according to the impact of the diseases on the benefits (PENAPH, 2010; Kipronoh et *al.*, 2011).

e. Pair-wise ranking

Pair-wise ranking is defined as a structured method for ranking a list of items in order of priority. Items are listed and two of them are compared at a time until all the items are compared against each other (Catley, 1997; PENAPH, 2010). Informants are asked to give reasons for considering one to be more important than the other. These reasons are used as "indicators".

f. Proportional piling

This is one method of scoring and ranking where informants are told to use 100 counters and divide them against diseases or other items. These are then counted and scored (Amare, 2004; Catley and Mariner, 2001). It is a semi-quantitative technique used for ranking items (PENAPH, 2010). This method has been used by a number of authors to study incidences, prevalence, mortality and morbidity rates of diseases (Catley et *al.*, 2002a; Swai and Neselle, 2010; Kipronoh et *al.*, 2011).

g. Seasonal Calendars

Seasonal calendars are diagrams constructed by informants which illustrate seasonal variations of events under investigation. Events such as diseases, feeding / pasture management and livestock sales can be studied (Catley, 1997; Catley et *al.*, 2002b). These events (indicators) are scored against the seasons using counters such as stones.

h. Time lines

Time lines are means of gathering information on historical events and, thus, can show the history of major recalled events in a community with approximate dates (Leyland, 1991). The informants try to remember key natural, socio-economic and political events and relate these to the prevalence of certain diseases (Barasa et *al.*, 2005). The researchers then consult relevant records in order to identify approximate dates these events occurred (Leyland, 1991).

i. Key informant interviews

Key informants are certain local people who are recognised as possessing particular knowledge and skills e.g. in animal health matters. They are also referred to as "local expert" and are useful in learning more about resource use and indigenous technical knowledge (Catley and Mariner, 2002 b; Catley and Admassu, 2003; Catley, 2005). "Key informants in communities know a lot about human and animal diseases and their clinical presentations" (PENAPH, 2010).

j. Triangulation

The term triangulation refers to the comparison of information obtained from multiple informants and multiple methods so as to check its consistency (Catley, 2000; Amare, 2004). "If the information suggests a uniform conclusion then the interpretation is relatively straight forward," (Catley and Mariner, 2001). Triangulation need not be confined to comparison of information from PE methods but rather includes information from the literature such as previous studies, reports and surveys or conventional veterinary methods, such as clinical examinations and laboratory tests (Catley, 2005; PENAPH, 2010).

k. Participatory mapping

Mapping is a visualisation method which is commonly used by health workers. The idea is not produce a nice diagram but rather to act as a focus for discussion; they should be bold and simple in design (Leyland, 1991). In pastoral communities participatory maps are important in prompting discussion on topics such as animal health problems that are location-specific, and access to veterinary services when herds are in different places at different times of the year (Catley, 2005). It is usually drawn on the ground using objects such as sticks. Landmarks such as rivers, markets, watering points and grazing sites are indicated. The information is then transferred to a note book as the map becomes crowded (Mariner and Admassu, 2002).

2.3.2 Advantages of participatory epidemiology over conventional epidemiology

Table 1: Advantages of participatory epidemiology over conventional epidemiology

Participatory epidemiology	**Conventional epidemiology**
Facilitative (FAO, 2000)	Extractive (FAO, 2000)
Flexible (FAO, 2000)	Inflexible (FAO, 2000)
Cheaper (FAO, 2000)	Costly and complex (FAO, 2000)
Uses qualitative intelligence to fill the gaps between available data (Catley and Mariner, 2001).	Quantitative data driven. Therefore faced with constraints in large pastoral areas with relatively small and mobile human population, limited modern infrastructure and frequent insecurity which makes random sampling difficult (Catley and Mariner, 2002a)
Uses combined methods (interviewing, scoring, ranking and visualisation methods) and triangulation which increases the reliability and validity of the result (Catley and Mariner, 2002a).	Data collected is often not representative hence the information resulting from such studies is biased and maybe misleading (Catley and Mariner, 2001)

2.3.3 Disadvantages of participatory epidemiology

According to Catley and Mariner, (2001) and Catley and Admassu, (2003) PE has the following drawbacks:

- requires training of researchers since the method needs careful explanation
- some information gained by qualitative methods are difficult to quantify,
- analysis tools are underdeveloped,
- poor standardization of methods
- lacks awareness among the policy makers and
- is characterised by recall bias.

2.4 Importance of indigenous knowledge in epidemiology

"Indigenous technical knowledge is found within every defined community and its relationship with customary and social values is increasingly acknowledged" (Leyland, 1991). According to Bedelian (2004), the pastoralists in Kenya have an intimate and extensive knowledge of their environment and are quite aware of the diseases affecting their livestock. Pastoralists were instrumental in the Pan African Rinderpest campaign in that their knowledge of Rinderpest was used to locate outbreaks in remote areas (Catley and Mariner, 2002b). The core of indigenous knowledge is clinical, pathological and epidemiological observations that organise disease information into recognisable entities described by traditional terminology (Catley and Mariner, 2002a). Their terms correspond to clinical case definitions (FAO, 2000; Catley and Mariner, 2002a). For instance, Rendille term for *haemorrhagic septicaemia* in camel '*khanid*' means lymph node. This is due to the fact that the main clinical sign is swollen lymph nodes of the head and neck region (Kaufmann, 1998; Koehler-Rollefson et *al.*, 2001). They possess good diagnostic skills and are aware of modes of disease transmission. Thus the pastoralists are the best source of traditional livestock knowledge (Catley and Mariner, 2002b; Catley and Mariner, 2002a). This knowledge has contributed to western veterinary medicine. For instance it was the Maasai who suggested that the wildebeest was associated with the epidemiology of malignant catarrhal fever (FAO, 2000).

3 MATERIALS AND METHODS

3.1 Study area

The study was done in three neighbouring Districts in northern Kenya, namely Marsabit North, Mandera West and Wajir East. Marsabit North is in greater Marsabit District which covers 65,422 square kilometres (KPHC, 2010; KNBS, 2010) bordering Ethiopia and Moyale to the north, Turkana to the west, Samburu to the south and Wajir and Isiolo to the east. The greater Marsabit District lies between 300 and 900 m above sea level (a.s.l.). Significant physical features are Mount Kulal (2,355 M a.s.l), Mt Marsabit (1865 M a.s.l) and Hurri Hills (1685M a.s.l). The lowest part receives less than 200 mm of rain while Mt Marsabit at higher elevation receives about 800 mm annually (ALRMP, 2005; FA0, 2007).

Wajir East District is situated in the greater Wajir District which covers an area of 56,501 square kilometres and borders Isiolo District to the southwest, Garissa to the south, Somalia to the east, Marsabit District to the west, Moyale to the northwest, Ethiopia to the north and Mandera District to the northeast. Altitude of the District ranges from 150 m a.s.l. in the south-east to 200 m a.s.l. at Buna in the northwest and 460 m a.s.l. in Bute. The annual average precipitation is about 280 mm. The northern part of the district comprising Bute and Gurar divisions receives higher rainfall ranging between 500 mm and 700 mm per year. Wajir East is described as "eastern bush lands" used mainly by camel herders (WDSP, 2005; FAO, 2007).

Mandera West is one of the three Districts of the greater Mandera District which covers an area of 26,470 square kilometres bordering Ethiopia to the north, Somalia to the east and larger Wajir District of Kenya to the south and south west. The greater Mandera District lies between 400 m and 970 m a.s.l. and has an erratic mean annual rainfall of 255 mm per year. It is characterised by very low and unreliable rainfall (MDSP, 2005; FAO, 2007).
These three Districts generally lie in arid and semi-arid zones (FAO, 2007) and are largely inhabited by nomadic pastoralists who keep camels, cattle, sheep and goats.

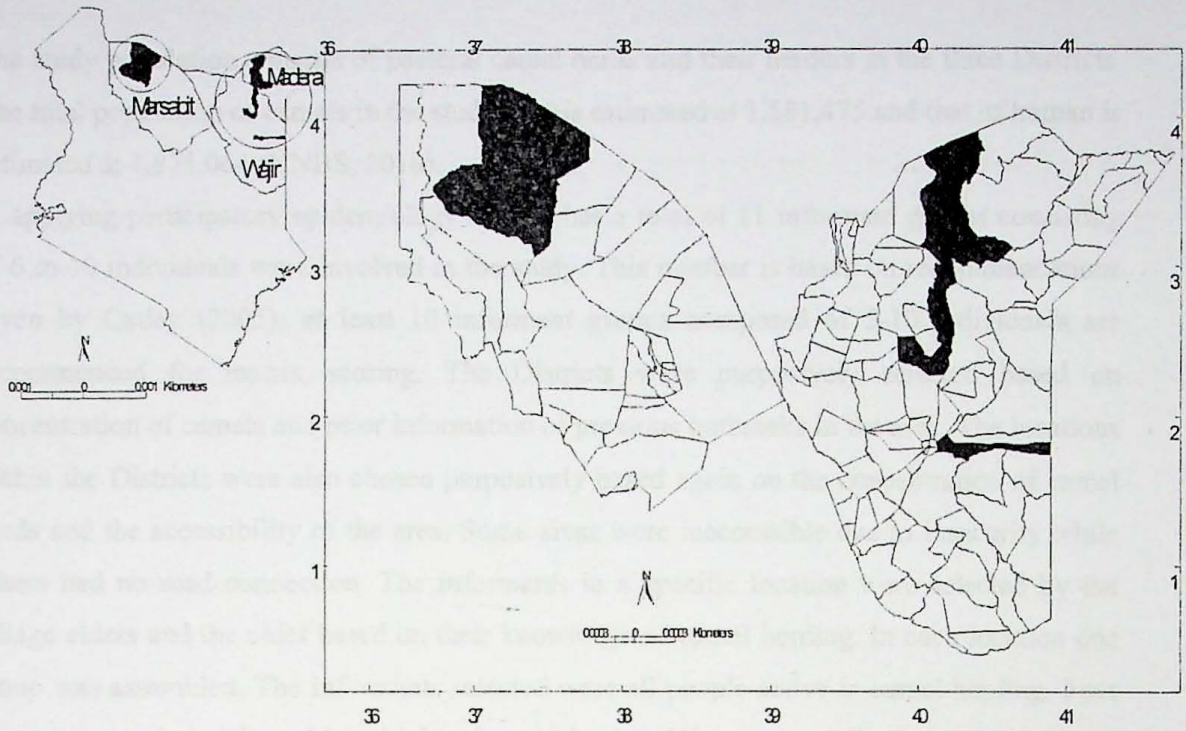


Figure 1: Map of Kenya showing the three study districts and study locations (in maroon colour)

Source: Ojwang, G. O, Chief Natural Resource Scientist, Department of Resource Surveys and Remote Sensing, Kenya.

3.1.1 Selection of the study area

Northern Kenya is chosen for the study based on its large population of camels. Marsabit north and Wajir east were included in the study area because of reports of previous outbreaks and/or sporadic cases of HS / SGS (Younan, pers. comm., 2010). Marsabit South which was said to be endemic for *Khanid* (the local name for SGS/ HS) was left out because of security reasons at the time of the study. Mandera West was later included because of its proximity to Wajir east.

3.2 Study population and sampling technique

The study population consists of pastoral camel herds and their herders in the three Districts. The total population of camels in the study area is estimated at 1,581,475 and that of human is estimated at 1,875,064 (KNBS, 2010).

In applying participatory epidemiology approaches a total of 11 informant groups consisting of 6 to 10 individuals were involved in the study. This number is based on recommendations given by Catley (2005): at least 10 informant groups composed of 5-10 individuals are recommended for matrix scoring. The Districts were purposively selected based on concentration of camels and prior information of previous outbreaks in the area. The locations within the Districts were also chosen purposively based again on the concentration of camel herds and the accessibility of the area. Some areas were inaccessible due to insecurity while others had no road connection. The informants in a specific location were selected by the village elders and the chief based on their knowledge of camel herding. In each location one group was assembled. The informants selected were all people active in camel herding. Four groups were selected from Marsabit North and Mandera West each, while three were selected from Wajir East.

3.3 Study Design

A cross-sectional study design was used.

3.4 Preliminary activities

A series of meetings were held with the sponsors, Kenya Arid and Semi-Arid Lands/ Kenya Agricultural Research Institute (KASAL/KARI) team at their headquarters in Nairobi to plan the logistics of the field work. Thereafter the researcher moved to Wajir East to be trained in participatory rural appraisal tools by a VSF –Suisse staff, Dr Machuchu. The researcher and the translator accompanied the VSF- Suisse team which went to various places in Wajir District to train pastoral herders in milk hygiene. After milk hygiene sessions, some herders were requested to volunteer in the training of the researcher and the translator for about an

hour. These sessions were also used to test the proposed PE tools and to make the necessary adjustment accordingly.

Meetings were held with the informants from the selected areas before the actual day of the exercise. The objective of the study was explained and the informants selected as described in the chapter sampling technique.

The veterinary officers in the areas were contacted and the objective of the study explained. They were requested to inform the team of any outbreaks of camel HS/SGS-like disease in the area.

3.5 Data collection

3.5.1 Secondary data review

Before interviewing the herders, secondary data such as field reports by veterinarians, conference papers and other literature were reviewed. This assisted in coming up with two clinical case definitions of the disease under investigation i.e. haemorrhagic septicaemia (HS) and Swollen Glands (SGS).

3.5.2 The indigenous knowledge of the pastoralists regarding camel diseases in general and HS/SGS in particular

a. Identification and ranking of ten camel diseases in the area

In each of the eleven locations a focus group discussion (FGD) was held with each group being composed of six to ten participants. The meeting itself was held at a neutral site easily accessible by the members. The facilitator then introduced the team and provided a friendly and relaxed environment for ease of exchange of information.

The informants were asked to list important camel diseases in the area and then rank and score the ten most important ones. Fifty stones were used to score the diseases: the stones were piled in order of importance, i.e. that the disease which is considered most important

gets the highest score and the least important of the ten gets the lowest score. The total number of stones used for scoring exercises was guided by number of items to be scored. Use of "five stones per item being scored" as recommended by Catley (2005) were applied to calculate the total number of stones required for all scoring and ranking exercises in the entire study. After the scoring then the informants were asked to describe the main clinical signs and postmortem lesions of those diseases and the reasons as to why they gave a disease a certain rank. Each clinical sign and postmortem lesion of HS/SGS was quantified by calculating the number of groups that mentioned it out of the eleven informant groups and the answers were given in percentage.

b. Relationship between local terminologies and modern veterinary names for diseases

SGS/HS together with three other diseases as controls were subjected to matrix scoring to establish the relationship between the local disease terminologies and modern veterinary names for diseases (Catley and Mariner, 2002a). Of these three control diseases, two share some clinical signs with SGS/HS. The third one (wry neck) was chosen because of the knowledge of the researcher regarding its major clinical signs thus enabling the researcher to see whether the informants have understood the exercise or not. From the clinical signs which were described by the informants in identifying the diseases, ten were drawn on cards and placed on the y-axis of the matrix. The diseases were represented by familiar objects and placed on the x-axis (Swai and Neselle, 2010). The informants were then asked to score each of the signs by dividing 20 stones against the other 4 diseases according to the relative prominence of a sign of a disease. It was ensured that all the stones were used. After the stones have been allocated to each sign, the scoring was checked with the informants. They were given time to alter the scores if they wanted to do so. The final scores were recorded and the informants were asked open-ended questions designed to prompt group discussions.

c. Temporal pattern of HS/SGS and other camel diseases

Camel disease seasonality was discussed applying a seasonal calendar (Catley *et al.*, 2002b). The informants were asked to name seasons in their own language. Various objects were placed on the ground representing the seasons in order of occurrence. A matrix was constructed with the seasons on the x-axis and indicators such as rainfall, pasture, ticks and diseases drawn on cards on the y-axis (Catley and Irungu, 2000; Ali et *al*, 2006). Twenty

stones were used to score the amount of rainfall; the season with the highest amount of rain got the highest score followed by the second highest, the third highest and the least, in that order. The pasture and tick population were also scored using the same number of stones. Finally, diseases were scored using 20 stones against each season. The seasons with high incidences of the disease in question were given high scores and the ones with low incidence were given low scores. One indicator was scored at a time until all indicators were completed. Then, the matrix was discussed and recorded.

d. Historical trend of SGS/ HS

Historical trends of HS/SGS were studied using historical time lines. Here, the first occurrence of the disease and major outbreaks in the past were discussed. Among the Gabra community a chronological calendar from 1914 to 2009 was used as guide to determine the exact time a particular event occurred including outbreaks of HS/SGS. Major events such as Islamic fasting period (Ramadhan), national elections and El-Niño rains were also used. In the process of discussions the informants were encouraged to discuss any other factors that were associated with the disease. Probing questions were posed to follow any interesting answers the informants gave which may help to unearth any hidden factors that may be related to HS/SGS in camel. The participants were also asked if there was presence of an HS-like disease in cattle during an outbreak in camel.

e. Spatial distribution of HS/ SGS and other priority camel diseases

Participatory mapping was carried out with the different groups of informants. The main objective was to find out areas of frequent outbreaks of HS/SGS. Therefore the informants were asked to indicate areas associated with HS/SGS and other camel diseases. The map also included wet season and dry season browsing, waters points, main human settlements, and elevation of the area (highlands and low lands). Rivers and main livestock markets were also indicated (Catley and Mariner, 2001). At the end of the exercise, the participants were asked to explain the map. The result of the different groups within one District were compared and merged into one map.

f. Relative frequency of occurrence of priority camel diseases and their relative response to treatment

The informants were asked to list the treatment options for six priority camel diseases including HS/SGS. Each disease represented by its major clinical signs drawn on a card was placed on the x-axis of a matrix on the ground. Frequency of occurrence of the diseases and their relative response to treatment were determined by scoring using 30 stones. One indicator was scored at a time. The most frequently occurring disease was given highest score and the least frequent was given lowest score. Relative response to treatment was determined the same way; the disease that responds best to treatment compared to the other five was given the highest score and the ones with relatively poor response to treatment was given low scores.

g. Clinical course and outbreak length of HS/SGS

The informants were asked to give the clinical course and duration of an outbreak (within a herd) of the 6 priority camel diseases. From the answers given in 11 groups, mean clinical course and length of outbreak in a herd of each of the six diseases were calculated and recorded.

h. Herd period prevalence and case fatality estimates of HS/SGS and other diseases

Proportional piling was used to determine period prevalence estimates of HS/SGS and other diseases (Barasa *et al.*, 2005; Bett *et al.*, 2009). A pile of 100 stones was made. Each informant was told that the pile represented his herd. Then he was asked to divide it into two piles to show healthy and sick camels during the last one year. The pile of stones representing sick camels was subdivided by the informant into different diseases that his camels were suffering from to show period prevalence of the diseases. The stones were then counted and scored (Catley and Mariner, 2001). The informant was further asked to divide the stones representing the incidence of each disease into two piles showing the camels that died and those that recovered from the disease. This represented estimated case fatality rates of each of those diseases.

i. Herd characteristics of HS/SGS

I. Within herd morbidity rate and case fatality rate of HS/SGS and other diseases

Proportional piling was used to assess within herd morbidity and case fatality rates (Kipronoh et *al.*, 2011). The informants were given hundred stones. They were asked to assume that the pile represents one herd. Beginning with one disease, the informants were asked to divide each pile into two portions representing the number of camels that become sick and those that remain healthy once the disease attacks the herd. The proportion that becomes sick was considered to be the morbidity rate of the disease. This proportion was further divided into two to indicate the camels that die due to the disease and those that recover in order to determine the within herd case fatality rate of the disease. This was calculated by dividing the number died by the number that were sick due to the disease and multiplying it by hundred. This exercise was repeated in the 11 groups.

II. Morbidity and case fatality estimates of HS/SGS and other diseases according to age groups

Semi-structured interviews (SSI) were used to understand age groupings of the camels. Informants were asked to define herd age structures as understood by their community. Then proportional piling technique was used to estimate morbidity and case fatality rates of HS/SGS and three other diseases according to age groups (Swai and Neselle, 2010; Kipronoh et *al.*, 2011). Piles of 100 stones representing different age groups were made. Beginning with one disease, the informants were asked to divide each pile into two piles representing the number of camels in this age group that become sick and those that remain healthy once the disease attacks the herd. The proportion that became sick represented the morbidity rate of the disease in each age group. To estimate case fatality rate of the disease, the piles representing the sick were further divided into two representing those that die due to the disease and those that recover. Scores were counted and recorded. This was repeated for all the four diseases.

j. Probing

Probing refers to asking further questions regarding information obtained by other tools such as scoring and ranking, mapping, seasonal calendar and so on, in order to get more details on

the topic of discussions and also to check consistency of information given by the informants (Catley and Mariner, 2001). This method was used throughout the PE sessions together with the other tools.

k. Key informants interview

Key informants interviews were held with those who have special knowledge regarding livestock health including the community animal health workers (CAHWs), traditional healers and animal health assistants (Hussain et *al.*, 2005; Kipronoh et *al.*, 2011). The information gathered from these key informants was used in triangulation. One group consisting of 15 CAHWs was interviewed in Wajir East regarding important camel diseases in the area and their spatial distribution. Semi-structured interviews, pair-wise ranking and participatory mapping were used. Two CAHWs and one traditional healer were interviewed in Marsabit North. One animal health assistant was interviewed regarding the local names of the diseases in Somali language.

3.5.3 Socioeconomic implications of HS/SGS and other priority diseases

a. Sociocultural and economic importance of camels in the community

Focus group discussion was used to determine the social and economic importance of camels among different tribal groups of the community in the study area. To begin with, the informants were asked to list means by which they earned their livelihoods. They were then asked to score and rank relative importance of the main livestock species in the area namely camel, cattle and sheep and goats (Kipronoh et *al*, 2011). At this point the informants were required to explain the reasons for ranking a species in a particular way. The informants were further asked to discuss the benefits derived from camels.

b. Sociocultural and economic importance of camels according to age/sex groups

Matrix scoring was used to score different benefits against different age and sex categories of camels as follows: ten most commonly mentioned benefits were selected out of the ones listed earlier. For each category of camels 50 stones were used to score benefits against the different

age/sex groups. The benefit which is associated most with that category received the highest number of stones.

c. Ranking of the benefits derived from camels in order of importance

Out of the earlier discussed benefits derived from camels, 9 commonly mentioned benefits were selected and ranked in order of importance using simple scoring and ranking. Forty five stones were used to score against the benefits. The most important benefit received the highest number of stones while the least important received the lowest (Kipronoh et *al*, 2011). The informants explained briefly why one benefit is more important than the other.

d. Effects of priority camel diseases on the various benefits derived from camels

Effects of priority camel diseases on benefits derived from camels were determined by scoring the earlier ranked nine benefits against five priority camel diseases in a matrix. Using sticks a matrix was constructed on the ground (Bedelian, 2004). The benefits were drawn on cards and placed on the y-axis while each disease represented by its major clinical sign was drawn on a card and placed on the x-axis (Kipronoh et *al.*, 2011). Then 25 stones were used per benefit and scored against the diseases. The disease with highest effect on that particular benefit received the highest score. After each benefit was scored against the five diseases, the matrix was discussed and recorded.

3.5.4 Clinical investigation

a. Examination and sampling of suspected cases of HS/SGS

There were a number of outbreaks of HS/SGS in Mandera West and Wajir East. Eight herds were investigated for the disease. Clinical examinations of the sick animals were carried out and the clinical signs were recorded. The history of some cases which were not accessible at the time were also taken and recorded. From tentatively diagnosed sick animals, nasal, pharyngeal and lymph node swabs together with EDTA blood were sampled. On the day of collection the samples were transported in modified Stuart transport medium in cool boxes with ice and stored at refrigeration temperature thereafter awaiting transportation to the lab. Then they were packed in an ice box and airlifted to the Analabs in Nairobi. Postmortem

examination of a 10 month old male calf that died of the disease was carried out within five minutes of its death. Swab samples were taken from the lungs, lymph nodes, heart, liver and the kidneys and handled the same way as the nasal, pharyngeal and lymph node swabs described above.

b. Culture and analysis of samples collected from animals tentatively diagnosed with HS/SGS

The samples were registered on arrival, given lab number, streaked on blood and chocolate agar and incubated under the CO_2 jar at 37°C for 24 to 48 hours. The plates were read for small flat grey colonies. Gram staining was done for gram negative coccobacillus. The Oxidase test was performed and all oxidase negative gram negative cocobacilli were subcultured on sheep blood and chocolate agar. Then, pure colonies were picked and analysed by API NE20. Colonies positive for pasteurella species were selected and put in tryptose soy broth with glycerine and kept at -21°C to be transported to Germany for future multiplex PCR analysis

c. API 20 NE analysis

Two millilitres of 0.85% saline was added to a sterile test tube. Using a sterile inoculating loop, 1-4 colonies of identical morphology from 24 hour old agar plate were carefully picked by touching the centre of well isolated colonies and thoroughly emulsified in the saline. The suspension turbidity was maintained at 0.5 McFarland standards. A sterile pipette was used to draw the bacterial suspension. This was then inoculated into the tube section of the NO_3 to PNPG microtubes by placing the tip of the pipette against the side of the cupule. 200 µl of API AUX medium was added to the remaining suspension and mixed well with the pipette while avoiding formation of air bubbles. This mixture was used to fill both the tube and cupule section of GLU to PAC. Care was taken not to overfill the cupules by ensuring slightly convex meniscus. After inoculation, the cupules of the underlined tests GLU, ADH and URE were filled with mineral oil. The plastic lid was placed on the tray and the strip incubated at 37° C for 24 hours. After 24 hours all reactions not requiring addition of reagents were recorded.

TRP and nitrate tests were performed as follows: one drop of Nitrate 1 and one drop of Nitrate 2 reagents were added to NO3 cupule. It was read after 5 minutes. One drop of James reagent was added to the TRP cupule. This was read immediately. The API 20 NE analytical profile index was used to interpret the result.

3.5.5 Data Management and Analysis

Data collected were entered into Microsoft Excel worksheets and some descriptive statistics such as mean, median and range were calculated. The data were then imported into SPSS version 18.0 and Kendall's coefficient of concordance was estimated to assess agreement between the results of different informants (Catley *et al.*, 2002b; Catley, 2005). Guidelines given by Siegel and Castellan (1994), cited by Kipronoh et al. (2011) were used to classify the agreement as weak for values less than 0.26, moderate for values between 0.26 and 0.38 at p values < 0.05 and good agreement for values over 0.38 at p values < 0.01 to < 0.001. Box plot graphs of morbidity and case fatality rates of priority diseases were also determined by SPSS version 18.0.

4 RESULTS

4.1 Indigenous knowledge regarding camel diseases in general and HS/SGS in particular

4.1.1 Disease description

a. Important priority camel diseases in the study area

HS/SGS (*qando* in Gabra dialect, *qarir* in Somali language and *Khandich* in Garri dialect) was ranked the top most important disease affecting the camels by the herders in northern Kenya (Table 2). The informants were left to decide what they considered important in ranking the diseases. The following are some of the reasons given for ranking HS/SGS as the most important disease: It is a killer disease (only second to anthrax), It either kills or brings the animal close to death, occurs frequently, spreads widely and has high morbidity (can affect up to half of the herd). It is said to affect one animal more than once and drastically reduces production e.g. milk and sale value of the camel are reduced to almost zero. Somali herders described *qarir* as mild form of anthrax while others said it is a "young one of anthrax". It is said to weaken the animal such that only "skeleton" is left. According to the Gabra herders, *qando* is responsible for reduced herd sizes in the community. Some vividly recounted past events where the disease hit the community badly killing large number of camels. As a result some years were named after the disease e.g. Khamis *qando* (1978) and Arbaa *Lugisa* (1949) - *Lugisa* is an old name for *qando*. Somali and Garri herders indicated that *qarir/khandich* causes isolation of infected herd by other herders, lingers in the herd for long time (can stay in the herd 3 to 6 months) and has no known effective treatment.

Other priority camel diseases were Respiratory disease complexes (RDC) which were described as two different entities by the informants hence referred to as RDC 1 and RDC 2 in this study, camel pox, wry neck, abscesses and trypanosomosis. Two diseases in Mandera west could not be associated with any known disease in the literature. These were Butal/Lesa and Iddi in Garri dialect. Iddi is a plant which shares same local name with Sodom apple (solanum caninum). It causes poisoning of camels leading to loss of sight and hearing. People

drinking the milk and eating the liver of such an animal were also said to be experiencing the same problem.

Table 2: Ten most important camel diseases as scored by 11 herder groups using 50 stones in each group, Northern Kenya, 2011

Disease	Number of herder groups	Total Score*	Average score	Overall Rank
HS/SGS	11	102	9.27	1
RDC 1	11	73	6.64	2
Camel Pox	11	66	6.00	3
Wry Neck	10	39	3.55	4
RDC 2	9	36	3.27	5
Abscess	6	27	2.45	6
Trypanosomosis	5	28	2.55	7
Lesa/Butal	3	32	2.91	8
Iddi	3	24	2.18	9
Mange	4	16	1.45	10

*This is the total score from 11 groups. Each group used 50 stones to score against 10 diseases. However, these diseases differ from group to group. Some diseases in this table are not mentioned by some groups.

d. Association of clinical signs with diseases

As the informants listed and ranked the most important camel diseases in their area, they also described the clinical signs and post mortem lesions of the following diseases: HS/SGS and three other diseases; respiratory disease complex 1 (RDC 1), respiratory disease complex 2 (RDC 2) and wry neck were chosen as 'controls' to score major clinical signs against the diseases using a matrix (Table 3). Ten clinical signs were chosen from the ones listed in the focused group discussion. These included major clinical signs of the four diseases.

Table 3: Scoring of the clinical signs of camel diseases in the study area as done by 10 herder groups using 20 stones to score clinical signs against the diseases, Northern Kenya, 2011

Clinical signs	Kendall's W*	Median score (range)			
		RDC1	RDC2	HS/SGS	Wry Neck
					●●●●●●●●●●
Bent/kinked neck	1.00***	0 (0-0)	0 (0-0)	0 (0-0)	●●●●●●●●●● 20 (20-20)
		●●●●	●●●●●	●●●●●●●●●	●
Lachrymation	0.592***	4 (2-7)	5 (2-12)	9 (3-14)	0.5 (0-5)
		●●●●	●●●	●●●●●●●●●●●●	
Enlarged lymph nodes	0.857***	4 (0-8)	3 (0-7)	12.5 (11-20)	0 (0-0)
		●●	●●●●	●●●●●●●	●●●●●●
Recumbency	0.34*	2 (0-5)	4 (1-10)	7 (3-13)	5.5 (0-10)
		●●●	●●●●●●●	●●●●●●●	●●●●●
Emaciation	0.257ns	3 (0-7)	6.5 (0-9)	7 (2-11)	4.5 (0-9)
		●●●●●	●●●●●●●●●●●●	●●●●	
Coughing	0.916***	5 (1-7)	11.5 (10-15)	3.5 (2-6)	0 (0-0)
		●●●●●	●●●●●	●●●●●●●●●●	
Fever	0.734***	4.5 (2-7)	4.5 (0-11)	10 (6-14)	0 (0-6)
		●●●●●●	●●	●●●●●●●●●●●	
Bad odour	0.773***	6 (2-11)	1.5 (0-7)	11 (7-18)	0 (0-2)
		●●●●●●●●●●●●●●	●	●●●●●	
Nasal discharge	0.865***	13.5 (9-20)	1 (0-6)	4.5 (0-7)	0 (0-1)
		●●●●●	●●	●●●●●●●●●	●●●●
Mortality	0.765***	5 (2-7)	2 (0-4)	9 (8-14)	3.5 (1-7)

Key: *Kendall's coefficient of concordance (W), (***P<0.001, **P<0.01, *P<0.05, ns=not significant). Black dots are median scores.

There was perfect agreement (W = 1) for clinical sign for bent/kinked neck. The agreements for nasal discharge, bad odour, fever, coughing, enlarged lymph nodes, lachrymation and mortality was good (W = 0.592-0.916). Recumbency had moderate agreement (W = 0.34)

while emaciation had no significant agreement (W = 0.257ns). Enlarged lymph nodes, bad odour, fever, lachrymation, mortality and recumbency were strongly associated with HS/SGS with median scores of 12.5, 11, 10, 9, 9 and 7 in that order.

Using semi-structured interview (SSI), additional clinical signs were given as: slight cough (soft cough) (91%), dullness (82%), retained urine ('kills faster') (82%), recumbency (lies down putting the chin on the ground) (64%), shivering (55%), anorexia (55%), reluctance to move (45%) and salivation (36%). The animal is said to be unconscious during the heat of the day but regaining consciousness in the cooler hours (55%), voids very tiny pellets of faeces which become hard, rough and smelly (*Qarir/khandich*) (36%). Furthermore, there is difficulty in breathing (18%), bloody diarrhoea (in some cases) (18%), bloating (18%), some swelling in the nose (boil-like) (9%) – which bleeds *(Qarir/khandich)* and rough and dark hair coat *(Qarir/khandich)* (9%).

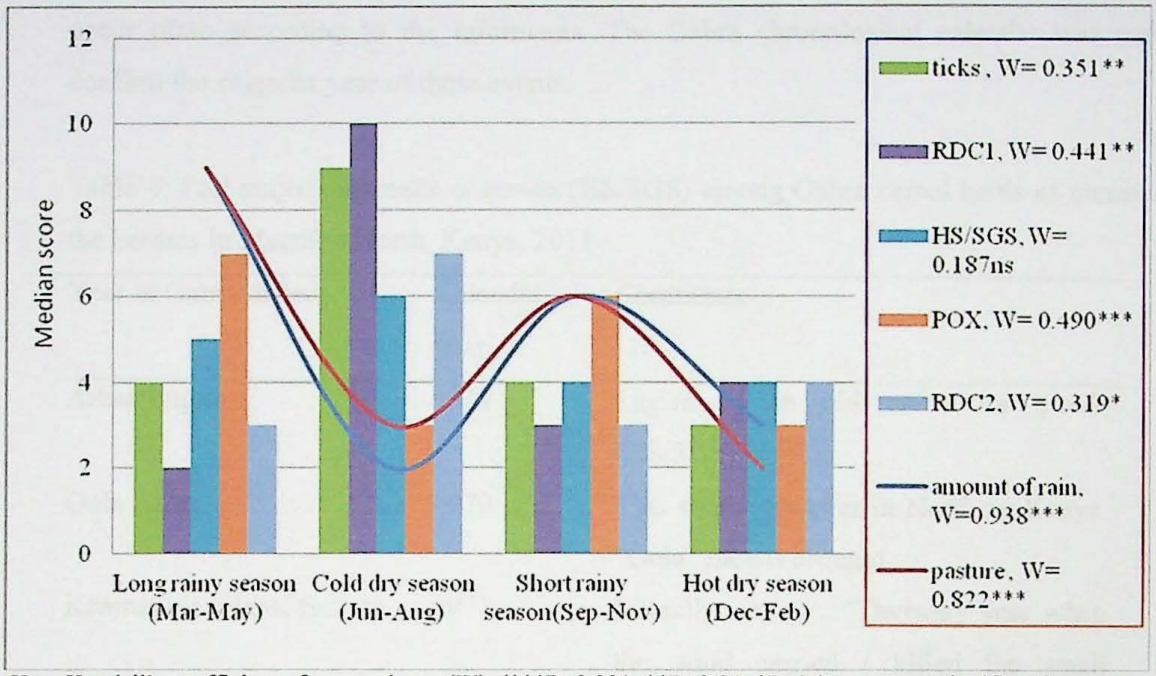
e. PM lesions of HS/SGS as described by the informants (n= 11 groups)

For HS/SGS most of the informants described haemorrhages in the intestines (73%) clots in/blood spot on the heart (55%), engorgement of blood vessels with blood (45%) and swollen liver (45%). The meat and subcutaneous tissues were said to be infiltrated by blood (36%), the lymph nodes were enlarged and dark on cutting (27%) and the lungs were swollen (27%). Some informants also reported that the meat of the camels suffering from HS/SGS have rubbery consistency and tasteless (18%). Other lesions mentioned were haemorrhagic/dark lungs (18) and increased pericardial fluids (9).

4.1.2 Temporal distribution of HS/SGS

A seasonal calendar was set up to determine the temporal pattern of HS/SGS and other camel diseases. The seasons in the study area were defined as: long rainy season between March and May, cold dry season between June and August, short rainy season from September to November and hot dry season between December and February. The seasons were given in local languages and related to the months of the year; thereafter, they were translated into English based on their descriptions.

The seasonal calendar shows that HS/SGS occurs in all seasons with slight increase from March to August, i.e. long rainy season and cold dry season (Figure 2). However, based on Kendall's W there was no significant agreement between the groups regarding the temporal patterns of HS/SGS. There were moderate to good agreements (0.319-0.938) regarding temporal distribution of rainfall, pasture, ticks and other diseases (figure 2).



Key: Kendall's coefficient of concordance (W), (***P<0.001, **P<0.01, *P<0.05, ns = not significant)

Figure 2: Scoring for seasonal patterns of rain, pasture ticks and 4 disease complexes investigated in Northern Kenya, 2011

4.1.3 Spatial distribution of HS/SGS

According to participatory mapping done by the informants (see annexes 9 and 10), HS/SGS is wide spread in the study area unlike one of the `control diseases´ i.e. camel trypanosomosis which is associated with specific areas e.g. along the rivers, swampy areas and lakes.

4.1.4 Historical trends of HS/SGS

All the informants indicated that the disease has always been there. However, they stated that it has been on the rise these days. Gabra herders recounted major outbreaks in the past and

listed them in their language. According to Gabra community years are named after the days of the week (*Ahad, Alsinin, Talasa, Arbaa, Khamis, Gumat, Sabdi,* i.e. Sunday to Saturday). For instance, to differentiate one "Sunday" year from another, major events that happened that year are mentioned. Thus, some of these years are named after *Qando* (HS/SGS) e.g. 1949 and 1978 (Table 4) as these are just the worst remembered outbreaks but other outbreaks also occur often according to the informants. The Gabra chronological calendar was used to confirm the calendar year of these events.

Table 4: Past major outbreaks of *qando* (HS/SGS) among Gabra camel herds as narrated by the herders in Marsabit North, Kenya, 2011

Year in Gabra dialect	Calendar year	Comments
Arbaa Lugisa	1949	*Lugisa* is an old name for *qando* (HS/SGS)
Oola Arbaa	1970	This was a dry year in Northern Kenya. "Oola" means drought.
Khamis ree qilensi fud'ate	1971	Literally means "Thursday year when the wind carried / killed the small ruminants"
Khamis qando	1978	Thursday year of *qando* (HS/SGS). There was heavy rain and increased population of biting flies (The Borana call it the `year of flies´)
Talasa elnino	1997	There was heavy El-Niño rain in Kenya.
Talasa Ijjolle Reqisa	??	

In the recent past, there was one outbreak 2010, and one in June 2011. According to the informants, the 2010 outbreak was limited to a place called D'osole in Marsabit North.

4.1.5 Period prevalence of priority camel diseases between June-August 2010 and June-August 2011

Period prevalence of HS/SGS and other priority diseases was assessed by interviewing 73 informants. Each informant described the one year period prevalence of several diseases in his herd by proportional piling (Figure 3). HS/SGS was the most prevalent disease followed by RDC 1.

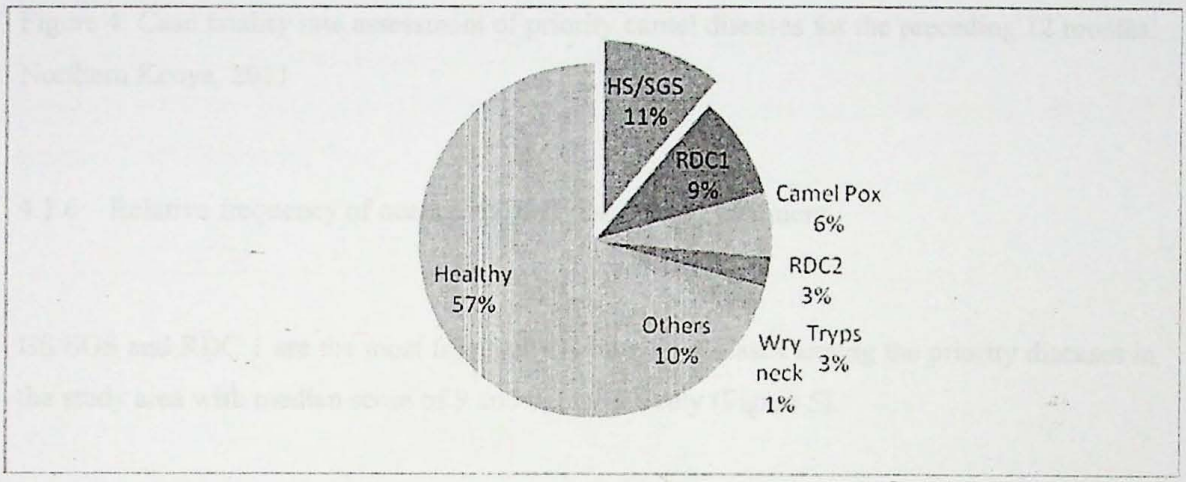


Figure 3: Period prevalence assessment of priority camel diseases for the preceding 12 months, Northern Kenya, 2011

Also the case fatality rates were determined in a similar way (Figure 4). Wry Neck had highest mean case fatality rate (42%) followed by HS/SGS (35%).

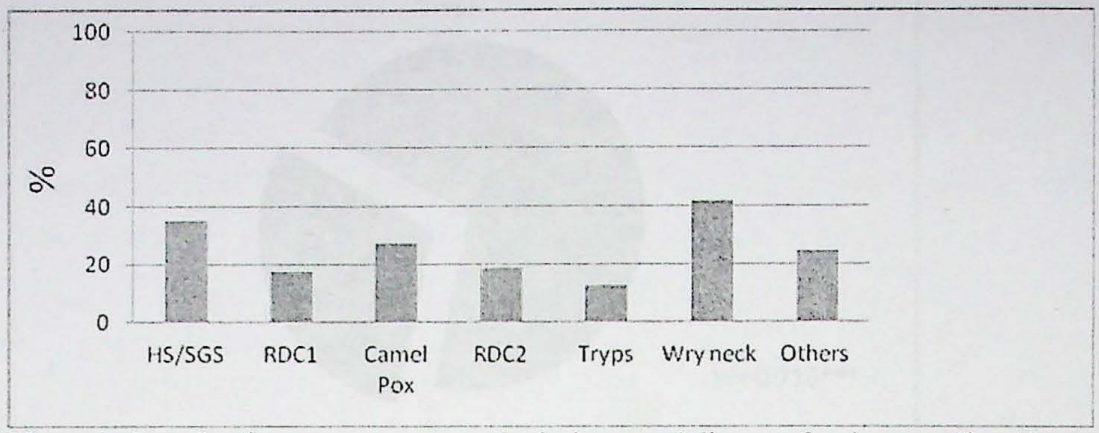
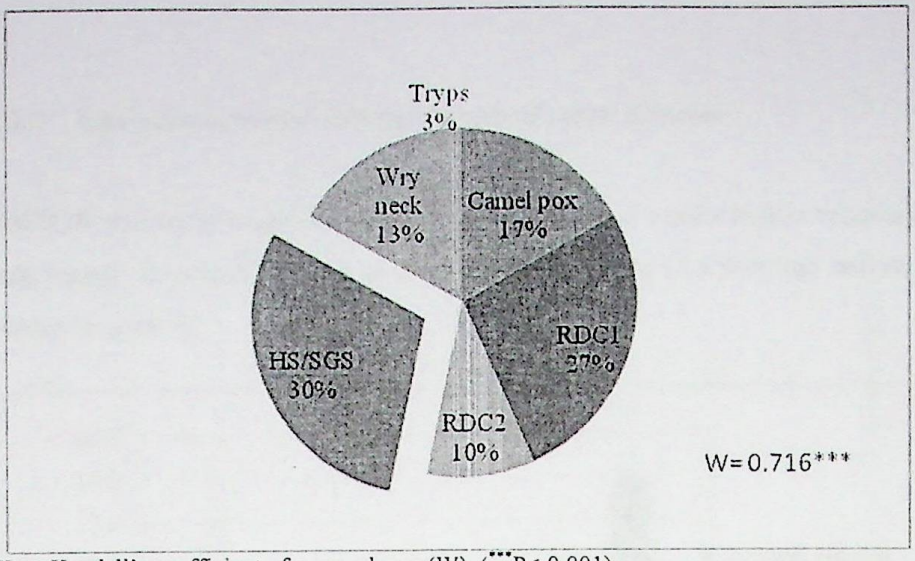


Figure 4: Case fatality rate assessment of priority camel diseases for the preceding 12 months, Northern Kenya, 2011

4.1.6 Relative frequency of occurrence and response to treatment

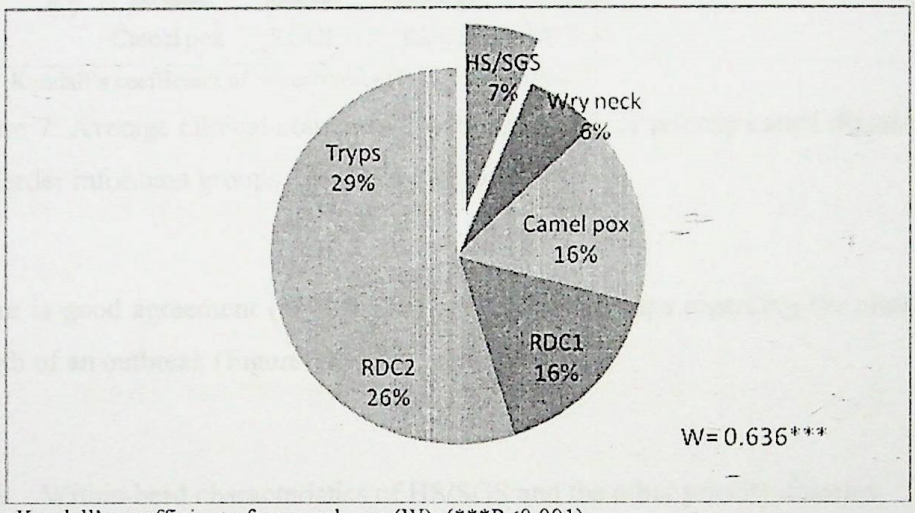
HS/SGS and RDC 1 are the most frequently occurring diseases among the priority diseases in the study area with median score of 9 and 8, respectively (Figure 5).

In terms of relative response to treatment, HS/SGS and Wry Neck are the poorest, each having median scores 2; camel trypanosomosis responds best to treatment, followed by RDC 2 (Figure 6). The agreements between the groups were good for both relative frequency of occurrence (W = 0.716) and relative response to treatment (W = 0.636) (Figures 5 and 6)



Key: Kendall's coefficient of concordance (W), (***P< 0.001)

Figure 5: Relative frequency of occurrence of camel diseases as scored by 11 informant groups, Northern Kenya, 2011.

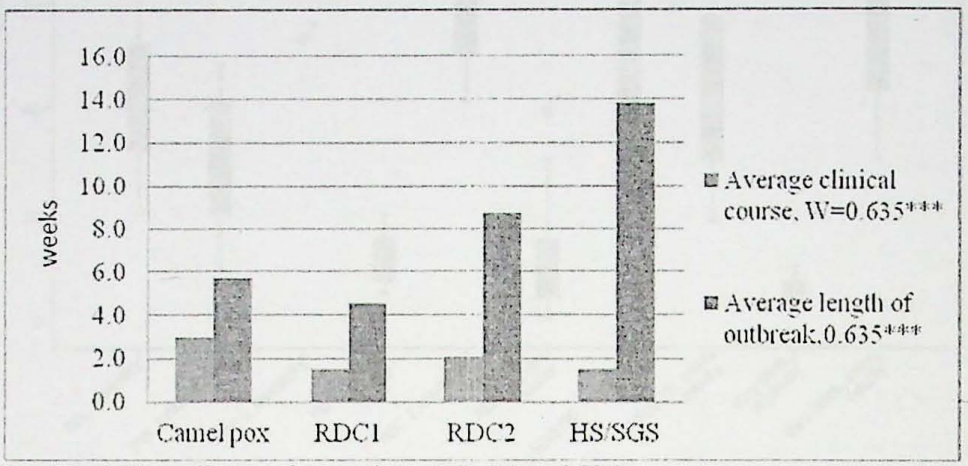


Key: Kendall's coefficient of concordance (W), (***P<0.001)

Figure 6: Relative response of 6 priority camel diseases to treatment according to 11 informant groups in northern Kenya, 2011.

4.1.7 Clinical course and outbreak length of camel diseases

HS/SGS runs an average clinical course of about two weeks before recovery according to the informants. In a herd it takes an average of 14 weeks (3.5 months) before such an outbreak ceases (Figure 7).



Key: Kendall's coefficient of concordance (W), (***P<0.001)

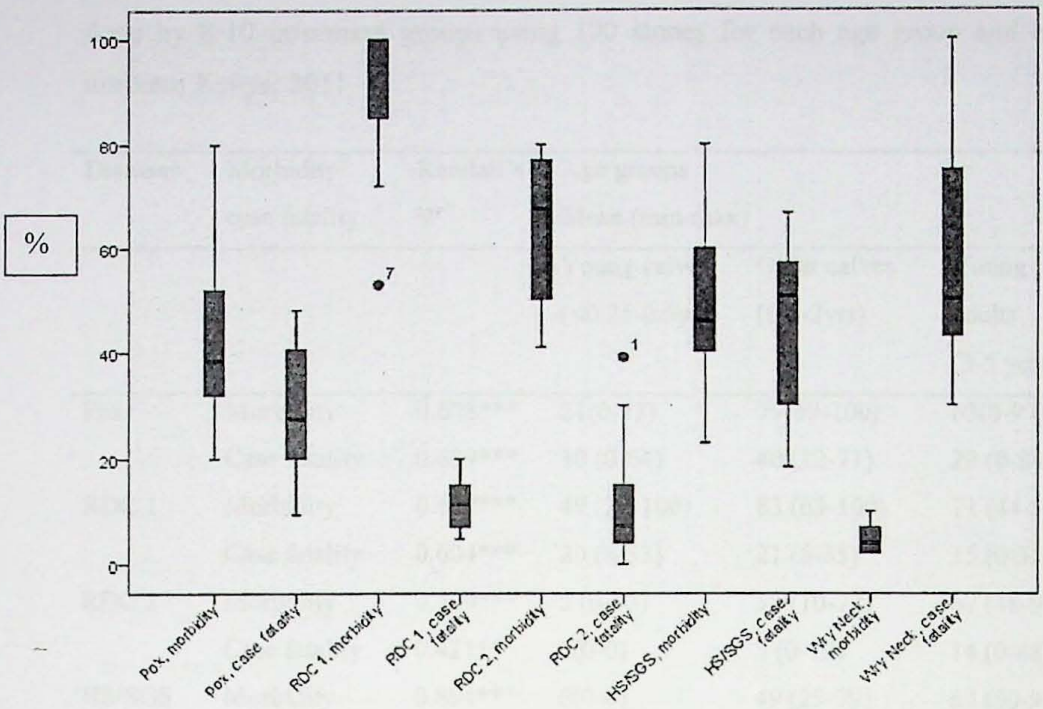
Figure 7: Average clinical course and outbreak length of priority camel diseases according to 11 herder informant groups, Northern Kenya, 2011.

There is good agreement (W = 0.635) between the groups regarding the clinical course and length of an outbreak (Figure 7)

4.1.8 Within-herd characteristics of HS/SGS and the other priority diseases

a. Expected morbidity and case fatality rate at the herd level

Expected within herd morbidity and case fatality rate of priority camel diseases were determined using proportional piling. Within herd mean morbidity and case fatality rates for HS/SGS were 49% and 46%, respectively (Figure 8). However, RDC 1 is said to have the highest morbidity rate (90%) while for Wry Neck at herd the highest case fatality rate (57%). The agreement between groups regarding the expected within herd morbidity and case fatality rates was good.



Morbidity rate, Kendall's W = 0.843***; Case fatality rate, Kendall's W= 0.750

Figure 8: Expected within herd morbidity (blue colour) and case fatality rates (red colour) of priority camel diseases at 95% confidence level according to 11 informant groups, Northern Kenya, 2011

b. Expected morbidity and case fatality rates of priority camel diseases by age group

For the age group Young Adults the highest expected mean morbidity and case fatality rate for HS/SGS of 67% and 51% respectively were determined. The next most affected group are older calves with expected mean morbidity and case fatality rates of 49% and 36% respectively, followed by the adults group with an expected mean morbidity rate of 18% and an expected case fatality rate of 19%. Smaller calves less than 3-6 months are said to be not affected by the disease (Table 5). In general, the agreement between groups was moderate to good (W = 0.421- 0.894) for all the diseases.

Table 5: Expected morbidity and case fatality rates of priority camel diseases by age group as done by 8-10 informant groups using 100 stones for each age group and each disease in northern Kenya, 2011

Diseases	Morbidity/ case fatality	Kendall's W*	Age groups Mean (min-max)			
			Young calves (<0.25-0.5yrs)	Older calves (0.5-2yrs)	Young adults (3-5 yrs)	Adults (>5yrs)
Pox	Morbidity	0.678***	21(0-53)	79(59-100)	63(0-97)	19(0-19)
	Case fatality	0.629***	30 (0-64)	40 (12-71)	29 (0-84)	1 (0-7)
RDC 1	Morbidity	0.687***	49 (23-100)	83 (63-100)	71 (44-97)	44 (11-86)
	Case fatality	0.604***	20 (8-33)	21 (5-35)	15 (0-32)	6 (0-26)
RDC 2	Morbidity	0.700***	5 (0-43)	38 (10-72)	67 (48-90)	56 (10-92)
	Case fatality	0.421**	0(0-0)	5 (0-19)	14 (0-48)	9 (0-26)
HS/SGS	Morbidity	0.894***	0(0-0)	49 (29-79)	67 (50-94)	18 (0-45)
	Case fatality	0.894***	0(0-0)	36 (24-50)	51 (43-72)	19 (0-51)

Key: *Kendall's coefficient of concordance (W), (***P<0.001, **P<0.01,

4.1.9 Comparative *qando* versus *qarir/khandich* data of HS/SGS

For the three communities living in the study area, the Gabra in Marsabit North, the Somali in Wajir East and the Garri in Mandera West, there are some differences in how they describe HS/SGS. The Gabra community call it *qando* which means "fever". The terms used by the Somali and Garri are *qarir* and *khandich* respectively which mean "lymph node". A number of aspects to be considered in order to understand this disease are summarised in Table 6

Table 6: Comparison of HS/SGS descriptions and epidemiology between the three communities resp. Districts in the study area, Northern Kenya, 2011

Disease terminology Ethnic group	Qando Gabra (n=4 groups)	Qarir Somali (n= 3 groups)	Khandich Garri (n= 4 groups)
Relative response to treatment (%)	10	10	0
average clinical course (weeks)	2	4	4
Average length of outbreak (weeks)	8	17	17
Within herd morbidity (%)	64	36	41
Within herd case fatality (%)	59	51	25
Cause/transmission	Wind/air	Ticks	Ticks

Relative response to treatment was determined by scoring 30 stones against 6 diseases. The median scores were used to calculate the percentage relative response. Generally, the relative response of HS/SGS to treatment is poor in all three communities.

Qando is said to respond to treatment with oxytetracycline if given early. This did not come out in the scoring probably because the scoring was relative and, thus *qando* was judged against other diseases which better respond to treatments. Garri community does not treat *khandich* because they believe that when antibiotics are injected the animal dies. Somali herders also said that *qarir* does not respond to treatment.

On average *qando* seems to take a shorter clinical course in an individual animal and an outbreak in a herd has a shorter duration.

Proportional piling showed that *qando* has higher morbidity rates compared to *qarir and khandich.* Case fatality rates of *qando* was also shown to be higher than that of qarir and *khandich*

Table 7: Comparison of age-group specific morbidity rates of HS/SGS as scored by a total of 10 herder groups from three communities in northern Kenya using 100 stones for each age-group, 2011

Community (local name for HS/SGS)	Number of groups	Age-groups			
		Young calves (<0.25-0.5 yrs)	Older calves (>0.5- 2yrs)	Young adults (3-5 yrs)	Adults (>5yrs)
Gabra (*Qando*)	4	0	51	69	34
Somali (*Qarir*)	2	0	36	67	13
Garri (*Khandich*)	4	0	54	65	6

The morbidity rate of *qando* is generally higher in all age groups compared to *qarir* and *khandich* (table 7)

Further, *qando* seems to be a more acute disease leading to death in 1 to 3 days according to the informants. *Qarir/khandich* appears to be more a sub-acute disease that kills the affected animal in about a week.

Overall, the description of the disease in terms of the clinical signs, with *qando* on one hand and *qarir/khandich* on the other hand, seems to be similar with only minor additions or omissions.

The Gabra herders said that the disease affects all ages except the very young calves though young adults are affected most. Garri and Somali herders said that it does not affect camels more than 12 years of age. This is supported by the figures presented in table 7 where estimated mean morbidity of *qando* in adult is 34% while that of *qarir* and *khandich* is 13% and 6% respectively.

Qarir and *khandich* are said to be associated with tick infestation (*far-dheer/san-gal*) (*Hyaloma dromedarii)* a view which is not shared by Gabra herders who say that *qando* is spread by air.

4.2 Socioeconomic implications of HS/SGS

4.2.1 Relative importance of livestock species

Camels were ranked as the most important livestock species (61%) by pastoral herders of northern Kenya (Figure 9). The small ruminants followed the camel in ranks (27%) while cattle were the least important (12%) of the three.

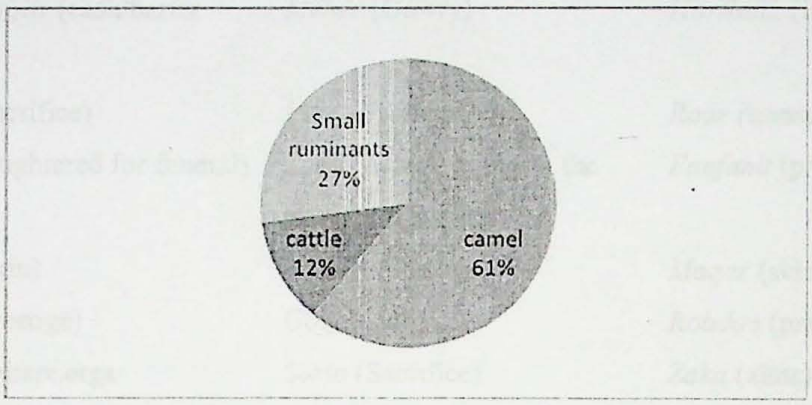


Figure 9: Relative importance of livestock as ranked by pastoral herders in Northern Kenya, 2011

4.2.2 Socioeconomic importance of camels

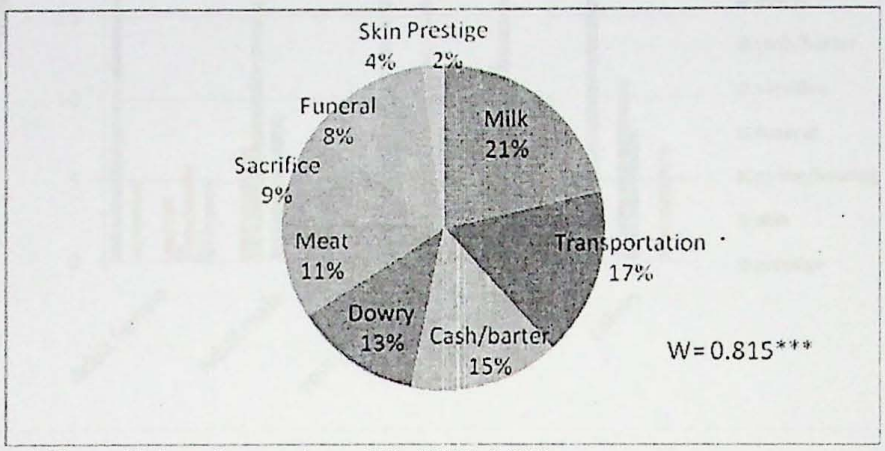
A number of sociocultural and economic benefits of camels were discussed in the different discussion groups. The summary of benefits is given in Table 8

Table 8: Summary of the benefits derived from camels according to different communities (not in a particular order), Northern Kenya, 2011

Gabra	Garri	Somali
Anan (milk)	*Awal* (Funeral)	*Aana* (milk)
Foon/qalm (meat/slaughter)	*Foon* (Meat)	Gathasha (selling)
Fais (transportation)	*Aanan* (Milk)	Meher(dowry)
Qarat (dowry)	*Biti* (Selling)	*Duug (*funeral*)*
Gurgur/jijiir (cash/barter trade)	*Meher* (Dowry)	*Hiir/hilib* (fat/meat)
Sorio (sacrifice)	*Faich* (Transport)	*Raar (*transport)
Jerr (slaughtered for funeral)	*Zaka* (Alms)-giving to the poor (compulsory)	*Fanfanit* (prestige)
Goga (skin)	*Faanki* (prestige)	*Maqar* (skin)
Balel (prestige)	*Goga* (skin)	*Robdon* (prayer/sacrifice)
Kheni/dabare,erga (gift/lending)	*Sorio* (Sacrifice)	*Zaka* (alms)
D'ibayu (libation) i.e. the act of pouring of milk on the ground to appease the ancestors	*Duksi* (paying for the teacher of the Holy Qur'an)	*ganax* (fine)
	Deni (paying debts)	*Hajji* (Islamic pilgrimage) - sold to attend hajj
	Khenni/dabare (giving/lending to the needy).	*sadaqa* (giving to the needy voluntarily)
	Hajji (Islamic pilgrimage) - sold to attend hajj	

4.2.3 Ranking the benefits derived from camels

Socioeconomic importance of camels was determined by listing all the benefits derived from camels. Nine of the commonly listed benefits were selected and ranked in order of importance Milk was ranked the highest followed by transport, cash/barter) and dowry. The agreement between groups was good (Figure 10).



Kendall's coefficient of concordance (W), (***P<0.001)

Figure 10: Ranking of the benefits derived from camels according to 11 groups of camel herders, Northern Kenya, 2011.

4.2.4 Benefits derived from different age groups of camels

Ten of the most commonly mentioned benefits were scored against different categories of camels in each of the communities in the study area. The Garri and Somali camel herders' results were merged because they use camel more or less the same way. Fifty stones were used to score the benefits against each category of camels. The median scores were calculated and presented in Figures 11 and 12.

a. Gabra community

According to the Gabra community, the main benefit derived from adult female camel is milk. Adult males are mainly used for transportation, and young females and young males for dowry payment but also sold for cash (Figure 11). Another benefit derived from young males

is transportation while young females are given to other members of the community who are in need. Calves are mainly useful in stimulating lactating camels to produce milk and for dowry payment.

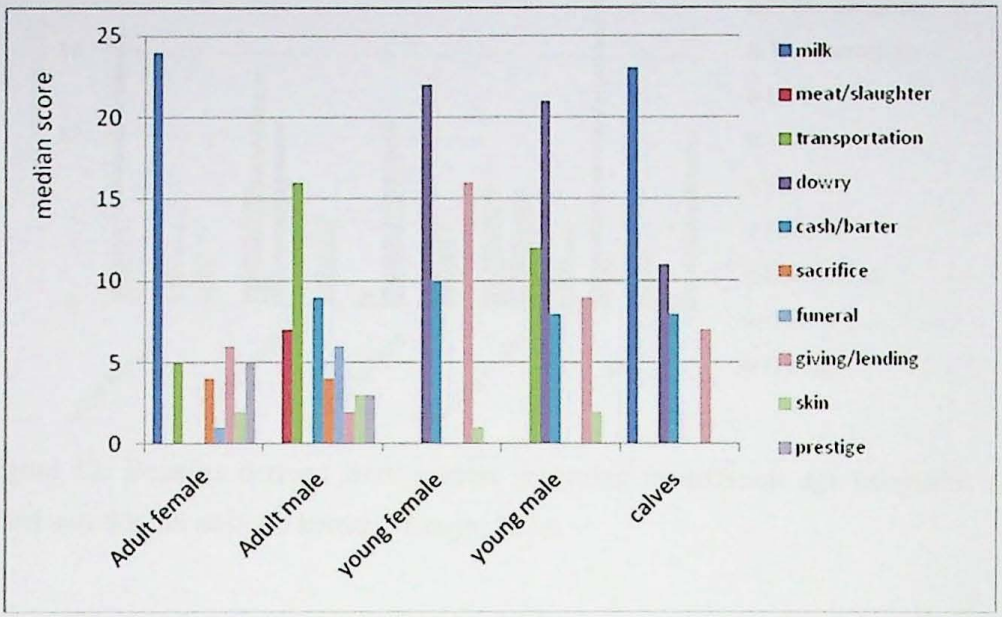


Figure 11: Benefits derived from camels according to different age groups among the Gabra pastoral herders, Kenya, 2011

b. Garri and Somali community

The Garri and Somali herders use adult female camels mainly for milk (median score, 16) and some cash/barter activities (Figure 12). Adult males are mainly used for transportation but also sold for cash. The main benefits from young females are *Zaka* (alms), dowry payment and cash/barter. Young males are used for meat, cash transport and as sacrifice/prayer.

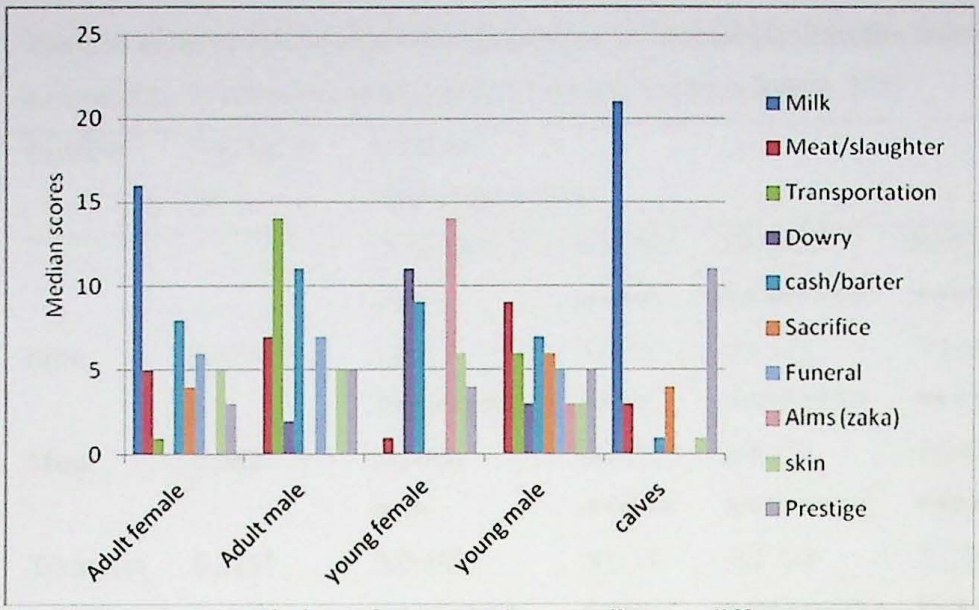


Figure 12: Benefits derived from camels according to different age categories among the Garri and Somali pastoral herders, Kenya, 2011.

4.2.5 Socioeconomic effects of the priority camel diseases studied

Matrix scoring of socioeconomic effects of priority camel diseases (Table 9) shows that HS/SGS has high relative effects on the benefits of camels: highest effects on dowry, milk, transport, prestige and funeral with median scores of 9 for dowry and 8 for the others.

A number of reasons were given for these high scores which include:

- it kills young adults which are used for paying dowry,
- it is very severe therefore reducing milk production to near zero (starts with the young but attacks up to 12 years of age),
- kills a lot of animals hence denying the family milk and transportation,
- it takes long in the herd,
- animals suffering from HS/SGS cannot be used for transportation until full recovery; furthermore, it weakens the animal so much that it reduces prestige

There was moderate to good agreement among the groups in most of the benefits. However, the agreement regarding the relative disease effects on transportation was weak and no significant agreement found for effects on funeral and cost of treatment of the diseases.

Table 9: Relative effects of priority diseases on socioeconomic benefits derived from camels as scored by 11 informant groups using 25 stones, Northern Kenya, 2011

Benefits	Kendall's W*	Diseases Median (min-max)				
		Camel pox	RDC1	HS/SGS	RDC2	Wry neck
		●●●	●●●●	●●●●●●●●	●●●●●●●	●●
Milk	0.374**	3 (0-7)	4(1-6)	8(2-11)	7(1-10)	2(0-11)
		●●●●●●●●	●●●●	●●●●●●●●	●●●●	●
Meat	0.562***	8(2-15)	4(0-5)	8(6-12)	4(0-8)	1(0-4)
		●●●	●●●●●	●●●●●●●●	●●●●●	●●●●
Transport	0.225*	3(0-10)	5(1-7)	8(2-10)	5(1-9)	4(1-9)
		●●●●●●●●	●●●●	●●●●●●●●●	●●●●	●
Dowry	0.677***	8(2-10)	4(2-6)	9(6-10)	4(2-7)	1(0-5)
		●●●●●●●	●●●●	●●●●●●●	●●●●●	●●●
Cash/barter	0.410***	7(0-10)	4(0-7)	7(4-12)	5(2-11)	3(1-5)
		●●●●●●●●●	●●●●	●●●●●●●	●●●●	●●●
Sacrifice	0.298**	9(0-11)	4(0-7)	7(3-12)	4(0-7)	3(1-17)
		●●●	●●●●●	●●●●●●●●	●●●●●	●●●
Funeral	0.143ns	3(0-10)	5(0-10)	8(1-10)	5(2-9)	3(1-14)
		●●●●●●●●●●		●●●		
		●●●●●●●●●●				
Skin	0.794***	19(10-25)	0(0-3)	3(0-9)	0(0-5)	0(0-8)
		●●●●●●●	●●●●	●●●●●●●●	●●●●	●
Prestige	0.308**	7(1-17)	4(0-8)	8(2-13)	4(0-12)	1(0-5)
		●●●●	●●●●●●	●●●●●	●●●●●●	●●●
Treatment cost	0.193ns	4(0-6)	6(2-10)	5(0-11)	6(1-13)	3(1-6)

Key: *Kendall's coefficient of concordance (W), (***P<0.001, **P<0.01, *P<0.05, ns=not significant). Black dots represent the median scores

c. Estimated economic losses as possibly caused by HS/SGS

To estimate economic losses likely due to HS/SGS first sales prices for camel of different age groups had to be obtained by means of focus group discussions (Table 10).

Table 10: Sale prices of different age-groups camels according to the herders in Northern Kenya, 2011

	Gabra		Somali	
Price in Ksh*.	Calves/young adult	Adult	Calves/young adult	Adult
Average	20,900	45,625	26,400	51,875
Minimum	8,000	30,000	7,000	27,500
Maximum	40,000	60,000	37,500	80,000

*The prices are summaries of the ranges given by different groups in the focus group discussion

The sum of the total losses attributable to mortality caused by HS/SGS incurred by a herder in one outbreak among the Gabra community is estimated at an average of Ksh 66,700. This can reach as high as Ksh 133,050 for herders with large herd sizes (Table 11). Among the Somali (which includes the Garri), the sum of the total loss for a herder is at about Ksh 75,000 on average but can reach as high as Ksh 150,000. The losses among the Gabra community are both due to mortality in adults and in younger camels while those of Somali herders are said to be mainly as a result of mortality in calves and young adults.

Table 11: Losses incurred by a herder due to mortality as a result HS/SGS in a herd in Northern Kenya

Community	Gabra		Somali/Garri	
	Average (min-max)		Average (min-max)	
Herd size*	16 (2-28)		33 (2-64)	
Age groups*	Young adults/calves	Adults	Young adults/calves	Adults
(In proportion of herd size)	(40%)	(60%)	(40%)	(60%)
Number in age-group*	6 (1-11)	10 (1-17)	13 (1-26)	20 (1-38)
Morbidity	40%	34%	38%	8%
Case fatality	41%	36%	45%	8%
Number sick	2 (0-4)	3 (0-6)	5 (0-10)	2 (0-3)
Actual losses	1 (0-2)	1 (0-2)	2 (0-4)	0
Losses due to mortality (Ksh) **	20,900	45,625	75,000	0
	(0-41,800)	(0-91,250)	(0-150,000)	

Key: Calves / young adults (0-5 years); Adults (>5 years)

*= adapted from Kaufmann (1998).

**= calculated by multiplying the average price (as taken from table 10) of each age group by the number of animals that die in that age group.

d. Milk loss due to morbidity attributed to HS/SGS

Qarir/khandich runs an average clinical course of two weeks while *qando* only of about one week. Full recovery, if at all, cannot be achieved before the third to fourth week because of the severity of the disease. The informants said that milk production drops to almost zero during this time. According to Kaufmann (1998) Gabra camel produces on average 3.2 litres per day for the first 15 months (medium producers) while the Somali produces 5.3 litres. If a lactating camel becomes sick large amounts of milk are lost (Table 12).

Table 12: Loss of milk incurred by a camel herder per lactating camel becoming diseased with HS/SGS, Northern Kenya, 2011

	Gabra	Somali
Average milk production* in litre/day	3.2	5.3
Average clinical course in days	7	14
Total amount of milk lost in litre	22.4	74.2
Monetary loss in Ksh (1 l= 40-60 Ksh)	896-1,344	2,968-4,452

*according to Kaufmann (1998)

This is just an estimation of losses during the period of sickness. Some more losses are expected during the recovery period. Moreover, this does not take into account the loss caused by mortality. Milk is also lost due to the loss of a calf because some camels refuse to be milked without their calves. These other losses are difficult to quantify. Therefore the amount of milk lost is expected to be higher than the estimation given in Table 12.

4.3 Clinical investigation

There was an outbreak of HS/SGS in a number of herds in Wajir East and Mandera West between March and August 2011. Details for 6 of those herds are shown in Table 13. The total number of camels in the affected herds was 485. The total number of diseased camels was 95 while the number that died as a result of the disease was 35, thus the average morbidity rate was 20% and average case fatality rate was 37%. Morbidity rate ranged from 14% to 32% while case fatality rate was between 13% and 62%. The age range of affected animals was mainly between 10 months and 8 years except in herd 3 where camels up to 12 years were affected. Most of camels whose ages were mentioned were the ones that died. This disease is said to take long in the herds according to the herders. At the time of data collection some of the herds were just at the beginning of the outbreak. Therefore, the actual morbidity and mortality rate could be underestimated.

Table 13: Morbidity and case fatality rates of HS/SGS in 6 herds encountering an outbreak of HS/SGS in Wajir East and Mandera West, Kenya, 2011

Herd number	Number of camels in the herd	Number of camels sick	Number of camels dead	Morbidity rate in (%)	Case fatality rate in (%)	Age range
1	100	15	2	15	13	2-4 yrs
2	80	24	7	30	29	10 m-8yrs
3	25	8	3	32	38	7-12 yrs
4	130	20	8	15	40	3-4 yrs
5	60	15	7	25	47	2-5 yrs
6	90	13	8	14	62	4 yrs
Total/mean	485	95	35	20	37	
	Range (%)			(14-32)	(13-62)	(10m-12yrs)

4.3.1 Observed clinical signs and postmortem lesions of suspected HS/SGS cases

Fourteen camels reported by the owners as suffering from *qarir* and *khandich* were examined. The most common clinical signs were: asymmetrical swelling of superficial lymph nodes (pre-parotid, subcervical, and inguinal) (100%[†]), slight cough (being soft, moist and painful as shown by arched back in most cases) (100%), dullness (63%), anorexia (63%), not chewing cud (63%), fever (63%), lachrymation (50%), abdominal breathing (50%), lethargy/reluctance to move (50%), shivering (38%), recumbency (38%) and serous nasal discharge (38%). In some cases there were congestion of conjunctiva (25%), straining during micturation (some drops of urine) (25%), tick infestation (25%), salivation (13%) and fly infestation (especially around the mouth and the nose) (9%).

One post mortem examination was performed. The significant findings included enlargement of subcutaneous and mesenteric lymph nodes, pulmonary edema and emphysema, abscesses

[†] all percentages given in brackets were calculated from the number of animals that presented the sign out of the total examined

in liver and muscles of sub-lumbar region; the lymph nodes were hemorrhagic and dark on cutting.

4.3.2 The disease HS/SGS

In the present study the herders in Northern Kenya described HS/SGS in detail. According to their descriptions and the observation of clinical cases in the field in 2011, *Qarir / khandich / qando* (HS/SGS) is characterised by asymmetrical swelling of superficial lymph nodes, dullness, lachrymation, fever, soft, moist and painful cough as shown by arched back, dyspnoea (abdominal breathing and dilated nostrils), anorexia, extreme weakness, shivering, little or no urine, reluctance to move, bad odour, and rough hair coat. Salivation, serous nasal discharge and congestion of conjunctiva are also seen in some cases. The main postmortem findings are swollen, dark and hemorrhagic lymph nodes, hemorrhagic intestines and subcutaneous tissue and in some cases pulmonary edema and emphysema. The disease runs a sub-acute course of 1 to 2 weeks, has a within herd mean morbidity estimate ranging from 20-49 % and a mean case fatality estimate of 35-46 %. It affects mostly young adults (3 - 5 years) with a mean morbidity estimate of 67% followed by older calves (>0.5 - 2 years) with 49% while adult camels (>5 years) are less affected with a mean morbidity estimate of 18%. The younger camel calves (<0.25-0.5 years) usually do not get the disease. HS/SGS occurs throughout the year and is widespread in northern Kenya. It occurs in prolonged outbreaks of about 2-6 months within a herd though *Qando* is said to take a little shorter duration compared to *Qarir/Khandich*. HS/SGS is reported to have a poor relative response to antibiotic treatment compared to other priority diseases in the area. There seems to be no immunity against HS/SGS; some herders reported that it can affect an individual even up to 3 times in its life time.

4.3.3 Laboratory result from specimen taken during the outbreak

Nasal, pharyngeal and lymph node swabs, and whole blood were sampled from 14 animals with clinical signs of HS/SGS. Examination of blood smears showed no blood parasites. On culture of samples from 7 animals *Pasteurella* like colonies were observed (Table 14); when tested with API 20 NE, they were positive for *Pasteurella* species. These samples were frozen to be transported eventually to Germany for analysis by multiplex PCR in future.

Haematological investigations showed high lymphocytes and low neutrophil numbers in all the camels whose blood were sampled except for the camels 6, 8 and 9 which had high neutrophils and low lymphocyte counts. In most cases PCV and RBC were low (Table 14). Out of these 14 camels tentatively diagnosed with HS/SGS, 11 were between 1 and 5 years old. Two were 8 years and one was 10 months old.



Figure 13: Suspected case of HS/SGS; swollen preparotid lymph node and lachrymation, 10 months old male calf in Mandera West, 2011



Figure 14: Enlarged and hemorrhagic lymph nodes, suspected case of HS/SGS in Mandera West, 2011

Table 14: Laboratory results of samples from camels tentatively diagnosed with HS/SGS in Northern Kenya, 2011.

Herd ID	Animal ID	Sex/age	Haematology	Culture	API 20 NE	Type of sample positive for P spp and/or BHS
A	1	F/3yr	N/A	P spp	P spp	Nasal swab
B	2	F/2yr	N/A	P spp	P spp	Nasal swab
C	3	F/4yr	N/A	-	-	-
D	4	F/2yr	Slightly low WBC	BHS		Nasal swab
E	5	F/8yr	PCV- low , RBC- low Neutrophils- low	P spp/BHS	P spp	Nasal swab- P spp & BHS Lymph node- BHS
F	6	F/2yr	PCV-low, RBC- low WBC- high Lymphocytes-low Neutrophils- high	-	-	-
	7	M/3yr	RBC- low Lymphocytes- high Neutrophils – low	-	-	-
	8	F/3yr	PCV- low, RBC- low Neutrophils- high	P spp	P spp	Nasal swab
G	9	M/1.5 yr	Lymphocytes – low Neutrophils – high			
	10	M/1.5 yr	WBC- low Lymphocytes – high Neutrophils – low	BHS/P spp	P spp	Nasal swab
	11	F/2yr	PCV- low, RBC- low WBC- high Lymphocytes – high Neutrophils – low	-	-	-
	12	M/8yr	PCV- low , RBC- low WBC- low Lymphocytes – high Neutrophils – low	-	-	-
	13	M/10 yr	PCV- low , RBC- low WBC- low Lymphocytes –high Neutrophils – low	BHS/ P spp	P spp	Nasal swab
	14	F/1yr	PCV- low, RBC- low Lymphocytes – high Neutrophils –low	BHS/P spp	P spp	Nasal swab
H	15	F/5yr	RBC- low Lymphocytes- high Neutrophils – low	-	-	-

Key: P spp= *Pasteurella* species, BHS= beta haemolytic *Streptococcus*, N/A= not sampled

5 DISCUSSION

5.1 Disease ranking

In the present study HS/SGS was ranked as the most important disease by both Somali and Gabra herders. Other diseases which are also considered 'priority diseases' were respiratory disease complex, camel pox and wry neck in that order. A number of studies have shown that HS/SGS is one of the most important diseases in pastoral communities of northern Kenya. According to Kaufmann (1998) Gabra and Rendille herders ranked the disease as top most important disease based on mortality caused by the disease; the Somali herders rated it the third most important disease after trypanosomosis and wry neck. Probably the reason why Somali herders ranked it as number one this time was because there was an outbreak in the area extending from Wajir East to Mandera West at the time of this study. According to Gluecks et *al.* (2010) HS/SGS was ranked among the first to fourth most important disease of camels by pastoralists in northern Kenya. In a study done by Mochabo et *al.* (2005) in Turkana District which neighbours Marsabit north to the west, camel HS was ranked the fourth most important disease in terms of annual incidence after trypanosomosis, mange and tick infestation.

The differences in ranking HS/SGS could be due to different ranking criteria. In this study the informants were left to decide what they considered important in ranking a disease. Thereafter, they gave their reasons for ranking a particular disease in a particular way. This approach was used as opposed to the researcher-defined ranking criteria so that a broader picture of the disease is developed right from the beginning of the exercise rather than limiting the herders to such criteria as mortality caused by the disease or frequency of occurrence.

Another reason is that the importance of a disease in an area changes over time depending on the actual disease situation in the area. For instance, in one area in Wajir East `Sudden death of camels' was ranked as the most important disease while it was not considered as priority disease by informants in other areas. This is because at the time of the exercise there was a scare due to some mysterious `sudden death' of camels in the area. However, the fact that

HS/SGS has been consistently ranked among the top four most important diseases of camels in a number of studies in northern Kenya (Kaufmann, 1998; Mochabo, 2005, Gluecks, et *al*, 2010) shows that the disease is really a problem to camel herders in the area. However, trypanosomosis was only ranked the 7th most important disease. This could be due to the fact that this disease is only important in certain areas along the lakes and rivers and also due to increased availability of effective treatment. Most of the informants in Wajir East for example said that they have not seen the disease in many years. Those who are familiar with it said that it has effective treatment these days, though, some herders say that it is still the worst disease in some areas where it is common.

5.2 Clinical signs and postmortem findings of HS/SGS

The clinical signs and postmortem findings described by the informants are largely in agreement with the description of SGS (Kaufmann, 1998; Koehler-Rollefson et *al.*, 2001;Younan, 2007) and partly with camel HS (Higgins, 1986; Schwartz and Dioli, 1992; Koehler-Rollefson et *al.*, 2001) in the literature. *Qando / qarir / khandich* appear to be largely swollen glands except for one outbreak of *qando* in 2010 described by Gabra herders which was characterised by swelling around the ventral aspect of the neck. However, this is just suggestive not conclusive because a number of the clinical signs and postmortem lesions are similar for both HS and SGS.

5.3 Temporal and spatial patterns of HS/SGS

First, in the focus group discussions seasonality as perceived and adopted by the respective camel herders had to be defined. The division of the year into four distinct seasons i.e. long rainy season, cold dry season, short rainy season and hot dry season is in agreement with Farah et *al.* (2004).

Though there was no significant agreement regarding the temporal distribution of HS/SG when tested by Kendall's coefficient of concordance; seasonal calendar scoring indicates that there are increased levels of HS/SGS during the cold dry period between June and August followed by the long rainy season from March to May. During probing, the informants said

that the disease is common throughout the year; some even said that it has no particular seasonal pattern. This is contrary to the description given by a number of authors who stated that camel HS mainly occurs during the rainy season (Schwartz and Dioli, 1992; Wernery and Kaaden, 1995; Koehler-Rollefson et *al.*, 2001; Gitao, 2006). However, a report by Younan (2007) on an outbreak in Puntland indicated that *Qanjiir Burr* (SGS) is associated with the windy cold season between June and August (*Haggaa)*. According to Younan and Bornstein (2004, personal communication), *khanid* (SGS) has no particular seasonality. The variability in the description of the seasonal pattern of HS/SGS by the informants is reflected by the disagreement shown by the Kendall's coefficient of concordance.

Participatory mapping in the study area indicated that HS/SGS is wide spread in northern Kenya. The herders, who know the area very well because of constant movement with their camels, sketched the maps and showed that in all the camel browsing areas the disease can be found. On probing further, some even said that wherever there is camel there is HS/SGS. Wilson (1984) described the disease as widespread in East Africa. HS/SGS has been reported in Laisamis in Marsabit south, Kalacha and Dukana in Marsabit north, Moyale and Wajir Districts (Kaufmann, 1998; Younan and Bornstein, 2004, Pers.comm, Younan, 2005, Pers.comm).

5.4 Historical trend reported for HS/SGS

According to the informants, HS/SGS is said to have always been there in northern Kenya but the outbreaks are more frequent nowadays. According to Younan and Bornstein (2004, Pers.comm.) *khanid* (SGS) is said to have an increased frequency of occurrence in the recent past occurring every 1 to 2 years.

Gabra herders listed most of the worst remembered cases where several camels were killed. Two years were named after *Qando* (HS/SGS) i.e. *Arbaa Lugisa* (1949) and *Khamis Qando* (1978). Gabra herders actually consider *Qando* (HS/SGS) as the worst disease in history. They indicated in 3 from 4 group discussions that it is responsible for reduced herd sizes of camels in their region.

5.5 Relative frequency of occurrence and response to treatment

HS/SGS was ranked the most frequently occurring disease in the area ahead of respiratory disease complex 1(*furri/hergeb*) and camel pox. However, as the disease in question is a 'killer disease', the informants might have remembered it more than other diseases, thus, a recall bias is quite likely.

The predominant antibiotic used for treatment of HS/SGS by the herders is 10% oxytetracycline because of its availability. Somali herders said that sick camel responds better to penicillin-streptomycin result but this compound is not often available. Garri herders do not treat the disease saying that it worsens the situation. Gabra herders report good results with oxytetracycline if treated early though they also prefer penicillin-streptomycin. However matrix scoring showed that the response to treatment is generally poor compared to other priority diseases such as trypanosomosis, RDC 2, RDC 1 and pox across the three communities. Higgins (1986) indicated that early treatment for camel HS with suitable antibiotics such as tetracycline and penicillin-streptomycin should be effective. Schwartz and Dioli (1992) also advised early treatment with sulfonamides and other antibacterial agents. Koehler-Rollefson et *al.* (2001) recommended early treatment with amoxicillin, tetracycline or sulphonamides. According to Khan (2011) the efficacy of oxytetracycline is low while penicillin-streptomycin combination has poor efficacy against camel HS. Kaufmann (1998) stated that there is no known effective treatment for SGS. Koehler-Rollefson et *al.* (2001) also indicated that this disease has no known successful treatment. Among the Rendille community *Khanid* treatment with antibiotics is contraindicated although some argue for early treatment (Younan and Bornstein, 2004, Pers.comm). In the case of *qanjiir buur* (SGS) outbreak in Puntland in 2007, there was "no obvious treatment effect" (Younan, 2007). In this study the investigator treated four cases of *Qarir/Khandich* (HS/SGS) with penstrep and one case with oxytetracycline (on the third day after the onset) in Northern Kenya between June and August 2011. However, the investigator was not able to follow up the first four camels treated with penstrep but the one that was treated with oxytetracycline died a day after the treatment. A number of traditional treatments are attempted. The Gabra use tobacco and roots of some herbs called "*bursa*". Among the Somali, sheep tail fat and meat soup mixed with blood is fed to the animal. They also brand the swollen lymph nodes. Somali herders prevent the animal from drinking water believing that it worsens the situation. However, the effectiveness of these traditional treatments was not determined in this study.

There could be a number of reasons why the response to treatment of HS/SGS is poor in the camel herds of northern Kenya. To begin with, the herders do not follow the proper dose of antibiotics. Most of them said that they injected once and only repeated after some days and even that sometimes at low doses. Another reason could be that most herders may not have quick access to veterinary drugs so early treatment might not be possible. Or maybe the most commonly used antibiotic which is oxytetracycline is not effective anymore against the pathogen. Schwartz and Dioli (1992) recommend high doses for treatment of camel HS. The situation is different for camel trypanosomosis which only requires a single treatment and in most cases even with the right dosage. Thus, in matrix scoring trypanosomosis had the best response to treatment.

5.6 Clinical course and outbreak length of HS/SGS

According to the informants the average clinical course of HS/SGS is about 2 weeks and the length of an outbreak in a herd is said to be about 14 weeks. *Qando* is said to kill mostly in 1-3 days while *qarir/khandich* kills within a week. In the literature camel HS is reported to kill the animal in 2-5 days (Higgins, 1986), in 24 to 48 hours (Schwartz and Dioli, 1992) and within 2-8 days (Koehler-Rollefson et *al.,* 2001). According to Younan (2007) *Qanjiir buur* (SGS) kills in 4-7 days and recovery is prolonged beginning from about 14 days. Younan et *al.* (2008) observed a prolonged outbreak of *khanid* which occurred in Marsabit south from February to April 2008. However, in this year's outbreak of *Qarir/Khandich* in northern Kenya, the outbreak lasted 3 to 6 months in some herds i.e. March to August 2011, according to herder reports in the focus group discussions.

5.7 Herd characteristics of HS/SGS

Expected within herd mean morbidity and case fatality rates of HS/SGS were 49% and 46% respectively. The informants reported that about one in three camels suffering from HS/SGS between June-August 2010 to June-August 2011 died. In the March-August 2011 outbreak in Wajir East and Mandera West, the average morbidity and case fatality rate was 20% (14-32)

and 37% (13-62) respectively, though the outbreak was not over yet at the time of the field investigations of this study.

These morbidity rates described by the herders and that of the 2011 outbreaks in northern Kenya do not agree with low morbidity rates as described for camel HS by some authors (Schwartz and Dioli, 1992; Gitao, 2006). Koehler-Rollefson et *al.* (2001) stated that only a few animals in a herd are affected. However, these authors put the case fatality rate at as high as 50-80%. Some authors who described SGS separately (Kaufmann, 1998; Koehler-Rollefson et *al.,* 2001) did not indicate quantified morbidity and case fatality rates for this disease. In an outbreak in Puntland in 2007 case fatality rates of SGS ranged from 17 to 20% (Younan, 2007, field note). However, since outbreaks are said to last for long periods in the herds, the reported figures might be lower than the actual figures encountered in the field.

Qarir/khandich affects mainly camels from 1 to 12 years of age according to the Somali and Garri herders. *Qando* is said to affect all ages but more young adults and older calves than adults. Average morbidity for both *qando* and *qarir/khandich* in young calves (<0.5 yrs), older calves (>0.5-2yrs), young adults (3-5yrs) and adults (>5yrs) are 0%, 49%, 67%, and 18%, respectively. This information is generally in agreement with what was observed in an outbreak that occurred in northern Kenya between March and August 2011 where 85.7% of the cases were between 0.8 and 5 years old and 14.3% were 8 year old adults. However, it is contrary to what is described by some authors who stated that Camel HS is more common in adults though it affects all ages (Schwartz and Dioli, 1992; Gitao, 2006). According to Kaufmann (1998) and Koehler-Rollefson et *al.* (2001) SGS affects both adults and calves over 3 months of age but they did not give differences in morbidity rates between different age groups. Some reports of recent outbreaks in Puntland and Marsabit south District of Kenya indicate that *qanjiir buur* and *khanid* (swollen glands) affect mainly older calves and young adults (Younan and Bornstein, 2004, Pers.comm; Younan, 2007, Younan et *al.,* 2008) which is in agreement with the picture given by the informants and what was observed in 2011 outbreak in Northern Kenya in this study. However, one outbreak of a disease which the herders called "*new qando*" in Dukana division of Marsabit district in 2005 was said to have attacked mainly adults and heifers of breeding age (Younan, 2005, Pers.comm).

Seven of the fourteen samples collected from the camels in 2011 outbreak in Northern Kenya were positive for *Pasteurella species* when tested by API 20 NE after culturing on blood and

chocolate agar media. The specific species of *Pasteurella* could not be determined at the time due to limited time and funds. Therefore, the isolates were stored under -21°C to await further analysis by PCR. Pasteurella multocida isolation from suspected cases of HS was reported by Hassan and Mustafa (1985, cited by Wernery and Kaaden, 1995) where serotype B was isolated from an outbreak in Sudan. In an outbreak in Pakistan, Khan (2011) reported *Pasteurella multocida subspecies multocida* based on the clinical signs, postmortem findings, colony and staining characteristics and biochemical tests. However, in an investigation done in all major camel keeping Districts in Kenya Gluecks et *al.* (2010) reported that no *Pasteurella multocida* Carter serotype *B:2 and E: 2* was isolated from nasal swabs of 392 camels.

5.8 *Qando* (Marsabit North) versus *Qarir/Khandich* (Wajir East/Mandera West)

The differences observed may be due to differences in the level of endemicity of the disease in Marsabit north on one hand and Wajir east/Mandera west on the other hand, the latter experiencing a relatively more endemic and, thus stable situation compared to the former although breed differences cannot be excluded. According to Wilson (1984), the main breed of camels kept by the Somali in Kenya is *benadir* while the Gabra mainly keep *gabra* breeds.

Some authors describe Camel HS and SGS as two diseases which just share the same local names in a number of communities. One of these "diseases" has a similar clinical presentation like HS in cattle and is hence referred to as Camel HS (Higgins, 1986: Schwartz and Dioli, 1992; Koehler-Rollefson et *al.*, 2001; Gitao, 2006), while the other "disease" which is mainly characterised by generalized lymphadenitis is called `Swollen Glands´ (Kaufmann, 1998; Koehler-Rollefson et *al.*, 2001,). However, one report from Puntland (Younan, 2007) describes these two "diseases" or forms or courses of one disease and identifies it by two different local names as *Qanjiir Buur* (Swollen glands) and *Garir/Guux* (camel HS). "*Qanjiir Buur*" literally means "Swollen glands". "*Garir*" means "shaking/shivering" while "*Guux*" is used to describe the sound of "expiratory grunt". Cattle HS which was ranked by livestock producers as the most important disease in Somalia in 2006 is also referred to *as Guux* (Okuthe et *al.*, 2006). It is important to note that here the name given to a disease basically describes the major clinical signs of the disease or the main factors associated with its occurrence. For instance, the Maasai name for Malignant Catarrhal Fever "*inkati*" means

"wildebeest" which is associated with the occurrence of the disease (Barnard et *al.*, 1994, cited by Bedelian, 2004). Contagious caprine pleuropneumonia is referred to as "*sombes*" by the Gabra and Borana community describing the organ which is mainly affected i.e. the "lung". Therefore this means that these two diseases at least have two major clinical signs, and/or organs, and/or species affected which should define the diseases as being different.

In this study, there was nothing pointing to the occurrence of typical Camel HS in Wajir East and Mandera West. However in Marsabit North, the picture is yet unclear. One group said to have experienced an outbreak of *qando* in the last year in a place called D'osole and described the disease as very acute, killing camels in one or two days. They also described the major clinical signs as fever and swelling of the throat. This points towards HS. On the other hand, they largely described *Qando* by using most of the clinical signs of SGS described by herders in other areas. What makes *Qando* more confusing is that the word "*qando*" refers to fever which is one of the major clinical signs of both camel HS and SGS, unlike in the other communities (Garri, Somali and Rendille) where the defining clinical sign is "swollen lymph nodes" which points more to SGS. This means that Gabra herders are likely to group the two diseases or forms/courses of diseases as one if both are present in the area. Indeed in one group discussion they said that if a disease presents fever as the major clinical sign and it is not *Furri* (RDC 1), not *Qufa'* (RDC 2) and not *Chirmale* (Anthrax), then it is considered as *Qando*. Another informant in giving reasons why *qando* is important said that it is "confusing"; hence one does not know a clear diagnosis or treatment.

Even in the literature, the two diseases or forms of a disease share a lot of clinical signs and possible aetiology e.g. one of the possible diagnosis of SGS is said to be hemorrhagic septicaemia (Koehler-Rollefson et *al.*, 2001). Older literature seem to discuss camel HS (Higgins, 1986; Schwartz and Dioli, 1992; Wernery and Kaaden, 1995) while the recent ones describe more of SGS in northern Kenya (Kaufmann, 1998; Koehler-Rollefson et *al.*, 2001; Younan and Bornstein, 2004, Pers.comm).

5.9 Socioeconomic implications of HS/SGS

5.9.1 Relative importance of livestock

Camel was ranked the most important species of livestock by the herders across the three communities involved in the study followed by small ruminants and cattle. However, this ranking may be biased because the herders interviewed were mainly camel herders. That notwithstanding, several authors have articulated the position of camels among the pastoral communities: "Camel is the most important species of livestock in the pastoral communities of Africa and Asia" (Ali et *al.*, 2009). Farah et *al.* (2004) stated that camel is considered the most valued livestock among the Somali and that camel production is a major source of livelihood for the pastoralists in the drier parts of Kenya. According to Gluecks et *al.* (2010) camel is the most important livestock species with regard to food security in northern Kenya.

5.9.2 Socioeconomic importance of camels

When nine benefits which were commonly mentioned by the informants in all the three different communities in the study area were picked and subjected to scoring and ranking, milk was ranked the most important benefit followed by transportation, selling and dowry. Others were meat, slaughter for funeral, sacrifice, skin and prestige in order of importance. According to Farah et *al.* (2004) and Moallin (2009) the importance of camels among the Somali is primarily due to milk and meat production and transportation; the same authors added that camels have social as well as cultural importance. The informants emphasised that selling camels for cash has overtaken the importance of meat nowadays. This sentiment is shared by Farah et *al.* (2004), who stated that the Somali community is changing the production system towards market orientation due to changing socioeconomic and environmental conditions.

It is interesting to note that each of the communities in northern Kenya uses different age and sex categories of camels for different purposes. Thus, defining the benefits of camels according to different age and sex categories is important in considering the impact of different diseases on the camel herding households. A disease which affects a specific age group impacts more on the benefits that are derived from that age group.

Each of the benefits derived from camels has its own importance. Milk is mainly used as food among all herders but the Gabra people use it for libation (*d'ibayu*) in addition. This is a very important exercise in such that one even has to borrow a lactating camel from friends just for this purpose. Milk is the first thing given to a child when it is born (*anqarsa*) and the last thing given to the sick before death (*qulammo*).

According to the herders, water is the most important commodity transported by camels. This is because the pastoralists need to live far from watering points in order to reach good pasture since pasture closer to the watering points are finished faster. Other things that are transported by camel are children, goats' kids, sick and old people. Among the Gabra community, the sick is believed to get well once carried on camel back. In times of war, if all the watering points are captured by the enemies, the camel can evacuate the entire household without going through the watering points because it can resist thirst and can walk for long distances. This helps the families escape through dry and even desolate lands where enemies cannot reach on foot. According to Moallin (2009) camel is used for transport of milk, water and nomadic household migration.

Dowry payment (2 young males and 1 young female) is especially important among the Gabra. It is a compulsory activity for a marriage where at least one young male camel has to be given before the wedding ceremonies can start. According to Kaufmann (1998) 4% of breeding females in the Gabra herds originate from bride price payments.

Camels are slaughtered only during certain ceremonies and during prolonged droughts where fat and meat is preserved in a particular way and eaten for a long period (Kaufmann, 1998). According to Mochabo (2005), camel meat is rarely eaten except to mark certain occasions in the Turkana community.

Among the Somali, camels are used to pay fines (*ganax*) for wrong doing. The herders said that the camel is the only animal that can be used to pay fine in case someone killed another man or woman. This sentiment is confirmed by Hussein (1993, cited by Farah *et al.*, 2004) who stated that camels are the only means of payment of 'blood money' to the lineage of the deceased in the case of tribal feuds.

5.9.3 Socioeconomic effects of priority camel diseases on the benefits derived from camels

HS/SGS significantly affects the most important benefits derived from camels compared to other priority diseases. For instance, it had the highest relative effects on milk, transport and dowry. According to the herders, HS/SGS kills a lot of animals denying the family benefits such as milk among others. According to Kaufmann (1998) SGS had the highest proportional mortality among the Rendille (52%) and the Gabra (46%) and was the third highest killer among the Somali (15%).

The informants particularly justified the effect on milk by saying that the disease is so severe hence reducing milk production to almost zero; even many of them said that no milk is produced at all during the period of sickness. Kaufmann (1998) mentions anorexia and sternal recumbency as the reasons for emaciation and reduced milk production. Considering that the disease does not have a high morbidity among the adults, the effect of HS/SGs on milk is actually expected to be lower. However, the informants tend to focus on the effect on one individual camel, and, moreover on calf losses as the presence of the calves stimulate milk-let down by the camels.

The informants justified the effect on meat by saying "only bones are left" as the animal becomes very weak and emaciated.

In justification for the effect on transport they said that when a camel suffers from HS/SGS, it cannot be used for transportation.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

The present study clearly showed that the pastoralists have an enormous knowledge of diseases affecting their livestock and they are as well able to diagnose a number of diseases among others largely based on their clinical signs, postmortem lesions and the age-groups affected. The herders keenly observe their animals and at times even differentiate closely related forms of a disease; this was indeed the case for the respiratory disease complex which is described by a number of authors under one disease complex (Schwartz and Dioli, 1992; Koehler-Rollefson et *al.*, 2001) but in this study herders describe it as two distinct disease entities.

This study confirmed the occurrence of camel HS/SGS in northern Kenya and boosted the available epidemiological data. The disease complex camel HS/SGS described by the herders in northern Kenya seems to be largely the `Swollen Glands´ syndrome. However, this does not completely rule out the occurrence of typical Camel HS in the area. Though both HS and SGS share most of the clinical signs and postmortem findings described in the literature, HS appears to be more acute. Moreover, HS is said to be more a disease of adult camels though it affects all ages which is clearly not the case in this study. The likelihood of occurrence of both the typical Camel HS and SGS together in Northern Kenya is higher in Marsabit north than in other areas as shown by the unclear descriptions of *Qando* (Gabra) compared to *Qarir/Khandich* (Somali/Garri) and also by the occasional reports of what appears to be camel HS/SGS in Marsabit North such as the outbreak in D'osole in 2010 and reports provided by Younan (2005, Pers.comm).

The study was not able to clearly determine the causative agent (s) of HS/SGS and whether SGS and HS are one disease or different entities.

It is also evident that the pastoralists themselves treat their animals using modern veterinary drugs and in most cases at inappropriate doses creating high likelihood occurrence of drug

resistance organisms and other public health concerns such as drug residues in livestock products due to negligence of withdrawal periods.

The study confirmed the vital roles the camel play among the pastoralists of Northern Kenya and the socioeconomic implications of priory camel diseases in the area. However, this was just a general highlight of relative effects of these priority diseases on the socioeconomic values of camels; a further quantification of these effects would be desirable.

6.2 Recommendations

This study could not clearly and distinctly enough describe camel HS and SGS, thus a more detailed and in-depth study is required to eventually reach at scientifically clear and sound definitions of these conditions if there are. Still, there is need to focus on finding the causative agents of this disease. Efforts should be put in detailed surveillance and investigation of the outbreaks in the camel keeping Districts of Kenya. Moreover, a broader approach should be taken considering rather other possible causes in the investigations than focussing on the "suspected" *Pasteurella multocida* alone.

More in-depth and quantitative investigations of the priority camel diseases are required to further determine the actual socioeconomic impact of camel HS/SGS.

The pastoralists of Northern Kenya should be educated regarding the proper use of veterinary drugs and the consequences of their improper use. In this regard there is need to boost veterinary services in Northern Kenya since the herders resort to treating their animals because of lack of veterinary services in these areas.

7 REFERENCES

Ahmad, S., Yaqoob, M., Hashmi, N., Ahmad, S., Zaman, M. A and Tariq, M. (2010): Economic Importance of Camel: Unique Alternative under Crisis, *Pak. Vet. J., 30 (4), 191-197.*

Ahuja, V. (2004): The economic rationale of public and private sector roles in the provision of animal health services, *Rev. Sci. tech. Off. int. Epiz. 23 (1), 33-45*

Alcamo, E. and Warner J. M. (2010): Schaum's outlines microbiology, second edition, the McGraw-Hill Companies Inc, USA. Pp 125.

Ali, I., Shafiq chaudhry, M. and Farooq U: (2009): Camel rearing in Cholistan desert of Pakistan, *Pak. Vet. J., 29 (2): 85-92.*

Ali, S. N., Asif, M., Rehman, A., Jat, L. A., Ali, Q and Hussain, M. (2006): Participatory Surveillance of Livestock Diseases in District Karachi–Pakistan. Intern. Journ. of Agric. & Bio. 1560–8530/2006/08–5–652–656.

ALRMP (2005): Marsabit District Vision and Strategy: 2005-2015, Arid Lands Resource Management Project (ALRMP), Ministry of State for Special Programmes, Kenya. Pg 3

Alwis, M. C. L (1992): Haemorrhagic septicaemia-a general review. *Br. Vet .J. 148, 99.*

Amare, D. T. (2004): A retrospective study of the impact of community based animal health service delivery system in Shinile zone, Somali National Regional State of Ethiopia, A master thesis, Faculty of Veterinary Medicine, Addis Ababa University, Master of Science in Tropical Veterinary Epidemiology.

Ataei, S., Burchmore, R., Hodgson J.C., Finucane, A., Parton, R. and Coote, J. G. (2009): Identification of immunogenic proteins associated with protection against haemorrhagic septicaemia after vaccination of calves with a live-attenuated aroA derivative of Pasteurella multocida B: 2. *Res. in Vet. Sci. 87, 207–210.*

AU/IBAR (2002): Contagious bovine pleuropneumonia in pastoralist areas of East Africa: Disease dynamics and control options. African Union/Interafrican Bureau for Animal Resources, Nairobi. Pp 3-4.

Awol, N., Ayelet, G., Jenberie, S., Gelaye, E., Sisay, T., and Nigussie, H. (2011): Bacteriological studies on pulmonary lesions of camel (*Camelus dromedarius*) slaughtered at Addis Ababa abattoir, Ethiopia, *Afri. Journ. of Microbiol. Res. 5 (5), 522-527.*

Barasa, M., Machuchu, D., Laqua, H. (2005): A Report on Participatory Impact Assessment of Foot and Mouth Disease in Koch County, Western Upper Nile, Southern Sudan. Veterinaires sans Frontieres-Suisse, Juba. Pp 8-12.

Bedelian, C. (2004): The Impact of Malignant Catarrhal Fever on Maasai Pastoral Communities in Kitengela Wildlife Dispersal Area, Kenya. A dissertation presented for the degree of Master of Science University of Edinburgh.

Bekele S. T. (2008): Gross and microscopic pulmonary lesions of camels from Eastern Ethiopia, *Trop. Anim. Hlth. Prod. , 40 (1):25-8*

Bekele, T. (1999): Studies on the respiratory disease `sonbobe' in camels in the eastern lowlands of Ethiopia. *Trop. Anim. Hlth. and Prod., 31 (6), 333-345*

Benkirane, A., Alwis, M.C.L. (2002): Haemorrhagic septicaemia, its significance, prevention and control in Asia. *Vet. Med. – Czech, 47, 234–240.*

Bett, B., Jost, C., Allport, R., and Mariner, J. (2009): Using participatory epidemiological techniques to estimate the relative incidence and impact on livelihoods of livestock diseases amongst nomadic pastoralists in Turkana South District, Kenya. *Prev. Vet. Med. 90, 194–203.*

Biswas, A., Shivachandra, S. B, Saxen, M. K., Kumar, A. A, Singh, V. P., and Srivastava, S. K. (2004): Molecular variability among strains of Pasteurella multocida isolated from an outbreak of hemorrhagic septicaemia in India. *Vet. Res. Comm. 28, 287-298.*

Cardellino, R., Rosati, A., and Mosconi, C. (2005): Current Status of Genetic Resources, Recording and Production systems in African, Asian and American Camelids; Proceedings of the ICAR/FAO seminar held in Sousse, Tunisia on 30th May 2004. Pg 2.

Catley, A (2000): The use of participatory appraisal by veterinarians in Africa, *Rev. Sci. tech. off. Int. Epiz. 19, 702-714.*

Catley, A and Irungu, P (2000): Participatory research on bovine trypanosomosis in Orma cattle, Tana River District, Kenya. Preliminary findings and identification of best-bet interventions, November 2000. Institute of Environmental Development. Pg 5-7.

Catley, A. (1997) Adapting Participatory Appraisal for the Veterinary Epidemiologist: PA Tools for Use in Livestock Disease Data Collection. SVEPM proceedings, Chester, 1997. Pp 3-4.

Catley, A. (2005): Participatory Epidemiology: a Guide for Trainers. Inter African Bureau for Animal Resources, Nairobi. Pp 18-19, 39-59, Annex 1 Pp 11

Catley, A. and Admassu, B. (2003): Using Participatory Epidemiology to Assess the Impact of Livestock Diseases, FAO-OIE-AU/IBAR-IAEA Consultative Group Meeting on Contagious Bovine Pleuropneumonia in Africa, 12-14 November, 2003, Rome, Italy. Pp 1-7

Catley, A. and Mariner J. (2001): Participatory epidemiology, lessons learned and future directions. Proceedings of workshop held in Addis Ababa, Ethiopia November 15th to 17th, 2001. Pp 4 and 25

Catley, A. and Mariner, J. (2002a): Where there is no data: participatory approaches to veterinary epidemiology in pastoral areas of the horn of Africa. International Initiative for Environment and Development Dry Land Programmes. Issue Paper no.110. Pp 10-16.

Catley, A. and Mariner, J. (2002b): Participatory Epidemiology and Strengthening Public Sector Veterinary Services. In: Implementing EMPRESS in an Environment of Weakening Public Veterinary Services. Sixth EMPRESS Expert Consultation. Pp 1-2.

Catley, A. and Mohamed, A. A. (1996): The use of livestock-disease scoring by a primary animal health project in Somaliland. *Prev. Vet. Med. 28, 175-186.*

Catley, A., Chibunda, R.T., Rangad, E., Makungu, S., Magayane, F.T., Magoma G., Madege M.J., Vosloo, W. (2004): Participatory diagnosis of a heat-intolerance syndrome in cattle in Tanzania and association with foot-and-mouth disease. *Prev Vet Med 65, 17-30.*

Catley, A., Irungu, P., Simiyu, K., Dadye, J., Kiragu, J, and Nyamwaro, S. O. (2002a): Participatory investigation of bovine Trypanosomiasis in Tana River District, Kenya. *Medical and Vet Entom. 16, 55-66.*

Catley, A., Okoth, S., Osman, J., Fison, T., Njiru, Z., Mwangi, J., Jones, B. A., and Leyland, T. J. (2001): Participatory diagnosis of a chronic wasting disease in cattle in southern Sudan, *Prev. Vet. Med. 51, 161-181.*

Catley, A., Osman, J., Mawien, C., Jones, B.A., Leyland, T.J. (2002b): Participatory analysis of seasonal incidences of diseases of cattle, disease vectors and rainfall in southern Sudan. *Prev. Vet. Med. 53, 275–284.*

Confer, A. W. (1993): Immunogens of Pasteurella. *Vet. Microbiol., 37, 353-368.*

Dirie, M.F. & Abdurahman, O. (2003): Observations on little known diseases of camels (Camelus dromedarius) in the Horn of Africa. *Rev. Sci. tech. Off. Int. Epiz. 22, 1043-1049.*

EPZA (2005): Meat production in Kenya, a report by Export Processing Zone Authority, Kenya, Pg1

FAO (1998); Meat and Meat Products in Human Nutrition in Developing Countries, FAO FOOD AND NUTRITION PAPER 53, Rome. Pp 1.

FAO (2000): Animal Health Manual on Participatory Epidemiology, Corporate Document Repository, version 10, Agriculture and Consumer Protection, chapter 1 and 2. URL: http://www.fao.org//DOCREP/003/X8833E/X8833E00.HTM accessed on 2011-01-22.

FAO (2001): The technology of making cheese from camel milk (*Camelus dromedarius*), FAO Animal Production and Health Paper 113. Pg 1

FAO (2002): Improved Animal Health for Poverty Eradication and Sustainable Livelihoods. FAO Animal Production and Health Paper 153, Rome.

FAO . (2009): Food and Agriculture Organization of the United Nations Database, http://faostat.fao.org/site/573/default.aspx#ancor, accessed on 2011-11-10

FAO Kenya (2007): Food security District profile report for 23 Districts, March 2007, Nairobi. Pg 3, 12 and 36

Farah, K.O., Nyariki, D.M., Ngugi, R.K., Noor I.M., and Guliye, A.Y (2004): The Somali and the Camel: Ecology, Management and Economics, Anthropologist, 6 (1): 45-55.

Farah, Z., Mollet, M., Younan, M., Dahir, R (2007): Camel dairy in Somalia: Limiting factors and development potential, *Lvstck. Sci. 110 (2007) 187–191*

Gitao, G.C (2006): A practical Guide to Camel Husbandry., Immediate Communications Limited, Nairobi Kenya. Pp. 121-122.

Gluecks, I. V. (2007): The Prevalence of Bacterial and Protozoal Intestinal Pathogens in Suckling Camel Calves in Northern Kenya. Inaugural Dissertation to attain the degree of Doctor of Veterinary Medicine at the Freie Universität of Berlin Journal-No.: 3148.

Gluecks, I.V., Younan, M., Maloo, S., Ewers, C., Bethe, A., Kehara, D., Kimari, J., (2010): Combination of participatory approaches and molecular diagnostics to investigate the epidemiology of Haemorrhagic Septicaemia in camels (*Camelus dromedaries*), Paper presentation at the International Camel Symposium - Linking Camel Science and Development for Sustainable Livelihoods, 7th - 10th June 2010, Garissa, Kenya (Abstract).

Gyles, C. L., Prescott, J. F., Songer, G., and Thoen, C. O (2010): Pathogenesis of bacterial infections in animals, fourth edition, Wiley-Blackwell.

Higgins, A. (1986): The Camel in Health and Disease, Bailliere Tindall 1986, Pp 103.

Hirsh, D. C (1999): Veterinary Microbiology, Blackwell Science, Inc. Pp 135-139

Horadagoda, N. U., Hodgson, J. C., Moon, G. M., Wijewardana, T. G. and Eckersall, P. D. (2002): Development of a clinical syndrome resembling haemorrhagic septicaemia in the buffalo following intravenous inoculation of Pasteurella multocida serotype B: 2 endotoxin and the role of tumour necrosis factor-a. *Res. in Vet. Sci., 72, 194-200.*

Horadagoda, N. U., Hodgson, J. C., Moon, G. M., Wijewardana, T. G. and Eckersall, P. D. (2001): Role of endotoxin in the pathogenesis of haemorrhagic septicaemia in the buffalo. *Micro. Path. 30, 171–178.*

Hussain, M., Malik, M. A., Fatima, Z and Yousuf, M. R. (2005): Participatory Surveillance of Livestock Diseases in Islamabad Capital Territory, *Intern. Journ. of Agric. & Bio. 1560–8530/2005/07–4–567–570.*

Kaufmann, B. (1998): Analysis of pastoral camel husbandry in northern Kenya. Margraf Verlag, Weikersheim, Germany. Pp 1.

Khan, F. M., (2011): Field epidemiology of an outbreak of hemorrhagic septicaemia in dromedary population of greater Cholistan desert (Pakistan), *Pak. Vet J, 31(x): xxx (uncorrected proof), http://www.pvj.com.pk/in_press/11-020.pdf*

Kipronoh, K. A., Gathuma, J. M., Kitala, P. M., and Kiara, H. K (2011): Pastoralists' perception of the impact of East Coast fever on cattle production under extensive management in Northern Rift Valley, Kenya, *Lvstck. Res. for Rur. Dev. 23 (6) 2011*

Kiptarus, J. K. (Director of Livestock Production, Kenya) (2005): Focus on Livestock Sector: Supply Policy Framework Strategies Status and Links with Value Addition, presented at Workshop on Value Asses Food & Export Investment, Nairobi, on 3rd March. Pp 3.

KNBS (Kenya National Bureau of Statistics) (2010): Kenya population and housing census, Volume II, population and household distribution by socio-economic characteristics. Pp 391-392.

Koehler-Rollefson, I., Munday, P., and Mathias, E. (2001): A field manual of camel diseases, traditional and modern health care for the dromedary, ITDG. Pp 156-158.

KPHC (Kenya population and housing census) (2010): http://www.knbs.or.ke/Census%20Results/KNBS%20Brochure.pdf

Kuria, S. G., Tura, I., Amboga, S., Walaga, H. K and Lesuper, J (2011): The current status of camel (Camelus dromedarius) calf management among pastoral communities of northern Kenya, *Lvstck Res. for Rur. Devt. 23 (7) 2011.*

Lane E. P., Kock, N. D., Hill, F. W. G. and Mohan, K. (1992): An outbreak of haemorrhagic septicaemia (septicaemic pasteurellosis) in cattle in Zimbabwe. *Trop. Anim. Hlth Prod. 24, 97-102.*

Leyland, T. (1991): Participation in the 80's and 90's: who asks the question in livestock development? A dissertation for Master of Science degree in Tropical Animal Production and Health, Centre for Tropical Veterinary Medicine, University of Edinburgh.

Mariner, J and Admassu, B (2002): Rinderpest Participatory Disease Searching in the Somali Ecosystem, workshop proceedings, Griftu, Kenya November 10th - 17th. Pp 32-33.

MDSP (2005): Mandera District Strategic Plan 2005 – 2010, For Implementation Of The National Population Policy For Sustainable Development, National Coordinating Agency for Population and Development, Ministry of Planning and National Development. Pg 3

Megersa, B. (2010): An epidemiological study of major camel diseases in the Borana lowland, Southern Ethiopia, Drylands Coordination Group Report No. 58, September 2010. Pp 1

Merck Veterinary Manual, 9th edition (2005). Pp. 607-608.

Moallin A.S.M (2009): Observations on diseases of the dromedary in Central Somalia, http://somalivetforum.org/Observations%20on%20diseases%20of%20the%20dromedary%20pdf.pdf accessed on 03/11/2011.

Mochabo, M. O., Kitala, P. M., Gathura, P. B., Ogara, W. O., Catley, A., Eregae, E. M. and Kaitho, T. D, (2005): Community Perceptions of Important Camel Diseases in Lapur Division of Turkana District, Kenya. *Trop. Anim. Hlth. Prod. 37, 187-204.*

Mochabo, M.O., Kitala, P.M., Gathura, P.B., Ogara, W.O., Eregae, E.M., Kaitho, T.D., Catley, A. (2006): The socio-economic impact of important camel diseases as perceived by a pastoralist community in Kenya. *Onderst. J. Vet. Res., 73 (4):269-74*

OIE (2011): Technical disease card. http://www.oie.int/fileadmin/home/eng/animal_health_in_the_world/docs/pdf/haemorrhagic_septicemia_final.pdf accessed on 2011-02-28.

Okuthe, S. O., Costagli, R., Matete, G. O., Omer Osman, O. I., Nur Hajji, A., Abdulle, M. H and Muuse, M (2006): Qualitative epidemiological assessment of Somali livestock diseases, proceedings of the 11th international Symposium on Veterinary Epidemiology and Economics. Pg 2

PENAPH (Participatory Epidemiology Network for Animal and Public Health) (2010): Introductory course to Participatory Epidemiology as part of Short Training Course on Surveillance, Emergency Preparedness and Response, Chiang Mai, 12 July 2010 – 6 August 2010. Pg 20

Sandford, J and Ashley, S (2008): Livestock Livelihoods and Institutions in the IGAD Region, Working Paper No. 10 – 08. Pg 1, 6.

Schwartz, H. J. and Dioli, M. (1992): The One Humped Camel (Camelus dromedarius) in Eastern Africa: a Pictorial Guide to Diseases, Health Care and Management. Verlag Josef Margraf. Pp 1-3, 159-160.

Seré, C. (2004): Assuring Food and Nutrition Security in Africa by 2020: Prioritizing Action, Strengthening Actors, and Facilitating Partnerships April 1-3, Kampala, Uganda, Summary Note. Pp 1.

Shafarin, M. S., Zamri-Saad, M., Jamil, S. M. Siti Khairani, B. and Saharee, A. A (2007), Experimental Transmission of Pasteurella multocida 6: B in Goats, *J. Vet. Med. A 54, 136–139.*

Shafarin, M. S., Zamri-Saad, M., Khairani, B. S. and Saharee, A. A. (2009): Pathological Changes in the Respiratory Tract of Goats Infected by Pasteurella multocida B: 2. *J. Comp. Path., 140, 194-197.*

Swai, E.S. and Neselle, M.O. (2010): Using Participatory Epidemiology Tools to Investigate Contagious Caprine Pleuropneumonia (CCPP) in Maasai Flocks, Northern Tanzania, *International J of Animal and Vet Advances, 2 (4): 141-147, 2010*

Tabatabaei, M., Liu, Z., Finucane, A., Parton R. and Coote, J. (2002): Protective Immunity Conferred by Attenuated aroA Derivatives of Pasteurella multocida B: 2 Strains in a Mouse Model of Hemorrhagic Septicaemia. *Infect. and Immun., 70, 3355–3362.*

WDSP (2005): Wajir District Strategic Plan 2005 – 2010 for Implementation of the National Population Policy for Sustainable Development , National Coordination Agency for Population and Development, Ministry of Planning and National Development. Pg 4.

Wernery, U. and Kaaden, O.R. (1995): Infectious Diseases of Camelids, Blackwell Wisssencschafts-Verlag.Berlin 1995. Pp 27-30.

Wilson, R.T. (1984): The Camel. Longman, Burnt Hill, Harlow, Essex UK. Pp 42-45, 121.

Younan (2005): Personal communication.

Younan and Bornstein (2004): Personal communication.

Younan, M. (2007): Evaluation of available information on Camel Haemorrhagic Septicaemia and Swollen Glands. Report for: "Livestock for Life" Wellcome Trust Grant Number 081073/Z/06/Z funded VSF-Suisse project 'Participatory Study on the Epidemiology of Haemorrhagic Septicaemia (HS) in Camels (*Camelus dromedarius*) in Northern Kenya complemented by Bacteriological Analysis and Molecular Identification and Differentiation'

Younan, M. (2010): Personal communication.

Younan, M., Agoi, K., Naida, F. (2008): Report on field investigation in Rendille camel herds in Marsabit district affected by swollen glands / 'khanid' wellcome trust project, participatory study on the epidemiology of haemorrhagic septicaemia in camels (Camelus dromedarius) in northern Kenya complemented by bacteriological analysis and molecular identification and differentiation.

8 APPENDICES

Annex 1: Names of the groups of informants according to their locations, Northern Kenya, 2011

Group number	Group name	District
1	Malabot	Marsabit North
2	North Horr (Horr-Gudha)	Marsabit North
3	Sarru	Marsabit North
4	Dukana	Marsabit North
5	Mansa	Wajir East
6	Wajir Bor	Wajir East
7	Dambas	Wajir East
8	Alokona	Mandera West
9	Bachille	Mandera West
10	Qotqot (Kiliwehiri)	Mandera West
11	Qoqaye	Mandera West

Annex 2: Clinical case definitions of camel SGS and camel HS

SGS in camels: **Khanid (Rendille language)/Qanjiir Buur/Qarir (Somali language)** (Kaufmann, 1998; Koehler-Rollefson et al., 2001; Younan, 2007).	**HS in camels:** **Garir/Guux (Somali language), Qando (Gabra/Borana language)** (Higgins, 1986; Schwartz and Dioli, 1992; Gitao, 2006, Younan, 2007).
1) Swelling of all subcutaneous lymph nodes (visible or palpable, most prominent are the parotidicus and cervicalis supf.) 2) Inappetance 3) Watery eyes 4) Lying down (the animal rests than usual, and at odd hours of the day) 5) Weakness 6) Diarrhoea 7) Little or no urine 8) Dullness and rough coat 9) Respiratory symptoms develop within 2-5 days (slight cough and difficulty in breathing) 10) Fever and shivering 11) Death may occur after about 4-7 days 12) "Pneumonic" lungs at post mortem 13) Recovery is prolonged and starts after about 14 days of clinical illness 14) Affects mainly weaners 2 to 3 years old and sometimes also big calves (1 year plus)	Peracute disease is characterised by sudden death. Acute ones show the following clinical signs: 1) General depression 2) Fever, 3) Anorexia, 4) Increased respiratory and pulse rate 5) Signs of dyspnoea; dilated nostrils, open mouth breathing, rapid and shallow breathing and cyanotic mucous membranes. 6) Enlarged mandibular and or cervical lymph nodes 7) Development of oedematous swellings in the pharyngeal and prescapular, 8) Death in 1 to 5 days. Abortions may occur. 9) Hemorrhagic enteritis shown by acute abdominal pain 10) Excretion of tarry faeces and discoloured urine 11) Animals seldom recover, dies in 24 to 48 hours 12) Postmortem lesions include: generalized internal e.g. under the serosa of intestines, the heart and the lymph nodes. Hemorrhagic enteritis and lesions of early pneumonia. 13) Affects all ages but usually seen in adults. 14) Low morbidity but high mortality of 50% to 80% 15) Common in rainy season and associated with stress such as heavy tick infestation and high humidity

Annex 3: Matrix scoring of clinical signs as done by 10 groups of herders using 20 stones to score each clinical sign against four diseases, Northern Kenya, 2011.

Groups	Clinical signs	RDC 1	RDC 2	HS/SGS	Wry Neck
1	Bent/kinked neck	0	0	0	20
	Lachrymation	4	6	10	0
	Enlarged lymph nodes	3	3	14	0
	Recumbency	2	4	6	8
	Emaciation	0	9	11	0
	Coughing	5	13	2	0
	Fever	2	4	14	0
	Bad odour	6	7	7	0
	Nasal discharge	20	0	0	0
	Mortality	2	3	14	1
2	Bent/kinked neck	0	0	0	20
	Lachrymation	3	5	12	0
	Enlarged lymph nodes	2	5	13	0
	Recumbency	2	4	13	1
	Emaciation	4	6	10	0
	Coughing	1	15	4	0
	Fever	2	5	13	0
	Bad odour	9	0	11	0
	Nasal discharge	15	2	3	0
	Mortality	5	4	9	2
3	Bent/kinked neck	0	0	0	20
	Lachrymation	4	3	13	0
	Enlarged lymph nodes	2	7	11	0
	Recumbency	2	5	3	10
	Emaciation	3	8	9	0
	Coughing	6	12	2	0
	Fever	5	4	11	0
	Bad odour	11	0	9	0
	Nasal discharge	20	0	0	0
	Mortality	5	4	9	2

Annex 3 continued

Groups	Clinical signs	RDC 1	RDC 2	HS/SGS	Wry Neck
5	Bent/kinked neck	0	0	0	20
	Lachrymation	2	4	14	0
	Enlarged lymph nodes	0	0	20	0
	Recumbency	0	2	13	5
	Emaciation	2	9	6	3
	Coughing	5	11	4	0
	Fever	6	4	10	0
	Bad odour	2	0	18	0
	Nasal discharge	14	0	6	0
	Mortality	3	2	11	4
6	Bent/kinked neck	0	0	0	20
	Lachrymation	7	2	8	3
	Enlarged lymph nodes	5	4	11	0
	Recumbency	4	1	6	9
	Emaciation	5	0	8	7
	Coughing	2	12	6	0
	Fever	7	0	13	0
	Bad odour	8	0	12	0
	Nasal discharge	11	4	5	0
	Mortality	5	0	8	7
7	Bent/kinked neck	0	0	0	20
	Lachrymation	6	5	8	1
	Enlarged lymph nodes	7	0	13	0
	Recumbency	1	5	8	6
	Emaciation	7	2	9	2
	Coughing	6	11	3	0
	Fever	5	5	10	0
	Bad odour	5	4	11	0
	Nasal discharge	9	4	6	1
	Mortality	4	3	9	4

Annex 3 continued

Groups	Clinical signs	RDC 1	RDC 2	HS/SGS	Wry Neck
8	Bent/kinked neck	0	0	0	20
	Lachrymation	4	9	5	2
	Enlarged lymph nodes	0	0	20	0
	Recumbency	2	3	6	9
	Emaciation	3	6	2	9
	Coughing	6	10	4	0
	Fever	5	7	8	0
	Bad odour	7	0	13	0
	Nasal discharge	20	0	0	0
	Mortality	5	2	9	4
9	Bent/kinked neck	0	0	0	20
	Lachrymation	2	4	9	5
	Enlarged lymph nodes	8	0	12	0
	Recumbency	5	2	9	4
	Emaciation	3	6	5	6
	Coughing	5	12	3	0
	Fever	3	4	7	6
	Bad odour	4	6	10	0
	Nasal discharge	11	2	7	0
	Mortality	5	2	10	3

Annex 3 continued

Groups	Clinical signs	RDC 1	RDC 2	HS/SGS	Wry Neck
10	Bent/kinked neck	0	0	0	20
	Lachrymation	3	7	9	1
	Enlarged lymph nodes	6	3	11	0
	Recumbency	3	7	9	1
	Emaciation	1	8	4	7
	Coughing	7	10	3	0
	Fever	4	6	9	1
	Bad odour	3	4	11	2
	Nasal discharge	9	6	4	1
	Mortality	6	1	9	4
11	Bent/kinked neck	0	0	0	20
	Lachrymation	5	12	3	0
	Enlarged lymph nodes	5	3	12	0
	Recumbency	4	10	6	0
	Emaciation	3	7	4	6
	Coughing	3	11	6	0
	Fever	3	11	6	0
	Bad odour	6	3	11	0
	Nasal discharge	13	0	7	0
	Mortality	7	0	10	3

Annex 4: Summary of clinical signs of HS/SGS according to 11 informants groups, Northern Kenya, 2011.

Clinical signs	groups											Score	%*
	1	2	3	4	5	6	7	8	9	10	11		
Swollen lymph nodes	+	+	+	+	+	+	+	+	+	+	+	11	100
Slight coughing	+	+	+		+	+	+	+	+	+	+	10	91
Dullness	+	+	+	+		+	+	+	+	+		9	82
Little or no urine	+	+	+		+		+	+	+	+	+	9	82
Lachrymation	+	+	+	+			+	+	+	+	+	9	82
Fever	+	+	+		+	+	+	+		+	+	9	82
Recumbency	+	+			+	+	+	+	+			7	64
Bad odour	+	+			+	+	+	+		+		7	64
Anorexia	+				+	+	+	+		+		6	55
Shivering	+	+	+	+			+				+	6	55
Unconscious during the heat		+		+				+	+	+	+	6	55
Reluctance to move					+		+	+		+	+	5	45
Salivation				+		+		+			+	4	36
Rough/hard pellets of dung					+	+	+	+				4	36
Nasal discharge	+					+	+					3	27
Bloating				+						+		2	18
Dyspnoea	+									+		2	18
Bloody diarrhea	+										+	2	18
Mass abortion			+	+								2	18
Yawning			+									1	9
Swellings (bleeding) in the nose						+						1	9
Rough hair coat						+						1	9

Key:

%*= Percentage was calculated as a proportion of the number of groups that mentioned the clinical sign out of the total number of groups

+= Clinical signs of HS/SGS that were mentioned by the group

Annex 5: Summary of Postmortem lesions of HS/SGS according to 11 informants groups, Northern Kenya, 2011.

pm lesions	groups											Score	%*
	1	2	3	4	5	6	7	8	9	10	11		
haemorrhages in the intestines	+	+	+	+	+			+	+	+		8	73
clots/blood spots on the heart	+	+	+		+	+				+		6	55
blood vessels engorged with blood	+		+	+	+				+			5	45
swollen liver	+		+	+				+	+			5	45
haemorrhages in the meat and subcutaneous tissue		+	+					+			+	4	36
dark lymph nodes			+	+					+			3	27
swollen lungs			+					+		+		3	27
Rubbery/tasteless meat							+		+			2	18
hemorrhagic /dark lungs						+			+			2	18
increased pericardial fluids						+						1	9

Key:

%*= Percentage was calculated as a proportion of the number of groups that mentioned the postmortem lesion out of the total number of groups

+= Postmortem lesions of HS/SGS that were mentioned by the group

Annex 6: Clinical signs of camel HS/SGS observed in 8 camels in an outbreak, Northern Kenya, 2011.

Clinical signs	Case numbers								Score	%*
	1	2	3	4	5	6	7	8		
Asymmetrical swelling of lymph nodes	+	+	+	+	+	+	+	+	8	100
Slight cough	+	+	+	+	+	+	+	+	8	100
Dullness	+		+		+	+	+		5	63
Anorexia/inappetance	+	+	+		+	+			5	63
Not chewing cud	+	+	+	+		+			5	63
Fever	+		+		+	+		+	5	63
Lachrymation	+		+		+	+			4	50
Dyspnoea (abdominal/open mouth breathing	+		+			+	+		4	50
Lethargy/reluctance to move		+	+	+				+	4	50
Shivering	+	+				+			3	38
Recumbency		+				+		+	3	38
Nasal discharge		+			+			+	3	38
Congestion of conjunctiva		+				+			2	25
Straining during micturation	+					+			2	25
Tick infestation			+	+					2	25
Fly infestation	+								1	13
Salivation				+					1	13

Key:

%*= Percentage was calculated as a proportion of the number of groups that mentioned the postmortem lesion out of the total number of groups

+= Postmortem lesions of HS/SGS that were mentioned by the group

Annex 7: Within herd morbidity and case fatality rates of priority camel diseases in northern Kenya as scored by 10 informant groups, 2011.

Groups	Diseases									
	Camel pox		RDC1		RDC2		HS/SGS		Wry neck	
	Morb	CF	Morb	CF	Morb	CF	Morb	CF	Morb	CF
1	32	41	72	13	41	39	49	57	2	50
2	80	30	85	5	80	8	66	67	2	50
3	30	17	100	10	80	13	60	50	2	50
4	20	25	100	20	50	30	80	63	4	100
5	32	9	88	10	77	6	42	52	6	67
6	35	31	100	7	66	3	43	51	4	75
7	50	20	53	15	69	7	23	48	9	33
8	52	48	100	5	50	4	40	25	2	75
9	42	48	100	15	66	15	30	30	7	43
11	61	25	100	16	75	0	54	19	10	30

Key:

Morb = Morbidity rate

CF = Case fatality rate

Annex 8: Relative socioeconomic effects of priority camel diseases in Northern Kenya as scored by 11 informant groups using 25 stones per indicator, 2011.

Group	Indicator	Disease effects				
		Pox	RDC 1	RDC 2	HS/SGS	Wry Neck
1	Milk	3	5	7	9	1
	Meat	4	5	6	8	2
	Transportation	1	3	7	8	6
	Dowry	8	4	6	7	0
	Cash/barter	3	5	7	8	2
	Sacrifice	1	5	7	9	3
	Funeral	3	5	7	9	1
	Skin	13	0	4	8	0
	Prestige	3	4	6	7	4
	Treatment cost	1	4	7	9	3
2	Milk	2	4	8	11	0
	Meat	2	4	7	12	0
	Transportation	0	5	7	9	4
	Dowry	10	2	6	7	0
	Cash/barter	0	0	11	12	2
	Sacrifice	0	3	2	3	17
	Funeral	0	0	5	6	14
	Skin	12	3	3	3	3
	Prestige	1	2	8	9	5
	Treatment cost	0	6	7	10	2
3	Milk	0	4	7	11	3
	Meat	4	3	8	9	1
	Transportation	0	5	5	9	4
	Dowry	4	6	5	8	2
	Cash/barter	2	3	7	8	5
	Sacrifice	3	5	6	7	4
	Funeral	0	5	7	10	3
	Skin	25	0	0	0	0
	Prestige	4	6	5	8	2
	Treatment cost	5	6	8	4	2

Annex 8 continued

4	Milk	3	5	7	8	2
	Meat	4	5	7	8	1
	Transportation	3	5	6	9	2
	Dowry	2	6	7	9	1
	Cash/barter	3	4	5	12	1
	Sacrifice	1	4	5	12	3
	Funeral	2	4	7	9	2
	Skin	10	0	5	7	3
	Prestige	7	2	3	10	1
	Treatment cost	5	2	6	10	1
5	Milk	4	3	6	11	1
	Meat	12	1	2	6	4
	Transportation	10	3	5	7	1
	Dowry	6	2	3	10	4
	Cash/barter	7	1	3	10	4
	Sacrifice	11	2	4	7	1
	Funeral	10	2	4	8	1
	Skin	10	1	3	8	4
	Prestige	17	0	0	8	0
	Treatment cost	3	2	4	11	5
6	Milk	2	1	8	3	11
	Meat	15	0	0	9	1
	Transportation	9	1	4	6	5
	Dowry	8	2	4	10	5
	Cash/barter	10	1	5	7	2
	Sacrifice	10	0	5	8	2
	Funeral	10	1	5	7	2
	Skin	25	0	0	0	0
	Prestige	8	2	4	6	5
	Treatment cost	6	8	4	5	3

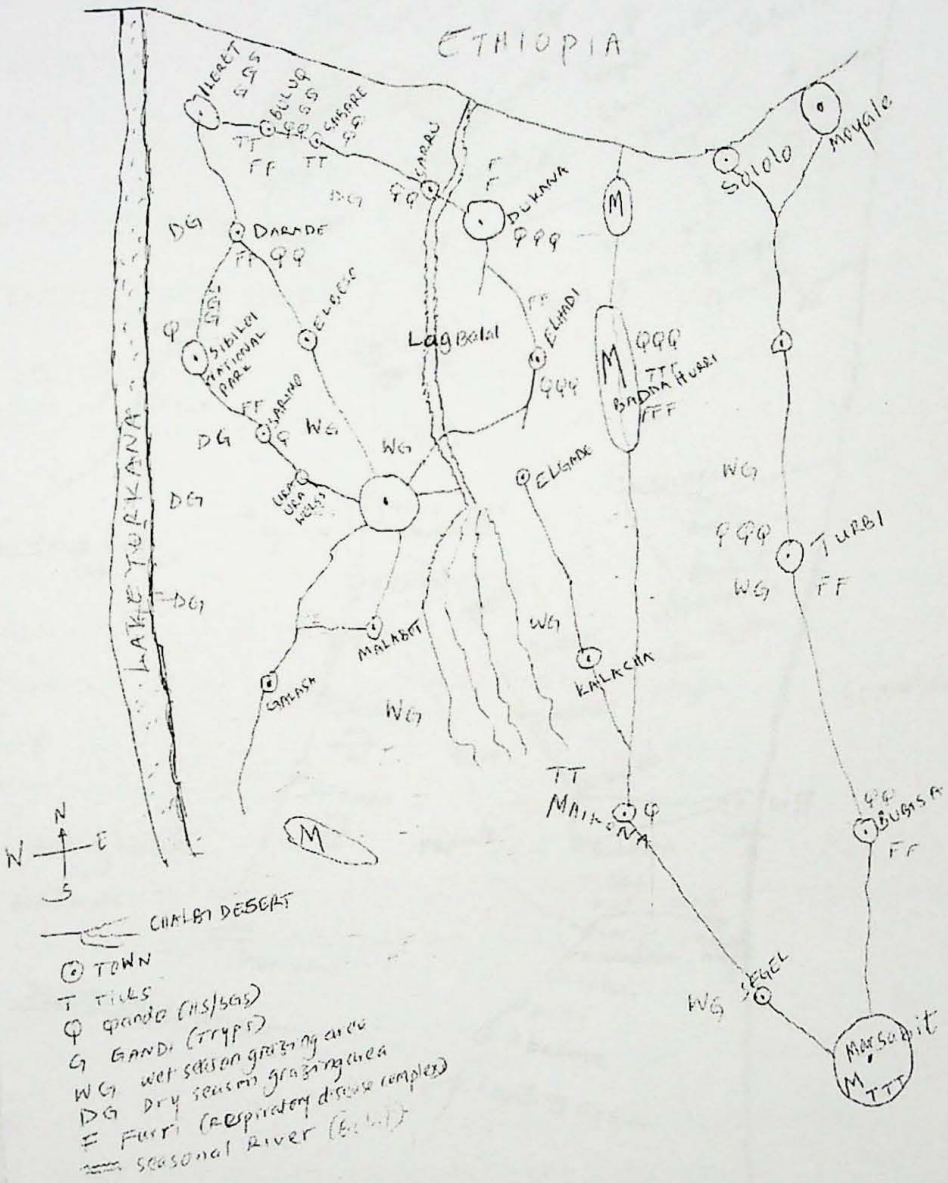
Annex 8 continued

7	Milk	5	4	7	8	0
	Meat	12	3	2	9	0
	Transportation	3	5	2	6	9
	Dowry	8	4	2	10	1
	Cash/barter	8	4	2	7	3
	Sacrifice	10	4	0	9	1
	Funeral	3	7	8	2	5
	Skin	17	0	0	0	8
	Prestige	3	6	0	13	2
	Treatment cost	4	6	1	8	5
8	Milk	4	6	7	3	5
	Meat	8	5	4	6	2
	Transportation	3	6	7	5	4
	Dowry	6	5	4	7	3
	Cash/barter	7	4	5	6	3
	Sacrifice	7	5	4	6	3
	Funeral	7	5	4	6	3
	Skin	19	0	0	6	0
	Prestige	4	7	12	2	0
	Treatment cost	0	8	13	0	3
9	Milk	3	6	9	2	5
	Meat	7	5	4	6	3
	Transportation	4	7	9	2	3
	Dowry	9	4	2	9	1
	Cash/barter	8	7	3	4	3
	Sacrifice	9	7	3	4	2
	Funeral	3	8	9	1	4
	Skin	19	0	0	6	0
	Prestige	7	8	6	4	0
	Treatment cost	0	9	10	0	6

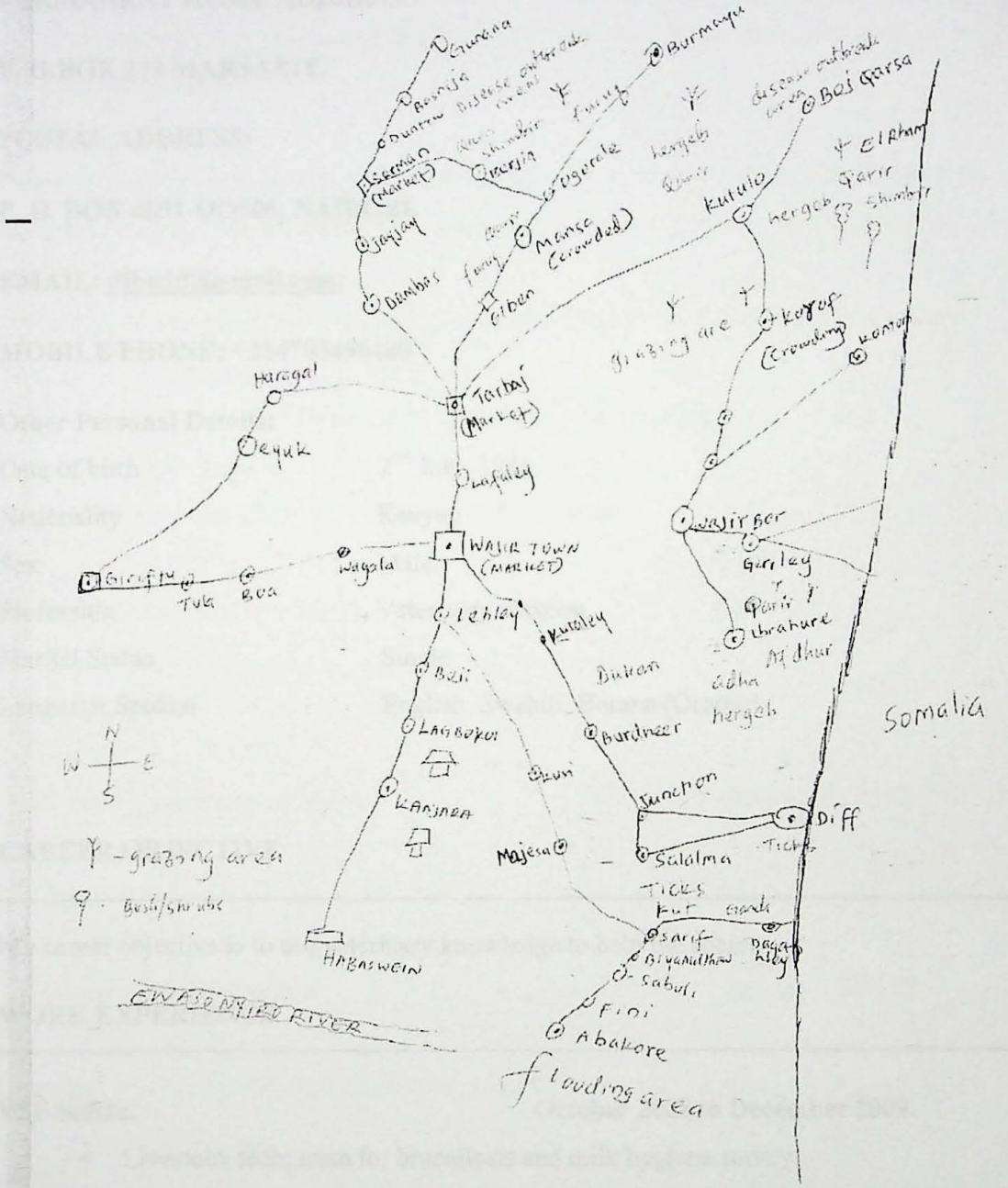
Annex 8 continued

10	Milk	3	4	10	5	3
	Meat	9	3	5	7	1
	Transportation	7	4	3	9	2
	Dowry	6	5	4	9	1
	Cash/barter	10	4	3	7	1
	Sacrifice	10	3	4	7	1
	Funeral	4	10	3	8	1
	Skin	25	0	0	0	0
	Prestige	12	1	1	10	1
	Treatment cost	4	6	6	2	5
11	Milk	7	6	1	8	2
	Meat	9	5	1	7	3
	Transportation	6	5	1	10	3
	Dowry	8	5	2	6	4
	Cash/barter	8	5	2	6	4
	Sacrifice	9	4	2	7	3
	Funeral	3	5	2	9	6
	Skin	25	0	0	0	0
	Prestige	9	5	2	8	1
	Treatment cost	6	10	5	0	4

Annex 9: Participatory map showing the outbreak areas of priority camel diseases as done by the informants in Marsabit north, Kenya, 2011.



Annex 10: Participatory map showing the outbreak areas of priority camel diseases as done by the informants in Wajir East, Kenya, 2011.



9 CURRICULUM VITAE

DR. DIBA DIDA WAKO

PERMANENT HOME ADDRESS:

P. O.BOX 273 MARSABIT.

POSTAL ADDRESS:

P. O. BOX 4891-OO506, NAIROBI.

EMAIL: dibadd@gmail.com,

MOBILE PHONE: +254703496480

Other Personal Details:

Date of birth	2nd July, 1981.
Nationality	Kenyan
Sex	Male.
Profession	Veterinary surgeon
Marital Status	Single
Language Spoken	English, Swahili, Borana (Oromo)

CAREER OBJECTIVE

My career objective is to use veterinary knowledge to help the society.

WORK EXPERIENCE

VSF Suisse. **October 2008 to December 2009.**

- Livestock technician for brucellosis and milk hygiene survey.
  - ✓ Conducting milk hygiene trainings.
  - ✓ Milk and serum sampling for quality analysis and brucellosis survey respectively.
  - ✓ Fodder establishment

- ✓ Supplementary feeding of animals
- ✓ Mass treatment and vaccinations
- ✓ Supervision of community animal health workers

Andy's Veterinary Clinic Riara Road, **September 2007**

- Involved in diagnosis and treatment of diseases, patient care, and assisting in surgeries.

Central Veterinary Laboratories Kabete, District Veterinary Office Nairobi, Dagoreti Slaughter house, Central Artificial Insemination Station (CAIS. July and August 2007

- Participated in disease diagnostic and biochemical Procedures in pathology, bacteriology, and virology.
- Diagnosis and treatment of diseases of both large and small animals.
- Meat inspection
- Semen collection, evaluation, and processing

Electoral Commission of Kenya **May 20003**

Registration clerk.

Electoral Commission of Kenya **December20002**

Polling clerk

Gar-Qarsa Primary School **January- July 2002**

Untrained teacher in Mathematics, Science, and CRE.

EDCATIONAL BACKGROUND

Analabs **October 2008**

Completed a three week course in Food anDairy hygiene laboratory service.

University of Nairobi

Bachelor of veterinary medicine **2003-2008**

Concept in animal welfare

Empowerment Resource Technologies Ltd **February 2007**

Participated and completed a course in transformational leadership

Lenana School **1998-2001**

Kenya certificate of secondary education.

Gar-Qarsa Primary School **1993 -1997**

Kenya certificate of primary education.

PRIZES AND AWARDS

Ultravetis East Africa Limited Award **2011**

The best final year Student in Veterinary Clinical studies, Faculty of Veterinary Medicine, University of Nairobi, 2007/2008 academic year

The Norbrook Award **2011**

The best final year student in the course of medicine in the faculty of veterinary medicine, University of Nairobi, 2007/2008 academic year

Central Artificial Insemination Station trophy **2011**

The best fifth year student in theriogenology, faculty of veterinary medicine, University of Nairobi, 2007/2008 academic year

RESPONSIBILITIES HELD

Veterinary Students Association. **2006/2007**

Secretary General.

The students organisation of Nairobi University **2005/2006**

Tana Hall congressman.

Lenana School **2001**

Deputy house-captain of Mumia house.

Gar-Qarsa primary School **1996-1997**

School Captain

PROFESSIONAL MEMBERSHIP

Member of Kenya Veterinary Association.

EXTRA-CURRICULAR ACTIVITIES

Athletics

Represented Nairobi province in 1500m and decathlone at national level.

2001

Represented Lenana school at provincial level in 1500 M and decathlone.

1998-2001

Played volleyball for Lenana school

Football for Gar-Qarsa primary school

HOBBIES

Playing and watching Soccer, Reading novels ,Watching movies and travelling.

REFEREES

Dr. Ilona Gluecks
Programme coordinator kenya
VSF Suisse
P. O. Box 25656-0603,
Nairobi, Kenya.
Tell: 254-20-4343441
Mobile phone: 0716974336
Email: igluecks@vsfsuisse.org/ igluecks@gmail.com

Genevieve Owuor
Livestock Technician
Vsf Suisse, Kenya.
P. O. Box 26656-0603,
Nairobi.
Mobile Phone: 0722814751
Email: gowuor@vsfsuisse.org/ geneowuor@yahoo.com

Dr. Victor T. Tsuma,
Department of clinical Studies,
University of Nairobi.
P.o. Box, 29053-00625
Nairobi.
Tel: 020-2055199
Mobile phone: 0721395799
Email: tsuma65@yahoo.com

10 DECLARATION

This thesis is my original work, has not been presented for a degree in any other university and that all sources of material used for the thesis have been duly acknowledged

Signature.....

Diba Dida Wako

This thesis has been submitted for examination with our approval as academic supervisors:

Signature. .....

Dr Baumann, Maximilian (Dr.med.vet. MPVM, DipECVPH)

Co-ordinator Postgraduate Studies in International Animal Health, Faculty Panel Veterinary Public Health, Faculty of Veterinary Medicine, Freie Universität- Berlin/Germany

Signature. .....

Dr Tessema, Tesfaye Sisay (DVM, Msc, PhD, assistant professor)

Head, Department of Microbiology, Immunology, Epidemiology and Public Health, Faculty of Veterinary Medicine, Addis Ababa University,

P. Box 34, Debre Zeit, Ethiopia.