Sudan University of Science and Technology
College of Veterinary Medicine

Epidemiology of Pest Des Petites Ruminants in Sudan (A Study on Knowledge and Perceptions and Potential Risk Factors)

وبائية مرض طاعون المجترات الصغيرة فى السودان (دراسة عن المعرفة والإدراك وعوامل الخطر المحتملة)

A Thesis Submitted in the Fulfillment of the Requirement for the Degree of PhD in Veterinary Medicine Epidemiology and Preventive Medicine

By

Nisreen Ahmed Hamid Hassan
MSc Tropical Animal Health, Preventive Medicine
University of Khartoum, 2007

Supervisor
Prof. Mohamed Abdalsalam Abdalla
April, 2021

DEDICATION

This work is dedicated to my family and friends, who believed in the importance of education and provide me support a long way. It is also dedicated to my beloved lost souls.

Nisreen

ACKNOWLEDGEMENTS

Above all, praise is to my almighty Allah for giving me a good health, wisdom, ability, and strength to carry out this work and for all other graces.

I would like to express my deep and sincere gratitude and appreciation to my supervisors Prof. Mohamed Abdalsalam Abdalla, College of Veterinary Medicine, Sudan University of Science and Technology; Prof. Siham Elyas Suliman, College of Veterinary Medicine, Sudan University of Science and Technology; for their excellent guidance, support, and constant encouragement throughout this study and also for their invaluable assistance and instructions, without which, it would not have been possible to accomplish this study and for reading and correcting the manuscript.

I would like to thank Mr. Mohammed Abdel Wahab Kanan and Mr. Abdelmoneim Mohammed, for their significant assistance during the statistical analysis.

I am grateful to the General Directorate of Animal Health and Epizootic Disease control, Ministry of Animal Resources (MAR), Khartoum, Sudan for their kind help during sampling and field missions.

I would also like to thank the Ministry of Animal Resources and the directorates of Animal Resources of Sinnar, Gadarif, Kassala, River Nile and White Nile States for their support, help and facilitating the field missions and sampling.

I am thankful to all my colleagues and sheep owners and herders for answering the questionnaires and also thankful to all people who helped me in way or another to accomplish this work.

I am really grateful to all my friends for thier kind cooperation and support and standing by.

Finally, I am thankful to my beloved sisters and brothers for their everlasting support and love.

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ABSTRACT

The study conducted during 2019 in: Sinnar, Gadarif, Kassala, River Nile and White Nile states. The objectives were to detect the epidemiology of PPR in Sudan and to investigate the knowledge and perception of sheep and goats owners and veterinarians on PPR disease in the five states. A semi-structured questionnaire was designed for veterinarians and sheep and goats herders and owners. Descriptive statistics of the variables were obtained for each variable (age, sex, breed, and locations) frequencies of observations within variable were also obtained. All the tested variables were first tested by univariate analysis. In a second step, potential risk factors with $p \leq 0.20$ in the univariate analysis were entered a logistic regression. Associations in the logistic regression model were deemed significant when $p \leq 0.05$.

The results of the questionnaire survey showed that sheep owners, herders and veterinarians in states under study have a solid good knowledge of PPR infection, host range, its clinical signs and transmission, incubation period, source of infection, season of occurrence, the effect of animal movements, practicing communal grazing and watering and their practices and attitude to prevent and control the disease spread and its impact on their animals. At the same time there exist considerable reservations of sizeable number of herders against PPR vaccination.

The results have also identified the potential risk factors that are associated with the PPRV outbreaks occurrence in sheep in: Sinnar, Gadarif, Kassala, River Nile and White Nile states. The results showed that Significant risk factors associated with PPRV in the univariate analysis using the chi square test were found to be species at animal level; and production system, migration, animal movement, vaccination and disease history at herd level, while livestock density, climatic changes, veterinary services and wildlife were identified as risk factors at area level. All the identified risk factors noticed that they were management and animal husbandry based problems. In contrast, age, sex and breed at animal level and herd size, mixed species, housing, water, communal dipping at herd level, and elevation, livestock marketing system at area level were found not to be significantly associated with the occurrence of PPRV outbreaks.

Knowledge of risk factors associated with PPR is an important pre-requisite for the design and implementation of effective control strategies and for management programs that can lead to the control and eradication of the disease. An understanding of these risk factors and their association and contributions to the occurrence and spreading of PPRV among small ruminant populations also is a good aid for clinical diagnosis and for determining PPR's epidemiology and patterns.

ARABIC ABSTRACT

أجُريت الدراسة خلال عام 2019 في ولايات: سنار، القضارف، كسلا، نهر النيل والنيل الأبيض. هدفت الى الكشف عن وبائية مرض طاعون المجترات الصغيرة في السودان والتحقيق في معرفة وتصور أصحاب الأغنام والماعز والأطباء البيطريين حول مرض طاعون المجترات الصغيرة في الولايات الخمس. تم تصميم أستبيان شبه منظم للأطباء البيطريين ورعاة وملاك الأغنام والماعز. تم الحصول على الإحصاء الوصفي للمتغيرات لكل متغير (العمر، الجنس، السلالة، الموقع) وترددات الملاحظات ضمن المتغير. تم أختبار جميع المتغيرات المختبرة أولاً عن طريق التحليل أحادي المتغير. في الخطوة الثانية، تم إدخال عوامل الخطر المحتملة مع $p \leq 0.20$ في التحليل أحادي المتغير في الإنحدار اللوجستي. أعتبرت الإرتباطات في نموذج الإنحدار اللوجستي مهمة عند $p \leq 0.05$.

أظهرت نتائج الاستبيان أن مربي الأغنام والرعاة والأطباء البيطريين في الولايات قيد الدراسة لديهم معرفة جيدة وقوية بعدوى طاعون المجترات الصغيرة: نطاق العائل، علاماته السريرية، أنتقاله، فترة الحضانة، مصدر العدوى، موسم الحدوث، تأثير تحركات الحيوانات وممارسة الرعي الجماعي والري وممارستهم وموقفهم للوقاية والسيطرة على أنتشار المرض وأثره على حيواناتهم. في الوقت نفسه ، توجد تحفظات كبيرة من عدد كبير من الرعاة ضد تطعيم طاعون المجترات الصغيرة.

كما حددت النتائج عوامل الخطر المحتملة المرتبطة بإنتشار طاعون المجترات الصغيرة في الأغنام في ولايات سنار والقضارف وكسلا ونهر النيل والنيل الأبيض. أظهرت النتائج أن عوامل الخطر الهامة المرتبطة بفيروس طاعون المجترات الصغيرة في التحليل أحادي المتغير بإستخدام أختبار مربع كاي وُجدت نوع الحيوان على مستوى الحيوان. نظام الإنتاج، الهجرة، حركة الحيوانات، التحصين وتاريخ المرض على مستوى القطيع. بينما تم تحديد كثافة الثروة الحيوانية، التغيرات المناخية، الخدمات البيطرية والحياة البرية كعوامل خطر على مستوى المنطقة. لوحظ أن جميع عوامل الخطر التي تم تحديدها هى مشاكل تتعلق بالإدارة وتربية الحيوانات. على النقيض من ذلك، تبين أن (العمر، الجنس، السلالة) على مستوى الحيوان و(حجم القطيع، الأنواع المختلطة، الإسكان، المياه، الغطس الجماعي) على مستوى القطيع، و(الإرتفاع، نظام تسويق الماشية) على مستوى المنطقة لا يرتبط أرتباطاً وثيقاً بحدوث وباء طاعون المجترات الصغيرة.

تعد معرفة عوامل الخطر المرتبطة بمرض طاعون المجترات الصغيرة شرطاً مسبقاً مهماً لتصميم وتنفيذ إستراتيجيات مكافحة فعالة ولبرامج الإدارة التي يمكن أن تؤدي إلى السيطرة على المرض والقضاء عليه. إن فهم عوامل الخطر هذه وإرتباطها وإسهاماتها في حدوث وإنتشار طاعون المجترات الصغيرة بين مجموعات الحيوانات المجترة الصغيرة هو أيضاً مساعدة جيدة للتشخيص السريري ولتحديد وبائيات وأنماط طاعون المجترات الصغيرة .

LIST OF ACRONYMS

AGID	Agar Gel Immunodiffusion
AGPT	Agar Gel Precipitation Test
AHDEC	Animal Health and Epizootic Disease Control Directorate
BT	Blue Tongue
^{o}C	Degree Centigrade
CBOS	Central Bank of Sudan
CCPP	Contagious Caprine Pleuro- Pneumonia
CD	Canine Distemper
cDNA	Complementary Deoxyribonucleic Acid
CE	Contagious Ecthyma
CLVR	Central Laboratory for Veterinary Research
c-ELISA	Competitive Enzyme Linked Immuno-Sorbent Assay
DEFRA	Department for Environment, Food and Rural Affairs
DIVA	Differentiation of Infected from Vaccinated Animals
DV	Distemper virus
F	The Fusion Gene
FAO	Food and Agriculture Organization of the United Nations
FEE	Foreign Exchange Earnings
FMD	Foot and Mouth Disease
GDP	Gross Domestic Product
H	The Haemagglutinin Gene
HA	Hemagglutination Test
IAEA	International Atomic Energy Agency
IcELISA	Immuno-capture Enzyme Linked Immuno-Sorbent Assay
ILRI	International Livestock Research Institute
MAb	Monoclonal Antibody

MAR	Ministry of Animal Resources
mi	Mile
mm	Millimeter
MV	Measles virus
N	The Nucleocapsid Gene
NPV	Net Present Value
OIE	World Organization for Animal Heath
PCR	Polymerase Chain Reaction
PCV	Packed Cell Volume
PFU	Plaque Forming Unit
pH	Measure of the Acidity or Basicity
PPR	Peste des petits ruminants
PPRV	Peste des petits ruminants virus
RBCs	Red Blood Cells
RP	Rinderpest
RPTC	Rinderpest Tissue Culture Vaccine
RPV	Rinderpest virus
SPC	Stomatitis - Pneumoenteritis Complex
SPP	Sheep Pox
SPSS	Statistical Package for Social Sciences
TCID	Tissue Culture Infective Dose
US$	United States Dollar
VNT	Virus Neutralization Test
WBCs	White Blood Cells

INTRODUCTION

Sudan had an estimated livestock population of 108.7 million head of which 40.8 million are sheep, 31.8 million goats, 31.2 million cattle and 4.9 million camels, in addition to more than three million equines (MAR, 2018). The breeds are well adapted to the harsh environment and often trek for long distances in search of feed and water. The livestock sector in the Sudan is an important contributor to the national economy, contributing 20% to the Gross Domestic Product (GDP), 60% to the agriculture sector, 27%to Foreign Exchange Earnings (FEE), and employing 43% of the country's population (CBOS, 2019). Besides that, livestock are used for a lot of different purposes in the Sudan. Statistical information from the government of the Sudan shows that 80% to 90% of Sudan's households own livestock, with perhaps one-third to one-half of all households reliant upon livestock for their livelihood (IGAD, 2007). The major animal production systems (APS) in the Sudan include: nomadic APS, the transhumant agropastoral system, sedentary APS, the migratory a gropastoral system, the sedentary irrigated crop-livestock system, and other systems that include ranching, feed lot operations and peri-urban backyard livestock production (Fadlalla and Ahmed, 2010). However, livestock keepers in all production systems are facing many problems and their livestock are afflicted with many deadly pathogens, including *Peste des petits ruminant* virus (PPRV).

Peste des petits ruminants (PPR) is an acute, highly contagious, infectious, and notifiable transboundary viral disease of domestic and wild small ruminants (FAO, 1999; Bailey *et al.*, 2005; Radostits *et al.*, 2007; Wang *et al.*, 2009; Balamurugan *et al.*, 2010; Khalafalla *et al.*, 2010; Luka *et al.*, 2011). The causative agent of PPR belongs to the genus *Morbillivirus* of the family *Paramyxoviridae.* This genus includes measles, rinderpest (cattle plague), canine distemper, phorcine distemper and the *morbilliviruses* found in whales, porpoises and dolphins. These viruses have had a huge impact on both human beings and animals for centuries. *Morbilliviruses* are known for their contagious nature and ability to cause some of the most devastating diseases world wide (FAO, 1999; Murphy *et al*., 1999; Bailey *et al.*, 2005; Olivier *et al.*, 2011).

Presently, PPR occurs in most African countries situated in a wide belt between the Sahara and the Equator (including the Sudan, Ethiopia, Kenya and Uganda), the Middle East, and the Indian subcontinent (FAO, 1999; Banyard *et al.*, 2010; Khalafalla *et al.*, 2010; Luka *et al.*, 2011). It has also been reported in the European part of Turkey (Ozkul *et al*., 2002; Banyard *et al.*, 2010). No sero-evidence of PPR has so far been reported in Africa south of the Equator; however, uncontrolled movement of livestock between countries is a potential danger for the spread of the disease (Lughano and Dominic, 1996). The virus was firstly diagnosed in West Africa and it has got an endemic pattern of occurrence there andacross much of the developing world (Lughano and Dominic, 1996; Banyard *et*

al., 2010). Infection with PPR virus in the Sudan was observed for the first time in 1972 in Al- Gedarif by Elhag Ali (1973) and by Elhag Ali and Taylor (1984) (cited by Intisar *et al.,* 2009; Khalafalla *et al.,* 2010). Since then continuous outbreaks occur in the country, affecting sheep and goats (Khalafalla *et al.,* 2010). Today the disease is thought to be endemic with prevalence varying from 58.1% to 93.8% in different states (Intisar *et al.,* 2009). PPR can cause serious economic losses due to its high morbidity that ranges from 50% to 90% and its case-fatality that reaches 55% to 85% in goats, 10% in sheep, and 50% in camels (Radostits *et al.,* 2007; Khalafalla *et al.,* 2010; Luka *et al.,* 2011). Dhar *et al.* (2002) reported that morbidity and mortality can be as high as 90% to 100%, respectively, and, when associated with other diseases such as capripox, mortality can be 100%. Antelopes and other small wild ruminant species as well as camels can also be severely affected by PPR (Abu Elzein *et al.,* 2004; Bailey *et al.,* 2005; Khalafalla *et al.,* 2010), and as a result the economic revenues coming from game and camel ranching and tourism are reduced. The Sudan reported the disease in wild animals as clinical disease to be present in the whole country (OIE, 2010).

Control of PPR depends mainly on vaccination, isolation and quarantine of infected animals, restriction of movement and disinfection of infected areas. During the first half of the year 2009, 11 outbreaks were reported in the Sudan (OIE, 2010), indicating that these approaches are not successful and that the disease

continues to spread in small ruminant populations, infecting new areas and expanding its prevalence across the country.

The main objective of this study is:

1. To detect the epidemiology of PPR in Sudan.

The specific objectives are:

2. To study the knowledge and perceptions of sheep herders and owners and veterinarians on PPR in Sudan.
3. To investigate potential risk factors associated with PPR.

CHAPTER ONE

LITERATURE REVIEW

1. 1 Definition:

Peste des petits ruminants (PPR), also known as goat plague, is an acute, highly contagious, infectious, and notifiable transboundary viral disease of domestic and wild small ruminants (Furley *et al.*, 1987; FAO, 1999; Bailey *et al.*, 2005; Radostits *et al.*, 2007; Wang *et al.*, 2009; Balamurugan *et al.*, 2010; Khalafalla *et al.*, 2010). It is an economically significant disease of small ruminants such as sheep and goats (Dhar *et al*., 2002; Baron *et al.*, 2011). PPR is characterized by fever, erosive stomatitis, gastroenteritis, conjunctivitis, pneumonia, and death (Lughano and Dominic, 1996; Radostits *et al.*, 2007; Mulindwa *et al.*, 2011).

PPR is a disease listed in the OIE Terrestrial Animal Health Code, and countries are obligated to report the disease to the OIE (OIE Terrestrial Animal Health Code (Chapter 14.7.) www.oie.int/ terrestrial code).

1. 2 History of PPR:

PPR was first described in 1942 in Cote d'lvoireduring the 2nd World War by Gargadennec and Lalanne (1942), where it used to be named as pseudorinderpest, Kata, stomatitis-pneumoenteritis syndrome and pneumoenteritis complex (Shuaib, 2011). It subsequently was recognized and confirmed to exist in Nigeria, Senegal and Ghana and in many other sub-Saharan countries that lie between the Atlantic

Ocean and the Red Sea (Braide, 1981; Chauhan *et al.*, 2009; Abubakar *et al.*, 2011; Baron *et al.*, 2011). For many years it was thought that PPR was restricted to the Western part of the African continent until the disease present in goats in the Sudan, which was originally diagnosed as rinderpest in 1972, then later confirmed to be PPR (FAO, 1999; Abubakar *et al.*, 2011). The realization that many of the cases diagnosed as rinderpest among small ruminants in India may instead also have involved the PPR virus, together with the emergence of the disease in other parts of Western and South Asia, signifying its ever-increasing importance (Shaila *et al*., 1996; FAO, 1999; Berhe, 2006; Abubakar *et al.*, 2011; Baron *et al.*, 2011). Firstly the disease was reported as a highly fatal disease resembling rinderpest but affecting only small ruminants. Cattle in contact with animals with this disease were not affected. Later Mornet *et al.* (1956) showed in experimental animals that the causative agents of rinderpest and PPR were closely related. From this experiment it was suggested that the second virus was a variant of the first one which is better adapted to small ruminants. Hamdy *et al*.(1976), Gibbs *et al.* (1979), Taylor (1984), Diallo *et al.* (1987) and Diallo *et al*.(1994) studied the two viruses with experiments and confirmed that there were in fact two different viruses, closely related but evolving independently in nature (Cited by Berhe, 2006).

1. 3 Epidemiology of PPR:

The virus which causes PPR, *Peste des petits ruminants virus* (PPRV) was assumed for a long time to be a variant of rinderpest virus (RPV) that had adapted to small ruminants. The classical courses of the diseases caused by RPV and PPRV in their respective hosts are very similar, with similar clinical signs and mortalities (Baron *et al.,* 2011). In contrast to rinderpest, PPR has only been recognized as a completely distinct disease in the past 30 years, based on virus cross-neutralization and by electron microscopy which showed that it was a *Morbillivirus* that had the physiochemical characteristic of a distinct virus biologically and antigenically related to RPV (Baron *et al.,* 2011).

PPRV belongs to the genus *Morbillivirus* of the family *Paramyxoviridae*, which is placed in the order *Mononegavirales*, together with *Rabdoviridae*, *Filoviridae* and *Bornaviridae* families (Murphy *et al.,* 1999). PPRV is closely related to the RPV of cattle and buffaloes, the measles virus (MV) of humans, and the distemper virus (DV) of dogs and some wild carnivores, and to the *Morbilliviruses* of aquatic mammals like whales, porpoises and dolphins. To date, there is only one serotype of PPRV and genetic characterization methods available have allowed organizing its isolates into four groups or lineages (lineage 1 - 4), three from Africa and one from Asia. One of the African groups of PPRV is also found in Asia and the Asian group has also been detected, isolated and characterized in Africa (FAO, 1999; Barrett *et al.,* 1993; Diallo *et al.,* 2007; Kerur

et al., 2008; Pawar *et al.*, 2008; Chauhan *et al.,* 2009; Balamurugan *et al.,* 2010; Olivier *et al.*, 2011).

The classification of PPRV as a member of the genus Morbillivirus was based on the morphology, growth in tissue culture, the nucleic acid composition and on antigen and physio-chemical properties (Barrett *et al.,* 1993; Baron *et al.,* 2011).

Members of the genus *Morbillivirus* have had a huge impact on both human beings and animals for centuries. *Morbilliviruses* are known for their contagious nature and ability to cause some of the most devastating diseases world wide (FAO, 1999; Murphy *et al.,* 1999; Bailey *et al.,* 2005; Baron *et al.,* 2011).

PPRV may survive at 60˚C for 60 seconds and is stable between pH 4.0 and pH 10.0. The virus is killed by alcohol, ether and detergent as well as by most disinfectants, phenol, sodium hydroxide and it has a long survival time in chilled and frozen tissues (Shuaib, 2011).

1. 4 Global Geographical Distribution:

PPRV has been identified as the cause of several serious outbreaks among small ruminant populations over the last three decades. Since the early 1990s, the Arabian Peninsula, the Middle East, and some parts of the Indian subcontinent have reported major epidemics. The virus is now considered endemic across these regions (FAO, 1999; Dhar *et al.,* 2002; Banyard *et al.,* 2010).

1. 5 Current Distribution of PPRV in Sudan:

The first outbreak of PPRV in sheep and goats in the Sudan was in three areas; in Al-Gadarif state, eastern Sudan in 1971, then it was detected in Sinnar state in goats in 1971 – 1972, and in Mieliq in 1972, the virus was also detected and isolated by El Hag Ali and Taylor (1984) (cited by Intisar *et al.,* 2009; Khalafalla *et al.,* 2010; Osama, 2010). Since then continuous outbreaks occur in the country, affecting sheep and goats (Khalafalla *et al.,* 2010; Banyard *et al.,* 2010). In the period from 2000 to 2007 the disease picture in the Sudan seemed to be alarming covering almost all the states following detection of many outbreaks in many parts of the country.

Today the disease has got an endemic pattern of occurrence in the Sudan like other countries of East Africa with a sero-prevalence rate varying from 58.1% to 93.8% in different states of the country (Intisar *et al.,* 2009; Banyard *et al.,* 2010). However, PPRV was isolated in western Sudan, in Darfur state by El-Rasih (1992) and sero-prevalence rates of 12.50% by using AGID and of 20.0% by using VNT were estimated. Another study from Darfur by Haroun *et al.,* (2002) showed an estimated sero-prevalence of 50.0% by cELISA. PPRV has also been detected and isolated from ocular and nasal discharge samples from sheep and goats in central Sudan in Al-Gazira state; in El-Hilalia in 1989- 1990 by Hassan *et al.* (1994), in Khartoum state by Zeidan (1994) and by El-Amin and Hassan (1998) by using an immunocapture enzyme linked immunosorbent assay (IcELISA).

Furthermore, the virus was detected and isolated from Al-Gazira state, White Nile state, Khartoum state, North Kordofan state, and River Nile state during 2000-2002 by Intisar (2002), Wifag (2009) and Osama (2010) used the Agar Gel Precipitation Test (AGPT), cell culture and cELISA. Nussieba (2005), Nussieba *et al.*, (2008), Nussieba *et al.*, (2009a) and Nussieba *et al.*, (2009b) detected antibodies against PPRV and isolated PPRV antigen from sheep and goats from different areas in the Sudan by using cELISA, AGPT and the Hemagglutination Test (HA). Khalafalla *et al.*, (2005; 2010) reported a new emerging respiratory disease in camel in eastern Sudan. Virus isolation on cell culture, AGID, IcELISA and PCR gave positive results to PPRV. Thoyba (2009) studied the growth of PPRV on embryonated chicken eggs and cell culture.

The highest number of reported outbreaks of PPR during the period from 2013 to 2018 was received from Kassala state in the Eastern region of Sudan, followed by River Nile state, Sinnar state, White Nile state and Gadarif state. Few outbreaks were reported by sates of Khartoum, Gazira, South Kordofan, Blue Nile and Northern states. Relatively, very few outbreaks reported in Red Sea and Darfur states (Anonymous, AHEDC, 2013- 2019).

In a study carried out by ILRI (2009), veterinarians ranked PPR as one of the most important animal diseases prevailing in three regions in the Sudan. Moreover, Faiza (2001) reported that the sero-prevalence rates of antibodies against PPRV in sheep sera were 74.0% in the Red Sea state, 62.0% in River Nile state, 65.0% in

Kassala state, 62.0% in Khartoum state, 59.0% in Sinnar state, 50.0% in the White Nile state, 59.0% in Kordofan state, 62.0% in South Darfur state and 52.0% in Western Bahar Al-Gazzal state.

Also, sero-prevalence rates estimated for antibodies against PPRV in sheep sera collected during 2002-2005 were 75.7% in Kordofan state, 60.4% in Khartoum state, 58.8% in the White Nile state, 52.5% in Darfur state, 66.7% in Sinnar state, 56.9% in Blue Nile state, 27.5% in the Red Sea state, 40.4% in Kassala state, 52.4% in Al-Gadarif state and 32.4% in the Northern state, resulting in an overall sero-prevalence rate of 59.7% (Intisar *et al.*, 2007; Intisar *et al.*, 2011).

In another study by Intisar *et al.*, (2009), the sero-prevalence rates were 93.8% in Khartoum state, 53.3% in northern Sudan, 90.9% in Eastern Sudan, 72.9% in central Sudan, 60.9% in western Sudan, and overall prevellance rate was 62.8%.

Furthermore, the importance of PPRV infection for owners and herders of small ruminants is reflected by its morbidity and case fatality rates.

1. 6 Host Range of PPRV:

PPR is a disease of small ruminant; sheep and goats which are considered the main natural hosts for PPR (Gargadennec and Lalanne, 1942; Gibbs *et al.*, 1979). Goats are more susceptible than sheep where the natural disease is more severe and causes heavy losses (Taylor, 1984; Lefevre, 1987; Roeder *et al.*, 1994). Sheep are less susceptible to PPR where disease is only occasionally sever (Mornet *et al.*,

1956). In some cases sheep living in close proximity to infected goats have remained unaffected (Durtnell, 1972; Shaila *et al.*, 1996; Kulkarni *et al.*, 1996). Roeder *et al.* (1994) confirmed PPR in goats in Ethiopia with both high morbidity and mortality rates while sheep remained unaffected. The severity of the disease in natural and experimental infection was proved more in goats than in sheep (Durojaiye, 1980; Durojaiye *et al.*, 1983).

Cattle and pigs are susceptible to experimental infection with PPR (Dardiri *et al.*, 1976; Gibbs *et al*., 1979; Nawathe and Taylor, 1979). They were infected subclinically, although they develop subsequent antibodies against the virus. Cattle infected with PPR are protected from challenge with virulent RPV (Gibbs *et al*., 1979). Cattle and pigs are apparently unable to transmit the disease to other animals and are considered dead end hosts for the disease. Sharma and Adlakha (1994) mentioned that experimentally infected deer and pigs supported virus multiplication. The American white-tailed deer (*Odocoileus virginianus*) was fully susceptible to experimental infection which caused both deaths and subclinical infection (Hamdy and Dardiri, 1976; Diallo, 2000; Diallo, 2004). Therefore cattle, pigs and dear are not important in the epidemiology of PPR (Nawathe and Taylor, 1979; Sharma and Adlakha, 1994).

In 1995 PPR was isolated from an outbreak of rinderpest-like disease in India buffaloes (*Bubalus bubalis*) (Govindarajan *et al*., 1997). In Ethiopia a disease thought to be caused by PPRV has been reported in one-humped camels during

1995 - 1996 (Roger *et al*., 2000; Roger *et al*., 2001). Roeder and Obi (1999) reported that cattle, buffaloes, camels and pigs can become infected but there is no evidence of disease associated with their infection.

Clinical PPR disease supported with virus isolation was reported in wild zoo animals resulting in deaths of gazelles (*Gazella dorcas*); ibex (*Capra ibex nubiana*); gemsbok (*Oryx gazella*) and laristan wild sheep (*Ovis orientalis laristaniea*) (Furley*et al*., 1987). Elzein *et al.,* (2004) isolated PPRV from a highly fatal outbreak in gazelles in Saudi Arabia. Rats experimentally inoculated with virulent PPRV produced subclinical infection without antibody response. Infected rates were unable to transmit the disease to incontact rats and goats co-housed together. Therefore, rats are not considered important in the epidemiology of PPR (Komolafe *et al*., 1987).

PPR is not infectious for human and poses no threat to human health as no report of human infection with the virus exists (Roeder and Obi, 1999; Diallo, 2000; Diallo, 2004).

1. 7 Transmission of PPRV:

1. 7.1 Natural Transmission of PPRV:

PPRV is transmitted by direct contact with secretions and excretions of infected animals. It is highly contagious and all discharges can carry the virus (Shuaib, 2011). Substantial quantities of virus are found in oculo-nasal discharges, oral discharges, and in the faeces late in the disease course in infected goats and

sheep (Chauhan *et al.,* 2009; Abubakar *et al.,* 2011). Fine infective droplets are released into the air from these secretions and excretions, particularly when affected animals cough or sneeze; animals in close contact inhale the droplets and are likely to become infected (Bundza *et al*., 1988). Since the virus is enveloped, it is extremely sensitive to inactivation by environmental factors such as heat, sunlight and chemicals. For this reason, close contact with infected animals is required for successful transmission (Braide, 1981; Gopilo, 2005; Abubakar *et al.,* 2011).

PPRV infected migratory animals may transmit the virus to susceptible sheep and goat populations while moving from one place to another (Shuaib, 2011). The movement of animals, therefore, plays an important role in the transmission and maintenance of PPRV in nature. Furthermore, limited fodder availability often leads to nutritional deficiency, resulting in increased susceptibility to infection. Consequently, large numbers of animals become infected during periods of food shortage and these animals then help to maintain the circulation of the virus throughout the year by frequent animal-to-animal transmission (Abubakar *et al.,* 2011). Trade in small ruminants, at markets where animals from different sources are brought into close contact with one another, affords increased opportunities for PPRV transmission, as does the aggregation of animals in intensive fattening units (Radostits *et al.,* 2007).

Although close contact is the most important way of transmitting the disease, it is suspected that infectious materials can also contaminate water, feed troughs and bedding, turning them into additional sources of infection. These particular hazards are, however, probably fairly short-term, since the PPRV, like rinderpest virus, would not be expected to survive for long time outside the host. Indirect transmission seems to be unlikely in view of the low resistance of the virus in the environment and its sensitivity to lipid solvents (Gopilo, 2005; Abubakar *et al.,* 2011).

However, Gopilo in 2005 reported that until that year no known carrier state for PPRV was known. A year later some cases of PPRV infection in sheep, goat, and camel populations have been described in Nigeria. Studies on their fecal materials by using haemagglutinin tests suggested that healthy animals may serve as carriers for PPRV (Obidike *et al.,* 2006). A possible role of camels in the dissemination of PPRV to goats also has been suggested in Ethiopia in 1995 by Roger *et al.*, (2001), but more recent surveys in the Sudan have suggested this route of dissemination as unlikely (Khalafalla *et al.,* 2010). Shedding of PPRV might continue for up to 12 weeks or longer posing a high risk for in-contact susceptible animals (OIE, 2008; Abubakar *et al.,* 2011).

1. 7.2 Experimental transmission of PPRV:

Experimentally, the virus has been transmitted parenterally through different routes: nasal, oral, subcutaneous, intraocular, intratracheal and intravenous or by

contact (Durtnell, 1972; Durojaiye, 1980). Durtnell (1972) used infective lymphoid tissue suspension to infect goats and sheep by PPRV after the propagation of the virus through three serial passages in goats. The tissue suspension failed to infect inoculated sheep and incontact sheep and goats. Isoun and Mann (1972) indicated that PPR is contagious due to the nature of the spread of the disease from kids to the adult goats. Nduaka and Ihemelandu (1973) also reported that PPR is contagious in the field. Hamdy *et al.* (1976) transmitted the disease through two passages in goats followed by one passage in cell culture then another one in goats. Dardiri *et al.* (1976) reported that the transmission of the disease from reacting goats to incontact cattle which develop lesions that would be diagnosed wrongly as RP.

Pigs infected subclinically with PPRV by inoculation or contact with infected goats was unable to transmit the virus either to goats or pigs (Nawathe and Taylor, 1979). Rats also infected subclinically could not transmit the virus to uninfected goats and rats housed in contact (Komolafe *et al*., 1987).

1. 8 PPRV Clinical Signs:

The pathogenesis of PPR is started after the entry of the virus through the respiratory system, then it localized first in the pharyngeal and mandibular lymph nodes and tonsils. Subsequent viremia results in dissemination to visceral lymph nodes, spleen, bone marrow and the mucosa of the gastrointestinal and the respiratory systems (Scott, 1981, cited by Bundza *et al.,* 1988). The virus is having

affinity for lymphoid and epithelial tissues of gastrointestinal and respiratory tracts in which it produces lesions (Scott, 1981).

The disease has per-acute, acute and sub-acute forms (Losos, 1986). In the majority of cases, PPR is an acute disease. The clinical signs in sheep are the same as in goats but generally less severe (Elhag Ali, 1973; Durojaiye, 1983; Shalia *et al.,* 1996). PPR is characterized by pyrexia, catarrhal inflammation of the ocular and nasal mucous membranes, erosive stomatitis, conjunctivitis, gastroenteritis and pneumonia (Taylor, 1984).

The animals affected with PPR usually have lymphocytopenia, elevated packed cell volume (PCV) (above 60% while normal is 35-45%) and a very high red blood cells count (RBCs) count, while the levels of haemoglobin and white blood cells count (WBCs) are normal (Furly *et al.,* 1987; Baron *et al.,* 2011).

1. 8.1 PPRV Per-acute syndrome

A per-acute form occurs frequently in goats after an incubation period of about 2 days and is characterized by fever, sudden death and high mortality. There is perfusing nasal catarrh, high fever, congested and eroded mucous membranes, dyspnea, anorexia and constipation. The diarrhoea starts after about 3 days of onset of clinical syndrome and death occur 4 - 6 days after illness (Sharma and Adlakha, 1994).

1. 8.2 PPRV Acute syndrome

In the majority of cases, PPR is an acute disease which appears after an incubation period of 2 to 6 days after natural infection of the virus (Roeder and Obi, 1999; Diallo, 2000; DEFRA, 2001; Diallo, 2004). The course of the disease takes 5 - 6 days which may terminate in death (Braide, 1981; Taylor, 1984; Lefevre and Diallo, 1990; Sharma and Adlakha, 1994).

The onset of illness was manifested by pyrexia with a rectal temperature that reached 40 - 41 ºC. The peak of temperature remaining for 3 - 8 days before slowly returning to normal (Sharma and Adlakha, 1994; Saliki, 1998; Roeder and Obi, 1999; Diallo, 2000; Diallo, 2004). Deaths usually occur during the late stage of fever when temperature drops below normal. With the onset of the fever the animal become anorexic, develops a dry muzzle and dull coat, restless and severely depressed (Aiello and Mays, 1998; Saliki, 1998). Also there is severe leukopenia in goats (Whitney *et al.*, 1967; Nduaka and Ihemelandu, 1973; Obi and Oduye, 1985). A highly characteristic syndrome begins with inflammation and erosions of the mucous membranes lining the upper respiratory, upper alimentary and urogenital tracts 1 - 2 days after onset of fever (Hamdy *et al.*, 1976). This was accompanied by serous oculonasal discharges which persisted for 2 - 7 days and progressively becomes mucopurulent (Whitney *et al.*, 1967; Nduaka and Ihemelandu, 1973; Saliki, 1998). The exudates developed an extensive encrustation at the lip commissures and consisted of brown scab material covering patchy erosions

(Whitney *et al.*, 1967; Nduaka and Ihemelandu, 1973; Hamdy *et al.*, 1976; Losos, 1986). The exudates can crust over blocking the nostrils and causing respiratory distress and give a putrid odor to the breath (Aiello and Mays, 1998). Conjunctivitis with discharges from the eyes causes matting of the eyelids (Nduaka and Ihemelandu, 1973; Roeder and Obi, 1999). Most animals develop severe profuse non haemorrhagic diarrhoea 2 - 3 days after the development of mouth lesions. Diarrhoea is usually accompanied by severe dehydration, emaciation, hypothermia and death within 5 - 10 days (Nduaka and Ihemelandu, 1973; Ezeokoli *et al.*, 1986; Saliki, 1998). Pneumonia, coughing, pleural rales and abdominal breathing also occur (Diallo, 2000; Diallo, 2004). Bronchopneumonia, evidenced by coughing is common feature (Saliki, 1998). Necrotic stomatitis affects the lower lip and gum and it may involve the dental pad, hard palate, cheeks with their papillae and the tongue (Saliki, 1998; Roeder and Obi, 1999). A common feature in the later stage of the disease is the formation of small nodular lesions in the skin on the outside of the lips around the muzzle. These lesions cause confusion because of their similarity to the symptoms of primary contagious ecthyma or sheep and goat pox (Roeder and Obi, 1999; Diallo, 2000; Diallo, 2004). The clinical picture may be complicated by secondary latent infection (Ugochukwu, 1985). During the recovery of the disease, orf-like labial lesions develop (Obi and Gibbs, 1978; Losos, 1986). Recovered animals do not appear to be carrier. PPR causes abortion in pregnant animals (Nduaka and Ihemelandu, 1973). Also vulvovaginitis has been reported as

one of the lesions of PPR (Wosu, 1992). Erosive lesions have been recorded in the vulva (Ezeokoli *et al.*, 1986) producing abortion and also keratitis with corneal opacity (Diallo, 2003). PPR does not appear to qualify as a reproductive disease (Ezeibe and Wosu, 1999) because it does not cause important structural damage to the female reproductive system. All goats that recovered from PPR carried pregnancy successfully. Therefore abortion commonly reported in PPR may be more due to general debility (Ezeibe and Wosu, 1999). In the only reported outbreak of PPR in domestic buffalo; congestion of conjunctiva, profuse saliva and depression were the only clinical signs observed. Buffalo calves developed only pyrexia 6 days after infection and died 30 days later exhibiting heamorrhagic and oedematous abomastitis in postmortem (Govindarajan *et al.*, 1997).

The prognosis of acute PPR is usually poor, especially when lesions do not resolve within 2 – 3 days or when extensive necrosis and bacterial infection give the animals breath an unpleasant fetid odor (Aiello and Mays, 1998). Morbidity is often as high as 100% and mortality can be up to 90% in the most severe outbreaks (Losos, 1986). In milder outbreaks mortality is still high; however the mortality rate may be closer to 50% (Diallo, 2000; Diallo, 2004).

Figure 1: Common clinical signs of acute PPRV infection in small ruminants: Ocular and nasal discharges (Baron *et al.*, 2011)

Figure2: Common clinical signs of acute PPRV infection in small ruminants: Early oral lesions and necrosis of the gum (Baron *et al.*, 2011).

1. 8.3 PPRV Sub-acute syndrome

Sheep and less frequently goats develop a sub-acute infection after a longer incubation period about 6 days and longer disease course (10 – 15 days). The disease is manifested by slight fever, nasal catarrh, recurring erosions of the oral mucosa, respiratory distress and intermittent diarrhoea. Recovery often follows after 10 – 14 days (Sharma and Adlakha, 1994; Aiello and Mays, 1998).

Peracute and most acute infections are fatal, death occurring 4 - 10 days

after the onset of illness (DEFRA, 2001). Convalescence in survivors is prolonged and often complicated by activated latent infections or super infections such as trypanosomiasis, dermatoplilosis and orf (DEFRA, 2001). The isolation of *Pasteurella* species and *E.coli* from cases of PPR (Ezeokoli *et al.*, 1986) supported the suggestion by other investigators that bacterial pathogens may be involved in the pathogenesis of PPR (Rowland *et al.*, 1971; Nawathe, 1980; Adetosoye and Ojo, 1983; Isitor *et al.*, 1984).

Severity depends upon the susceptibility of the population. Goats are generally more susceptible to PPR than sheep. Infection rates in sheep and goats rise with age, and the disease which varies in severity, is rapidly fatal in young animals (Taylor, 1979; Obi, 1982; Lefevre and Diallo, 1990; Wosu, 1994; Ozkul *et al.*, 2002). Young animals 4 – 8 months of age often have more severe disease (Ozkul *et al.*, 2002). Morbidity and mortality rates are higher in young animals than in adult (Nduaka and Ihemelandu, 1973). Also, poor nutrition, stress of movement, and concurrent parasitic and bacterial infections worsen the clinical signs (Saliki, 1998).

Although PPR infection occur under all forms of husbandry conditions, the disease produces the highest morbidity and mortality when large numbers of goats or sheep are reared together or following the introduction of new animals into established herds (Braide, 1981; Scott,1981; Obi *et al.*, 1983; Reoder and Obi, 1999). Epidemics tend to occur during rainy season when goats are herded together

and around Christmas when movement to wards markets increases (Durojaiye, 1983; Opasina and Putt, 1985; Roeder and Obi, 1999). The seasonal occurrence of the disease was observed by Whitney *et al.*(1967) and Nduaka and Ihemelandu (1973).

1. 9 Pathology of PPRV Infection

The principal pathological findings of PPR were confined to the alimentary and respiratory tracts (Losos, 1986; Barker *et al.*, 1993). Necropsy findings in PPR were characterized by mucosal erosions, haemorrhagic gastroenteritis and pneumonia (Rowland *et al.*, 1969). In general animals were emaciated and severely dehydrated (Whitney *et al.*, 1967; Toplu, 2004). The perineum and posterior aspects of the hind limbs were soiled with watery, sometimes blood-tinged, faeces (Whitney *et al.*, 1967).

The lips were oedematous and their margins showed a progressive accumulation of golden-brown scab material particularly at the commissures (Whitney *et al.*, 1967).

In the digestive system, there is usually severe erosions, necrotic stomatitis and enterocolitis (Scott, 1990). In the buccal cavity erosive areas measuring 3 to 5 mm in diameter were present in mucous membranes of the upper and lower lip, the cheek, the dental pad, hard and soft palate and severe lesions occurred in the pharynx and may extended to the oesophagus (Whitney *et al.*,1967; Isoun and Mann, 1972; Nduaka and Ihemelandu, 1973). Gross changes in glandular mucosa

of the alimentary tract from abomasum to rectum were often inconspicuous (Rowland *et al.,* 1969). The digestive tract was usually characterized by erosions of mucosa of various parts (Nduaka and Ihemelandu, 1973). In rumen, reticulum and omasum, no abnormalitis were detected except of a single ruminal ulcer. The abomasum was oedematous, congested and showed severe haemorrhagic inflammation and filled with foetid watery fluid (Whitney *et al.,* 1967; Rowland *et al.,* 1969; Nduaka and Ihemelandu, 1973). Also haemorrhage and ulcer were observed in the pylorus (Whitney *et al.,* 1967; Rowland *et al.,* 1969).

The contents of small intestine were limited, consisting of a bile-tinged watery fluid. In the mucosa of terminal ileum there was diffuse erythma (Whitney *et al.,* 1967; Nduaka and Ihemelandu, 1973). Payer's patches were enlarged and prominent. The duodenum showed evidence of severe inflammation (Nduaka and Ihemelandu, 1973). The ileo-cecal orifice was characterized by haemorrhagic ring around the orifice (Nduaka and Ihemelandu, 1973). In the large intestine, the contents were fluid (Rowland *et al.,* 1969). The changes, which were variable in their severity and distribution, were dramatic with "zebra-striping" of the caecum, colon and rectum (Whitney *et al.,* 1967). They were seen constantly at the caeco-colic junction which enlarged and haemorrhagic. The caecum, colon and rectum often showed evidence of linear haemorrhages. In the rectum there were areas of ulcerations (Whitney *et al.,* 1967; Nduaka and Ihemelandu, 1973).

There was considerable variation in the gross lesions in the respiratory tract, depending on the duration of the lesions. In the nasal cavity there was an intense congestion, petechial haemorrhage and ulcers on the mucosa (Whitney *et al.*, 1967). The lungs were congested and emphysematous (Whitney *et al.*, 1967). In the acute stages of the disease, there was tracheitis which was characterized by haemorrhagic to frothy mucopurulent exudate in the trachea and bronchi (Nduaka and Ihemelandu, 1973). Pneumonia was usually observed in a few lung lobes. The one most commonly involved was the right apical lobe while the intermediate and cardiac lobes were involved less often (Nduaka and Ihemelandu, 1973). Bronchopneumonias with diffuse consolidation of the apical, cardiac and diaphragmatic lobes were observed (Isoun and Mann, 1972; Nduaka and Ihemelandu, 1973). In some animals there was focal consolidation measuring 4 to 5 cm in diameter at the dorsal region of the diaphragmatic lobe with fibrinous adhesions of the apical lobe to themselves, to the parietal pleura and to the pericardial sac (Isoun and Mann, 1972; TopIu, 2004).

The lymphoid tissue showed little evidence of involvement (Rowland *et al.*, 1969). The spleen was congested and contracted (Whitney *et al.*, 1967; Aruni *et al.*, 1998). The lymph nodes were also congested, oedematous and slightly enlarged (Aruni *et al.*, 1998; Toplu, 2004). The carcass lymph nodes were swollen and oedematous (Whitney *et al.*, 1967). The liver was pale and sometimes friable and the cut surface showed tiny, whitish- grey necrotic foci (Toplu, 2004).

No abnormalitis were observed in the urogenital system other than petecial haemorrhage or diffuse erythema of the mucosa of the bladder (Whitney *et al.*, 1967). There was no evidence, clinically or pathologically, of involvement of the central nervous system, skeletal muscle, skin and feet (Rowland *et al.*, 1969).

1. 10 Immunity to PPRV Infection

Sheep and goats that recover from PPR develop an active immunity against the disease and resist infection with PPR (Sharma and Adlakha, 1994). Antibodies have been demonstrated for four years after infection (Durojaiye, 1984; Durojaiye and Taylor, 1984), however, immunity is lifelong (Sharma and Adlakha, 1994; Dialio, 2000; Diallo, 2004). Young animals from dams with previous history of PPR are protected up to 3 - 4 months of age by maternal antibodies (Ata *et al.*, 1989; Bidjeh *et al.*, 1999). Clostral immunity protects kids and lambs until they are weaned (Sharma and Adlakha, 1994). Therefore, the age of three months should be considered a suitable and optimum time for effective immunization of small ruminants against PPR. The presence of high level of maternal antibodies has an immunosuppressive effect on the immune system of neonates and would interfere with the degree of immunologic response to active immunization (Trautwein, 1980 cited by Ata *et al.*, 1989). The duration of passive immunity is 120 days as estimated by the VNT compared to 90 days by C-ELISA (Libeau *et al.*, 1995). There were no differences in the length of maternal immunity in dams vaccinated with TCRP vaccine between 0 and 2 months and those vaccinated at 5 months

(Bidjeh *et al.,* 1999). Sheep and goats vaccinated with the attenuated RBOK strain of RP virus did not develop clinical disease when infected with PPR virus (Gibbs *et al.,* 1979). The Schwarz vaccine strain of measles virus did not protect sheep and goats against PPR virus while canine distemper virus did have some cross-protection (Gibbs *et al.,* 1979; Losos, 1986). The challenge PPR virus was found to multiply in those animals which had been immunized with RP, CD or measles but not in animals recovered from PPR (Gibbs *et al.,* 1979).

1. 11 Diagnosis of PPRV Infection

1. 11.1 Clinical Diagnosis

A provisional diagnosis of PPR can be made from epidemiological and clinical features (FAO, 1999; Abubakar *et al.,* 2011; Dilli *et al.,* 2011). Clinical diagnosis is based mainly on the clinical signs and the post mortem lesions observed. The disease characterized by discharges, diarrhoea and deaths with breathing problems in sheep and/or goats, but not incontact-cattle, with mainly adolescents being affected and dying, must arouse a suspicion of PPR. However, since RPR is within the list A of the Office International des Epizootics (OIE), this diagnosis should be considered provisional until laboratory confirmation, particularly in the case of epidemic or new area (Diallo, 2003). This confirmation is important because PPR can be confused clinically with many other small ruminant diseases (Diallo, 2003).

1. 11.2 Laboratory Diagnosis

Samples required for diagnosis from live animals: swabs of the conjunctival discharges, and from the nasal, buccal and rectal mucosa should be taken. During the early stage of the disease, whole blood is also collected in anticoagulant for virus isolation, PCR and haematology (Diallo, 2000; Diallo, 2004).

Samples should be taken from animals with high body temperatures preferably before diarrhoea starts. Samples should also be collected aseptically, chilled on ice and transported under refrigation (Diallo, 2000; Diallo, 2004).

A necropsy: lymph nodes especially the mesenteric and bronchial nodes, lungs, spleen, and intestinal mucosa should be collected. Fragments of organs collected for histopathology are placed in 10% formalin. At the end of the outbreak blood can be collected for diagnosis (Diallo, 2000; Diallo, 2004).

1. 11.3 Differential Diagnosis of PPRV Infection

The differential diagnosis has to be made to differentiate between PPR and diseases with stomatitis lesions, enteritis symptoms and respiratory distress (Adetosoye and Ojo, 1983; Elhag Ali and Taylor, 1984; Bidjeh *et al.*, 1995).

In addition to Rinderpest, other conditions that should be considered in differential diagnosis include: Blue Tongue (BT), Pasteurellosis, Contagious Ecthyma (CE) or Orf, Foot and mouth disease (FMD), Heart Water, Coccidiosis, Sheep Pox, Contagious Caprine Pleuro- Pneumonia (CCPP), Plant or Mineral Poisoning, Nairobi SheepDisease, Salmonellosis and Gastrointestinal helminths

infestations (Saliki, 1998; Roeder and Obi, 1999).

As RP virus can cause clinical disease in small ruminants, however sometimes it is asymptomatic (Anderson *et al.,* 1990; Couacy-Hymann *et al.,* 1995). The differentiation of PPR from RP is often difficult in the field as the clinical signs are similar. In the laboratory, PPR is normally differentiated from RP through reciprocal cross-neutralization (Taylor and Abegunde,1979), reciprocal cross-protection (Hamdy *et al.,*1975), Haemagglutination test (Wosu, 1985; Wosu, 1991), differences in the mobility of 'N' protein of PPRV and RPV (Diallo *et al.,*1987), differences in the base sequence of N gene detected by cDNA probes (Shaila *et al.,*1989; Pandey *et al.,* 1992) and by monoclonal antibodies (MAb) directed against each protein of the virus (McCullough *et al.,*1986). One way cross neutralization test with RPV hyperimmune antiserum can aid in differentiation of these two related viruses (Chandran *et al.,* 1995). Similarly PPRV antibodies can be differentiated from RPV antibodies by competitive ELISA (Libeau *et al.,* 1992; Libeau *et al.,* 1995) and serum neutralization test (Diallo *et al.,* 1995).

1. 12 Risk Factors for PPRV Infection

There are often a number of risk factors that contribute to the overall risk of diseases transmission in a particular community, production system or value chain (Elsawalhy *et al.,* 2010). These risk factors are often quite simple attributes of the sub-population such as the amount of movement, exchange of animals between households and flocks as a result of social practices and changes in economic

conditions that exhibit seasonal patterns, distance from services, lack of large scale vaccination campaigns, altitude, season and inter-species contact or interaction with wildlife (Radostits *et al.,* 2007; Waret-Szkuta *et al.,* 2008; Elsawalhy *et al.,* 2010). In addition, age, sex, species, and breed are very important individual risk factors (Radostits *et al.,* 2007; Waret-Szkuta *et al.,* 2008).

Encouraging climatic factors for the survival and spread of the virus contribute to the seasonal occurrence of PPR outbreaks. During the rainy season in Pakistan, the migratory activity of animals is reduced due to the increased availability of local fodder (Abubakar *et al.,* 2011). The nutritional status of the animals also improves, resulting in an increased resistance to infection. These factors may play a key role in limiting the transmission of disease (Abubakar *et al.,* 2011; Sarker and Hemayeatul, 2011). Although the outbreaks which occur in West Africa coincide with the wet rainy season, the incidence seems to rise rapidly and get a peak in winter. This could be related to the dry, cold and dusty weather accompanied with poor nutrition by this time in Pakistan and West Africa (Abubakar *et al.,* 2011; Sarker and Hemayeatul, 2011).

Due to an ongoing decrease in available pasture land and forest area, sheep and goats often travel long distances during the dry season in search of fodder and water in some parts of the world, like East Africa and the Indian Sub-Continent (Nanda *et al.,* 1996). The movement of animals, therefore, determines the pattern of PPRV outbreaks and infection (Abd El-Rahim *et al.,* 2010; Abubakar *et al.,* 2011).

The epidemiological patterns of PPRV outbreaks and infections have been observed to be diverse in different ecological systems in various geographical regions (Waret-Szkuta *et al.,* 2008; Abd El-Rahim *et al.,* 2010; Abubakar *et al.,* 2011). However, Ozkul *et al.* (2002) indicated that the occurrence of PPRV outbreaks did not vary substantially by geographic locations of the livestock tested in Turkey. PPRV outbreaks and infections in humid areas always occurred in an epizootic form that may have remarkable consequences with morbidity of 80 – 90% and mortality 50 – 80%, while in arid and semi-arid regions, PPR is often fatal and usually occurs as a subclinical or in-apparent infection opening the door for other infections such as Pasteurellosis (Abd El-Rahim *et al.,* 2010; Abubakar *et al.,* 2011).

Age appeared to be a risk factor for sero-positive status, and its linear effect suggested that PPRV is highly immunogenic and naturally infected animals remaining positive for a long time (Waret-Szkuta *et al.,* 2008). However, new born animals become susceptible to PPRV infection at three to four months of age (Srinivas and Gopal, 1996), corresponding with the natural decline in maternal antibodies (Saliki *et al.,* 1993); after losing maternal immunity, young animals of both sheep and goats are at higher risk than adults and have a better chance to be sero-positive to PPRV (Ozkul *et al.,* 2002; Singh *et al.,* 2004; Abd El-Rahim *et al.,* 2010). However, serological evidences revealed that antibodies occur in all age groups from 4 to 24 months indicating a constant circulation of the virus (Waret-

Szkuta *et al.,* 2008; Abubakar *et al.,* 2011). High morbidity (90%) and mortality (70%) has been reported in all age groups (Abu Elzein *et al.,* 1990; Gopilo, 2005; Waret-Szkuta *et al.,* 2008; Abubakar *et al.,* 2011).

Abubakar *et al.* (2009) suggested that there is a species variation in the susceptibility to PPRV infection. It is more severe in goats than sheep, based on serological investigations and clinical observations. It has been reported that European sheep and goats most commonly show a mild sub-acute form of PPRV infection based on experimental infections in highly secure units (Baron *et al.,* 2011).

However, PPR was significantly also associated with breeds where it has been found to be more prevalent in indigenous breeds of Bengali goats than in exotic breeds of goats. The Guinean breeds (West African dwarf, Iogoon, kindi and Djallonke) are recognized as highly susceptible (Abubakar *et al.,* 2011).

Moreover, PPRV infection was also significantly associated with sex where he-goats were apparently more prone to PPR infection than she-goats (Abubakar *et al.,* 2011; Sarker and Hemayeatul, 2011).

1. 13 Control and Prophylaxis of PPRV

Currently PPR is one of the priorities subsequent to Rinderpest for international organizations like FAO, OIE and IAEA to control and finally eradicate it (Kumar *et al.,* 2014). Controlling of PPR may seem to be relatively easy compared to other economically viral diseases, such as foot and mouth disease

and blue tongue. This may be attributed to high antigenic stability, single serotype of the virus and the induction of a lifelong immune response after vaccination (Singh, 2011).

Control of PPR infection relies on movement control (quarantine) combined with the use of focused 'ring' vaccination and prophylactic immunization in high risk of animal population including proper disposal of carcasses and contact fomites beside decontamination (Roeder and Obi, 1999). *Peste des petits ruminants* infection is mostly a result of introduction of infected animals into a herd. Thus the restriction of animal importation from affected areas is a very important part in the face of all epidemics and in prevention (Roeder and Obi, 1999). The only effective way to control PPR in endemic areas is by vaccination of the animals. Rinderpest vaccine has been used as a heterologous vaccine to protect small ruminants against PPR (Bourdin *et al.*, 1970; Bourdin, 1973; Nduaka and Ihemelandu, 1975). The attenuated RP vaccine provides protection of goats for at least one year possibly through an antibody-mediated immune response (Taylor, 1979; Bourdin *et al.*, 1970). Taylor (1979) found that the resultant neutralizing antibodies were directed primarily against RP while there are high level of antibodies to both RP and PPR viruses following challenge with PPR virus. Nduaka and Ihemelandu (1975) successfully controlled stomatitis-pneumoniaenteritis complex (SPC) by the use of chloroform-inactivated RPTC vaccine. This vaccine immunized goats for 18 months (Mariner *et al.*, 1993). Wosu and co-workers (1990) suggested that the

optimal time for vaccination of goats against PPR with RPTC vaccine in tropical zones of West Africa is from late November to middle of December according to the incidence of PPR. The use of RP vaccine to protect small ruminant against PPR is now contra indicated due to production of antibodies to RP which compromise sero-surveillance for RP and there by the OIE pathway and the Global RP Eradication Programme (GREP) (Roeder and Obi, 1999). Couacy-Hymann and co-workers (1995) reported that PPRV protected small ruminants against both PPRV and RPV.

Recently, a very efficient PPR homologous vaccine was developed with the attenuated PPRV Nigeria 75/1 isolate (PPR 75/1 LK6 BK2 Vero70) (Diallo *et al.,* 1989). The homologous vaccine provides a lifelong immunity against PPR which extended for 3 years (Roeder and Obi, 1999). It was also able to protect goats against virulent RP virus (Couacy-Hymann *et al.,* 1995). The attenuated freeze-dried PPR vaccine is thermolabile which needed preservation at -20°C. Martrenchar *et al.* (1999) evaluated the use of attenuated PPR vaccine in the field and proved it's effectively in vaccinating animal.

Lyophilisation was used for long term preservation of the vaccine (Worrall *et al.,* 2001). They showed that thermolabile viruses can be dehydrated in vitro within 18 hours in an excipient containing trehalose. The vaccine in the dehydrate state is capable of resisting 45ºC for a period of 14 days with minimal loss of potency. The lyophilisation is a short, cheap and simple procedure leading to greater confidence

in vaccine stability, potency and efficacy (Worrall *et al.*, 2001).

Goats vaccinated with a recombinant capripoxvirus containing either the fusion (F) gene or the haemagglutinin (H) gene of RP virus were protected against a lethal challenge of PPR virus (Romero *et al.*, 1995). The H gene recombinant produces high titers of neutralizing antibody to RP virus whereas the F gene recombinant failed to simulate detectable levels of neutralizing antibody in the vaccinated goats (Romero *et al.*, 1995). A recombinant capripox virus vaccine containing a cDNA of the PPR virus fusion protein and haemagglutinin protein genes was constructed (Berhe *et al.*, 2003; Diallo, 2003). Aquick and efficient method was used to select a highly purified recombinant virus clone. A capripox virus recombinant that expresses the PPR F protein can protect goats against PPR and Capripox. A dose of this recombinant, as low as 0.1 plaque forming unit (PFU), protected goats against challenge with a virulent PPRV strain (Berhe *et al.*, 2003).

In Sudan, a homologous PPR vaccine was produced successfully locally in the Soba Central Laboratory for Veterinary Research (CLVR) was established in 2002 (Shuaib, 2011) and used in the field and for exporting animals (Fadol and El Hussein, 2004). Currently used vaccines require effective cold chains and hence high costs are required to conduct vaccination campaign. The thermo-stability of the current PPRV homologous vaccine has been dramatically improved by a new freeze-drying process and addition of stabilizing agents (Shuaib, 2011). A single

dose of PPR vaccine containing 10^3 $TCID_{50}$ of Vero cell attenuated PPRV, is believed to provide protective immunity in sheep and goats for about 4 years (Kumar *et al.*, 2014).

Vaccination can be divided into three inter _ dependent stages, based on prioritizing available resources. These stages are; 1) Reducing disease intensity through vaccinating targeted populations, 2) Controlling PPR by intensive vaccination, 3) Implementing mass vaccination campaigns that provide high levels of vaccination coverage. In case of eradication, it is important and preferable to use marker vaccines or chimeric vaccine for differentiating infected from vaccinated animals (DIVA) (Singh, 2011).

1. 14 Treatment of PPRV Infection

There is no treatment for PPR. However mortality rates may be decreased by the use of broad spectrum antibiotics and antiparasiticides which control bacterial and parasitic complications. Specifically, oxytetracycline and chlortetracycline are recommended to prevent secondary pulmonary infections (Diallo, 2000; Diallo, 2004). Supportive care including fluid therapy can also decrease deaths loss due to dehydration and subsequent electrolyte imbalance (Wosu, 1989).

Isoun and Mann (1972) found that antibiotic treatment of natural SPC in sheep was of limited value. They mentioned that pneumonia responded to Sulphadimidine and Terramycin to some extent, however, the diarrhoea and high body temperatures continue despite treatment. Clinical cases of acute PPR can be

adequately and successfully treated even in advanced cases particularly if treatment is started early (Omamegbe and Mecha, 1984). They suggested that a rapid lowering of the body temperature using anti-pyretic drugs and the suppression of coughing using antitussives enhance the chances or successful therapy. The arrest of the diarrhoea and replacement of the lost body fluids and ions would appear to be more important than the use of antibacterial agents. They mentioned that the use of broad spectrum antibiotics, fluid therapy, gastro-intestinal sedatives, antipyretics, antitussive and good nursing resulted in a survival rate of 45%. Anene *et al.* (1987) demonstrated poor clinical response of naturally infected goats treated with oxytetracycline, chloramphenicol 25% aqueous solution or metamerazine, thiabendazole, codeine and vitamin B complex. Clinical cases of PPR disease in goats were preferably treated symptomatically (Wosu, 1989). Broad spectrum antibiotics, intestinal sedatives and fluid therapy were used to treat pneumonia, diarrhoea and restore body fluid ionic balance. Good feeding and nursing in warm draught-free pens are necessary. Wosu (1989) proved that scrubbing the orf-like labial scabs with lemon (*Sour orange*) fruit (*Citrus oranitium*) cut in half resulted in earlier healing than spraying with an iodine-antibiotic mixture. The combination of the lemon fruit treatment of mouth scabs with antibiotics find chemotherapy raised the survival rate of goats by 13.3% (Wosu, 1989). Goats infected with pneumo-entritis syndrome were treated with norfloxacin together with oral and i/v administration of electrolytes and liver detoxifying agent (Ayaz *et al.*, 1997). This

method raises the survival rate by 20%.

Adu and Joannis (1984) proved that goats given hyperimmnune serum and virulent PPR virus simultaneously developed a durable immunity without noticed clinical signs. It was also observed that administration of hyperimmune serum to animals incubating the disease or in the early stages of the disease before the onset of diarrhoea resulted in protection and recovery (Adu and Joannis, 1984). However, administration during the diarrhoeic stage was not protective and is thus not recommended. They reported that goats given 8 ml of hyperimmune serum and 4 ml of the virulent PPR virus suspension survived challenge with virulent PPR after a period of 9 months. Ihemelandu *et al.* (1985) mentioned that hyper immune serum was very effective in reversing the process of the disease if administered at the fever stage but not in animals that had progressed and passed it. These goats which given the hyperimmune serum survived for 10 days before showing evidence of re-infection.

1. 15 Eradication of PPRV

Eradication of PPR could be achieved and there are several aspects that assist in eradication such as; there is only one serotype of PPRV and it is believed that perfect cross protection appears to exist within strains from different lineages. Also the virus does not survive for a long period of time outside the host, as it is readily destroyed by heat and sunlight and hence needs continuous source of susceptible animals for survival. It is very important in the eradication process to consider and

understand the role of other ruminants -whether wild or domestic- in the maintenance of PPRV in the environment in order to be able to initiate successful control strategies (Kumar *et al.,* 2014).

1. 16 The Economic Importance of the PPR Disease

PPRV is currently considered one of the main animal trans-boundary pathogens that constitute a significant threat to livestock production in developing countries. In those areas affected by the disease, PPR is considered a major limiting factor in the development of the small ruminant industry (Shuaib, 2011). This is especially evident in many countries in Africa and Asia where sheep and goats play an integral role in sustainable agriculture and employment (Baron *et al.*, 2011). The potential and real economic impacts of PPR outbreaks are extremely high and the impact of the disease on the poorer sections of society is disproportionate, reflecting an intrinsic dependence on sheep and goat farming (Baron *et al.,* 2011).

Its economic impacts are reflected by the ability of PPR to cause high morbidity, ranging from 50% to 90%, and by its case-fatality rate that reaches 55% to 85% in goats, 10% in sheep and 50% in camels (Radostits *et al.,* 2007; Khalafalla *et al.,* 2010). Dhar *et al.,* (2002) reported that morbidity and mortality can be as high as 90% to 100%, respectively, and when associated with other diseases such as capripox, mortality can be 100%. Antelopes and other small wild ruminant species as well as camels can also be severely affected by PPRV (Abu Elzein *et al.,* 2004; Bailey *et al*., 2005; Khalafalla *et al.,* 2010), and, as a result, the

economic revenues coming from game ranching and tourism are reduced. Although PPR remains the principal killing disease of small ruminants in most African, Asian and Middle East countries, as recognized in an international survey, few economic studies have been made on this disease (Berhe, 2006; Abubakar *et al.,* 2011; Baron *et al.,* 2011).

Due to confusion with other diseases, the economic impacts of PPR are probably underestimated, but it is believed that PPR is one of the major constraints of small ruminant farming in the tropic (Gopilo, 2005; Abubakar *et al.,* 2011; Baron *et al.,* 2011). Based on the assumption that goats experience an outbreak every 5 years, Opasina and Putt (1985) estimated an annual sum ranging from 2.47£ per goat at high loss to 0.36£ per goat at lowest loss. Losses due to PPR in Nigeria were estimated to be 1.5 million dollars annually (Hamdy *et al*., 1976; Gopilo, 2005; Abubakar *et al.,* 2011; Baron *et al.,* 2011). The economic loss due to PPRV alone in India has been estimated annually at 1.800 million Indian Rupees (39 million US$) (Bandyopadhyay, 2002; Gopilo, 2005; Chauhan *et al*., 2009; Abubakar *et al.*, 2011; Baron *et al.,* 2011).

An economic analysis to assess benefits of vaccination against PPR in Niger revealed that such a program was highly beneficial with an anticipated net present value (NPV) in five years of 24 million US$, following an investment of two million US$ (Gopilo, 2005; Abubakar *et al.*, 2011; Baron *et al.,* 2011). After confirming PPR in Kenya in 1992, the virus rapidly spread in the country where it

has been associated with severe socioeconomic consequences for food security and having impact on the livelihoods of the local population. Mortality rates varied according to animal's age with 100% mortality in kids, 40% in young animals and 10% in adult animals. Between 2006 and 2008, it is estimated that more than 5 million animals were affected across Kenya, with more than half of the infected animals succumbing to the disease.

The annual loss attributed to PPR in Kenya is currently thought to be in excess of US$15 million. However, inadequate funding, limited stocks of available vaccine, shortage of trained staff to coordinate vaccination programs, tribal clashes, drought and the mobility of the pastoral communities involved continue to make control tasks problematic (Wamwayi *et al*., 1995; FAO, 2008; Banyard *et al.*, 2010; Baron *et al.*, 2011).

PPRV has now spread into Uganda and Tanzania and, extremely worrying, has recently spread throughout the length of Tanzania towards its southern border with Mozambique (Shuaib, 2011). This puts many millions of sheep and goats in several southern African countries (Zambia, Zimbabwe, Mozambique, Malawi, Botswana and South Africa), where PPR has never previously been reported, at severe risk (Baron *et al.*, 2011).

CHAPTER TWO

MATERIALS AND METHODS

2. 1 Study area

This study was conducted in Sudan, Which is located in the north eastern part of Africa, with an 853 km (530 mi) coastline bordering the Red Sea. The total area of Sudan is 1,886,068 km^2 (728,215 sq mi), and it is the third largest country in the continent (after Algeria and Democratic Republic of the Congo) and the sixteenth largest country in the world. Sudan lies between latitudes 15° and 32°N.

Sudan has different ecological zones; desert, semi- desert and low rainfall wood land savanna. One third of the total land area being desert, about 40% suitable for grazing and less than one- quarter potentially arable. Livestock sector in Sudan is an important contributor to the national economy, accounting for 20% of the GDP and employing 43% of the country`s population (CBS, 2019). The total sheep population is 40,846,000 and goat population is 31,837,000 (MARF - Information Centre, 2018). The study was conducted in five states; Sinnar, Gadarif, Kassala, River Nile and White Nile.

Sinnar state is located in the South east of Sudan between Latitudes 32 and 58 North and Longitudes 35 and 42 East, with area 40,680 Km^2 and population is 1,400,000. The state shared borders with Ethiopia from the East, ElGazira and Gedarif states from North and White Nile state from the West, Blue Nile state from the south and with republic of South Sudan from the South West. It is located in the

Sudanese rain belt in the rich savannah region, and is characterized by hot rainy summers with the highest temperature in April 41°C, and the minimum temperature drops to 17°C in January. The rains begin in March to stop in November, reaching their highest in August, 172 millimeters and an annual average of 512 mm. Sinnar localities are**:** Singa, Abuhugar, Sinnar, East sinnar, Eldali & Elmazmom, Elsuki and Eldindir - Small ruminants populations in Sinnar state is 3,141,617 head.

Gadarif state is located in the East of Sudan between Latitudes 12 and 17 North and Longitudes 34, 36 with Area 75.263 Km^2 and population is 1,148,262. The state is shared borders with Kassala state and the Sudanese-Ethiopian border from the East, Sinnar state from the South and Khartoum and ElGazira states from the North West. The state is famous of its fertile soil and wide cultivated areas, and also has rich pastures like in Elbotana locality. The climate is hot and rainy in summer (rainy season June to October with average rainfall 700 _ 900 mm) and it is dry and moderate cool in winter. Localities of the state are: El Gadarif, Wasat Elgadarif, Eastern Galabat, Western Galabat, Basonda, Elgorisha, Elfashaga, Gala elnahal, Elrahad, Elfao, Elmafaza and Elbotana - Small ruminants populations in Gadarif state is 3,330,598 head.

Kassala State is located in the East of Sudan between Latitudes 15 and 45 North and Longitudes 36, 40 East with Area 42,282 Km^2 and population is 1,523,214. The state is shared borders with Eritrea from the East and South, Gadarif state from the South, River Nile and Red Sea states from the North and

Khartoum state from the West. Localities of the state are: Kassala, West Kassala, Nahr atbara, Aroma, Hamashkorib, Halfa el Jadida, Wadahelew, Khashm el Girba, Telkuk, North aldalta and Rural Kassal - Small ruminants populations in Kassala state is 3,851,475 head.

River Nile state is located in the north of Sudan between Latitudes 16 and 22 North and Longitudes 30 and 32 East, with area of 124,000 Km^2 and population is 1,300,000. The state shared borders with Egypt from the North, Red Sea and Kassala states from the East, Northern state from the West and with Khartoum state from the South. Climatic distribution of the state are: dry desert climate in north state with rainfall 0 _ 100 mm and semi_ desert with rainfall 100_ 200 mm in the south of the state and temperatures range from 47°C in the summer maximum to a minimum of 8°C in winter. Localities of the state are: Eldamar, Atbra, Barbar, Abu Hamad, Shendi, Elmatama and Elbohaira -Small ruminants populations in River Nile state is 2,333,504 head.

White Nile state is located in the South of Sudan between Latitudes 15, 47 North and Longitudes 32, 43 East with area of 39,701 Km^2 and population is 1,140,694. The state shared borders with Khartoum state from the North, Al-Gazira and Sinnar states from the East, North Kordofan state from the west and with South Kordofan state from the South. The state has predominantly arid and semi-arid, with annual rainfall ranging from 300 mm in the north to more than 600 mm in the south**.** Localities of the state are: Ad Douiem, Al Gutaina, Kosti, Al Jabalian,

Rabak, Tandalti, Om Ramata, Gali and El Salam - Small ruminants populations in White Nile state is 5,327,459 head.

2. 2 Study population

The study was conducted from April to July 2019 and population was all sheep and goats herders and owners and veterinarians in the localities of Sinnar, Gadarif, Kassala, River Nile and White Nile states. Different breeds of sheep were sampled from different production systems (nomadic, semi-nomadic, sedentary, and semi-sedentary), husbandry systems and ecological conditions. Normally, after raising, sheep and goats are usually sold in local markets and transported to secondary markets in Um-Durman, Khartoum state, where animals are finally sold and taken for meat or live exports, based on approval to be fit for export by ante-mortem and post-mortem examinations by legal authorities. Animals for meat are slaughtered at Ganawah or Kadarrow abattoirs while live animals are transported to Sawakin or Port-Sudan quarantines and then shipped to international markets.

2. 3 Sample size

Five hundred questionnaires were proposed to be filled by sheep and goats owners hundred questionnaires for each State, 100 questionnaires were proposed to be filled by veterinarians 20 questionnaires for each State. Sample size was calculated by using the following formula (Thrusfield; M. 2018):

where:

$$N = \frac{1.96^2 P_{exp} (1 - P_{exp})}{d^2}$$

N: Required sample size

1.96: z value with confidence level 95%

P_{exp}: Expected proportion of population knowing about PPR is 50 %

d^2: Desired absolute precision (0.05)

2. 4 Questionnaire for data collections and risk factors investigations

Structured questionnaires were administered and discussed, based on willingness, with owners and herders of sheep. General subject introductions and clarifications were made immediately after giving out the questionnaires and while discussing. Questions included in the questionnaire covered herd size, number of young animals, males, and females within the herd, the probable number of animals involved when outbreaks happen (morbidity and mortality rates), measures taken when introducing new animals into the herd, breed of the animals reared, mixing different species of livestock, mixing herds with each other at pasture or watering points, moving from place to place looking for water and pasture, source of income, farming system practiced, the frequency of PPR outbreaks, period(s) of the year when outbreaks occur, the source and actions to control outbreaks of PPR at local level, and general knowledge and perceptions on PPR, its clinical signs, impact on their animals, their attitude to vaccination and the effect of animal

movements on disease spread. Answers to questions were recorded by ticking pre-written choices; additional information could be supplied in extra spaces provided.

Semi-structured questionnaires further were administered, based on willingness, to veterinarians. These questionnaires addressed the occurrence of PPR outbreaks, perceptions on risk factors and characteristics of outbreaks. General subject introductions and clarifications were made immediately after distribution of the questionnaires. Questions included were ranks of the most economically important diseases and conditions of animals, basis of diagnosis and control of these ranked diseases and of PPR outbreaks, the frequency of PPR outbreaks, period(s) of the year when outbreaks occur, the most susceptible species, sex, age group, and breed to PPR, the source and actions to control outbreaks of PPR at local level, problems faced when implementing a disease control program and advices to help MARF to control animal diseases more efficiently. Answers to questions were recorded by ticking pre-written choices; additional information could be supplied in extra spaces provided. A template of the used questionnaire is shown in the annexes.

2. 5 Data management and analysis

The Statistical Package for Social Sciences (SPSS) for Windows® version 18.0 (SPSS Inc., Chicago, Illinois) was used for all appropriate statistical analysis.

Descriptive statistics of the variables were obtained. For each variable (age, sex, breed, and locations), frequencies (number of observations within variable) were also obtained.

Hypotheses of differences of age group, breed, sex, and locations between PPR outbreaks occurrence and none PPR outbreak occurrence were first tested by univariate analysis by means of the 2-tailed chi-square test. In the second step, a logistic regression model was used to assess the association between the potential risk factors sex, breed, state, and locality and the outcome PPR outbreak status. Age and potential risk factors with $p \leq 0.20$ in the univariate analysis were entered into the regression model. Associations in the logistic regression model were deemed significant when $p \leq 0.05$.

Opinions, perceptions and data collected from veterinarians and herders and owners were entered, coded and stored electronically in the Microsoft® Excel for Windows® 2007 data base as well. Uni-variable frequencies (number of observations within variable) and multiple responses were calculated. Hypothesized associations between some risk factors collected in the questionnaire survey. In the second step, as with the herd demographic data above, a logistic regression model was developed, data and results displayed in tables.

CHAPTER THREE

RESULTS

3. 1 Owners' and Herders' Questionnaire outcomes

A total number of 500 questionnaires (100 questionnaires for each state) were delivered to sheep owners and herders and discussed with them. Summary of general information is presented in table (1). All responders were males (100%; n = 500) and 51.4% (n = 257) had undergone primary school and 18 % (n = 90) uneducated, 14.6 % (n = 73) secondary school, 16 % (n = 80) graduated, and nobody had taken professional trainings. About 17.8 % (n = 89) were within the age group 15 to 29 years, 23.2 % (n = 116) within 30 - 45 years and the majority of 59.0 % (n = 295) older than 45 years. However, 20.6 % (n = 103) responders had ≤ 10 years of experience in animal business, 18 % (n = 90) had 11- 20 years of experience, 20.6% (n = 103) had 21 - 30 years of experience and 40.8% (n = 204) had > 30 years of experience.

Table (2) summarized the responses of sheep owners and herders on management and knowledge of the PPR and host range in their herds in Sinnar, Gadarif, Kassala, River Nile and White Nile states. About (17.8 %, n = 89) of the owners and herders followed the sedentary system is their animal husbandry, while (14.6 %, n = 73) followed the semi-sedentary system, the majority (67.6 %, n = 338) followed the nomadic (free range of grazing) and 82.2 % followed the migratory route, while

17.8 did not. About (84.6 %, n = 423) indicated the herd origin and (15.4 %, n = 77) did not. About 14.6 % (n = 73) kept their herds in the yard, 17.8 % (n = 89) in farms, but the majority (67.6 %) in free range of grazing (nomadic). About 20.8 % (n = 104) of the owners and herders have ≤ 1000 animals, 30.8 % (n = 154) have >1000 _ 2000 animals, 26.2 % (n = 106) have > 2000 _ 3000 animals, 26.2 % (n = 106) have > 3000 _ 4000 animals and 6% have more than 4000 animals. One hundred thirty eight (27.6 %) of the owners and herders who introduced new animals into the herd indicated that they do quarantine and vaccination first, while 72.4 % (n = 362) mixing them with the old ones. All owners and herders (100 %, n = 500) reported that the animals in herd have not identification numbers. About 74.4 % (n = 372) of the owners and herders did mix different species, while 25.6 % (n = 128) did not.

Table (1): Number and frequencies of owners' and herders' (n = 500) general information in Sinnar, Gadarif, Kassala, River Nile and White Nile states

Risk factors with level	Number	%
State		
Sinnar	100	20.0
Gadarif	100	20.0
Kassala	100	20.0
River Nile	100	20.0
White Nile	100	20.0
Locality		
Singa	50	10.0
East sinnar	50	10.0
El Gadarif	52	10.4
Elbotana	48	9.6
Kassala	47	9.4
Rural Kassala	53	10.6
Eldamar	49	9.8
Barbar	51	10.2
Tandalti	53	10.6
El Salam	47	9.4
Sex		
Male	500	100
Female	0	0
Age (years)		
15 _ 29	89	17.8
30 – 45	116	23.2
> 45	295	59.0
Educational Level		
Uneducated	90	18.0
Primary School	257	51.4
Secondary school	73	14.6
Graduate	80	16.0
Professional Training	0	0
Years of Experience		
≤ 10	103	20.6
11 – 20	90	18.0
21 – 30	103	20.6
> 30	204	40.8

Table (2): Number and frequencies of responses of sheep owners and herders (n = 500) on management and knowledge of PPR and host range in Sinnar, Gadarif, Kassala, River Nile and White Nile States

Variable with Levels	Number	%
Animal Husbandry		
Sedentary	89	17.8
Semi-sedentary	73	14.6
Nomadic (Free range of grazing)	338	67.6
Indicate the migratory route		
Indicated	411	82.2
Unindicated	89	17.8
Herd origin		
Indicated	423	84.6
Unindicated	77	15.4
Herd kept		
Yard	73	14.6
Farm	89	17.8
Nomadic (Free range or grazing)	338	67.6
Animal population		
≤1000	104	20.8
>1000 - 2000	154	30.8
>2000 - 3000	106	21.2
>3000 – 4000	106	21.2
>4000	30	6.0
Action when introducing new animals into the herd		
Quarantine and vaccination	138	27.6
Mixing them with the old ones	362	72.4
Do animals in the herd have identification numbers?		
Yes	0	0.00
No	500	100
Do you mix different species?		
Yes	372	74.4
No	128	25.6

Table (3) summarized the responses of sheep owners and herders on knowledge of PPR, source of the infection and seasonality. Concerning occurrence of PPR outbreak, 52.8 % (n = 264) answered that the last outbreak of PPRV in their flocks was in 2019, 29.6 % reported it is occurrence between 2016 and 2018, 17.6 % reported it is occurrence between 2013 and 2015, but had not occurred before 2013. Fifteen point six of the owners indicated that animals are the source of infection, 12.2% contaminated water, 10 % contaminated feeds, 20.0 % vaccination of animals, but the majority (42.2 %) suggested multiple sources. Contaminated trought were given no role. About 80% (n = 400) admitted that PPR is a disease, while 20% (n = 100) denied. In regards to seasonality and frequency of occurrence to PPR, 15 % (n = 75) perceived the rainy season as major outbreak season, 20 % (n = 100) in the cold season, while 15% (n = 75) reported it occurred in both the rainy and cold seasons of a year, but 50.0 % (n = 250) decleared no specific association with any season.

Table (3): Number and frequencies of responses of sheep owners and herders (n = 500) on knowledge of PPR, source of infection and seasonality in Sinnar, Gadarif, Kassala, River Nile and White Nile States

Variable with Levels	Number	%
Last PPR outbreak		
Before 2013	0	0
2013 to 2015	88	17.6
2016 to 2018	148	29.6
2019	264	52.8
Source of infection		
Contact with infected animals	78	15.6
Contaminated water	61	12.2
Contaminated feeds	50	10.0
Contaminated troughs	100	20.0
Vaccination	211	42.2
Can sheep or goat get PPR disease?		
Yes	408	81.6
No	92	18.4
Cause of PPR		
Disease	400	80.0
Seasonal case	100	20.0
Season of occurrence		
Rainy season	75	15.0
Cold season	100	20.0
Rainy and Cold	75	15.0
Not specifically associated	250	50.0

Table (4) summarized the responses of sheep owners and herders on affected species and the susceptibility of different age groups and sex of sheep to PPRV infection in Sinnar, Gadarif, Kassala, River Nile and White Nile states. About 9% (n = 45) perceived that sheep are the most affected species, 14% (n = 70) goats, 9% (n = 45) camels, while the majority 68% (n = 340) both sheep and goats are the most affected species. Concerning susceptible age group to PPRV, 97% (n = 485) perceived that sheep ≤ 1 year are the most susceptible age group, 1.6 % (n = 8)

sheep 1 - 2 year and 1.4% (n = 7) had no idea. In regards to sex and PPR, 4.4 % (n = 22) considered females are most susceptible to PPRV, 92.6 % (n = 463) no difference between both sexes, 3 % (n = 15) unable to identify a particular sex. No owner and herder named males to be the most susceptible sex for PPRV infection.

Table (4): Number and frequencies of responses of sheep owners and herders (n = 500) on affected species and the susceptibility of different age groups and sexes of sheep to PPRV infection in Sinnar, Gadarif, Kassala, River Nile and White Nile States

Variable with Levels	Number	%
Susceptible Species		
Sheep	45	9.0
Goat	70	14.0
Camel	45	9.0
Sheep, Goat	340	68.0
Susceptible age		
≤ 1 year	485	97.0
1-2 year	8	1.6
Do not Know	7	1.4
Susceptible sex		
Females	22	4.4
Both equally	463	92.6
Don’t know	15	3.0

Table (5) summarized responses of sheep owners and herders on the mode of transmission, symptoms and incubation period of PPRV infection in their herds in Sinnar, Gadarif, Kassala, River Nile and White Nile States. Importantly, three quarters (75.4 %, n = 377) indicated that PPR disease is transmited from animal to animal while the rest quarter (24.60 %, n = 123) refused the idea. Forty six (9%) perceived the indirect contact is the mode of PPRV transmission, but the majority

59% (n = 295) the direct contact, while 13.6 % (n= 68) both direct and indirect contact, but 18.2% (n= 91) have no idea. Loose faeces, droplet from cough or sneeze, saliva, discharge from eyes, nose and mouth were perceived to be the mode of direct transmission by 15 % (n = 75), but 15.2 % (n = 76) adopted contact with infected animals, while the majorty 42.2 % (n = 211) adopted mix of both route. In regards to indirect contact 27.6 % (n = 138) considered contaminated materials is the mode of PPRV indirect contact transmission.

Importantly, majority 78.2% (n = 391) indicated that the PPR is fatal disease, while 20.0% (n = 100) it is not fatal disease and 1.8% (n = 9) they do not know. The clinical sign loss of appetite was perceived by 3.5 % (n = 152), lacrimation by 10.6 % (n = 459), fever, depression and dullness by 1.8 % (n = 77), stomatitis by 7.4 % (n = 321), respiratory distress by 7.3 % (n = 316), Dyspnea and coughing by 6.4 % (n = 280), loss of weight, weakness and emaciation by 6.4 % (n = 280), serous or mucopurulent occulonasal discharges by 7.5 % (n = 326), erection of hair and rough coat by 5.1 % (n = 220), mucoid or blood tinged diarrhoea by 3.7 % (n = 162), low milk production by 2.7 % (n = 118), erosions in the vulva or prepuce and mucous membranes by 4.2 % (n = 181), high mortality in youngs by 4% (n = 174), high mortality in adults by 2.3 % (n = 101), high morbidity by 4 % (n = 176), abortions by 8.7 % (n = 378), breath putrid odor by 9% (n = 391) and conjunctivitis by 5.4 % (n = 236) . About 91.8 % (n = 459) stated that the incubation period of

PPRV infection is 3 to 4 days, 2.2 % (n = 11) is 8 to 13 days, while 6 % (n = 30) do not know.

Table (5): Number and frequencies of responses of sheep owners and herders (n = 500) on the mode of transmission, symptoms and incubation period of PPRV infection in Sinnar, Gadarif, Kassala, River Nile and White Nile States

Variable with Levels	Number	%
Transmit from animal to animal		
Yes	377	75.4
No	123	24.6
Mode of transmission		
Direct contact	295	59.0
In Direct contact	46	9.2
All	68	13.6
Do not know	91	18.2
Mode of direct transmission		
Saliva, discharge from eyes, nose and mouth	75	15.0
Contact with infected animals	76	15.2
All	211	42.2
Mode of indirect transmission		
Contaminated materials	138	27.6
Is PPR disease fatal?		
Yes	391	78.2
No	100	20.0
Do not know	9	1.8
Signs and symptoms		
Respiratory distress	316	7.3
Dyspnea and coughing	280	6.4
Serous or mucopurulantocculonasal discharges	326	7.5
Stomatitis	321	7.4
Mucoid or blood tinged diarrohea	162	3.7
Erosions in the vulva or prepuce and mucous membranes	181	4.2
Abortions	378	8.7
High mortality in youngs	174	4.0
High mortality in adults	101	2.3
High morbidity	176	4.0
Loss of weight, weakness and emaciation	280	6.4
Low milk production	118	2.7

Loss of appetite	152	3.5
Fever, restless and Depression	77	1.8
Erection of hair and rough coat	220	5.1
Lacrimation	459	10.6
Breath putrid odor	391	9.0
Conjunctivitis	236	5.4
Incubation period		
Immediately	0	0
3-4 days	459	91.8
8-13 days	11	2.2
Do not know	30	6.0

Table (6) showed that responses of sheep owners and herders on vaccination against PPRV and number of vaccinated animals in Sinnar, Gadarif, Kassala, River Nile and White Nile states. About 47.2% (n = 236) stated that they had positive attitude to vaccination their animals against the diseases, while 52.8% (n = 264) do positives responders to vaccination, 100% (n = 236) had vaccinated the born in herd/ brought in animals against sheep pox and PPR, 30.1 % (n = 71) had vaccinated against anthrax, while 69.9 % (n = 165) did not, 52.5 % (n = 124) had vaccinated against HS, while 47.5 % (n = 112) did not and nobody had vaccinated their animals agaist botulism. All positive responders to vaccination (n = 236) reported that they had vaccinated in the year 2019; where as 203 (86 %) vaccinated animals in the period between 2016 and 2018 but not had vaccinated before 2013 or between 2013 and 2015. Sixty eight (28.8 %) vaccinated ≤ 1000 animals, 30.1 % (n = 77) vaccinated >1000 _ 2000 animals, 18.6 % (n = 44) vaccinated > 2000 _ 3000 animals, 22.5 % (n = 53) vaccinated > 3000 _ 4000 animals, and nobody (n = 0) vaccinated more than 4000 animals.

Table (6): Number and frequencies of responses of sheep owners and herders (n = 500) on vaccination against PPRV and number of vaccinated animals in Sinnar, Gadarif, Kassala, River Nile and White Nile States

Variable with Levels	Number	%
Attitude to vaccine		
Positive	236	47.2
Negative	264	52.8
Vaccinations born in herd/ brought in		
Yes	236	47.2
No	264	52.8
Do you vaccinate against the following?		
Sheep pox		
Yes	236	100
No	0	0
PPR		
Yes	236	100
No	0	0
Anthrax		
Yes	71	30.1
No	165	69.9
HS		
Yes	124	52.5
No	112	47.5
Botilism		
Yes	0	0
No	236	100
Last Vaccination		
2016 to 2018	203	86
2019	236	100
Vaccinated animals		
≤1000	68	28.8
>1000 - 2000	71	30.1
>2000 - 3000	44	18.6
>3000 - 4000	53	22.5

Table (7) summarized the responses of sheep owners and herders on the control and prevention measures against PPRV infection in Sinnar, Gadarif, Kassala, River Nile and White Nile States. Eighty eight (17.6%) perceived the treatment as the best action after PPRV outbreaks, 4 % (n = 20) vaccination, but the majority (55 %, n = 275) perceived isolation of infected animals, while 5.6% (n = 28) did not give any opinion, but (17.8 %, n = 89) perceive all this measres were the best actions after PPRV outbreaks.

Regarding action taking to dead animal by owners and herders, 55.8 % (n = 279) left the dead animal behind, 9.6 % (n = 48) burn the dead animal, 13.2 % (n = 66) burial the dead animal and 21.4 % (n = 107) burn and burial the dead animal.

During a PPRV outbreak the owners and herders were taken some protective measures like stop moving or move away (18.4 %), preventing contact with animals and other herds (57 %) or reporting to veterinary authorities (19 %). A considerable number (5.6 %) did not take any action at all. Nobody stopped contacts with other people.

Table (7): Number and frequencies of responses of sheep owners and herders (n = 500) on the control and prevention measures against PPRV infection in Sinnar, Gadarif, Kassala, River Nile and White Nile States

Variable with Levels	Number	%
Action taking after infection		
Isolation of infected animals	275	55.0
Treatment	88	17.6
Vaccination in time	20	4.0
All	89	17.8
Don't know	28	5.6
Action taking to dead animals		
Left behind	279	55.8
Burn	48	9.6
Burial	66	13.2
Burn and Burial	107	21.4
Action when an outbreak of PPR or any other disease occurs in the next herd:		
Stop movement	92	18.4
Prevent contact with other herd or animals	285	57.0
Report to the authorities	95	19.0
Do not Take Action	28	5.6

Table 8 summarized the responses of sheep owners and herders on the potential risk factors associated with PPR infection at animal level in Sinnar, Gadarif, Kassala, River Nile and White Nile states. Regarding susceptible species the majority 68% (n = 340) noticed that both sheep and goats are the most susceptible species, 9% (n = 45) sheep, 14% (n = 70) goats while 9% (n = 45) camels. Susceptible age group as factor showed a significant association with odds ratio of 29.161 and *p*- value of .004. Ninty seven percent of the owners and herders agreed that sheep ≤ 1 year are the most susceptible age group, 1.6 % (n = 8) sheep 1 - 2 year old and 1.4% (n = 7) had no idea. Sex as a risk factor showed insignificant

association with odds ratio of 4.128 and *p*- value of .845. The majority, 92.6 % (n = 463) reported that no difference between both sexes, but 4.4 % (n = 22) considered females the most susceptible to PPR, while 3 % (n = 15) unable to identify a particular sex. Breed as a risk factor for PPR showed insignificant association with odds ratio of 4.675 and *p*- value of .792. About 88.2 % of owners and herders saied that PPRV outbreaks occurred in the local breed and 7.4 % in the imported breed and 4.4 % in the cross.

Table (8): Number and frequencies of responses of sheep owners and herders (n = 500) on the potential risk factors associated with PPR infection at animal level in Sinnar, Gadarif, Kassala, River Nile and White Nile States

Risk Factors with Levels	Number	%	Chi square value	*p*- value
Species:			29.161	.004
Sheep	45	9.0		
Goat	70	14.0		
Camel	45	9.0		
Sheep, Goat	340	68.0		
Age:			4.128	.845
≤ 1 year	485	97.0		
1-2 year	8	1.6		
Do not know	7	1.4		
Sex:			4.675	.792
Males	15	3.0		
Females	22	4.4		
Both equally	463	92.6		
Breed:			8.648	.373
Local	441	88.2		
Imported	37	7.4		
Cross	22	4.4		

Table (9) summarized the responses of sheep owners and herders on the potential risk factors associated with PPR infection at herd level in Sinnar, Gadarif, Kassala, River Nile and White Nile states. About 55.2 % (n = 276) stated that herd size is a risk factor, while 44.8% (n = 224) did not, the risk factor showed an insignificant association with odds ratio of 0.275 and *p*- value of .991. About 61.2 % (n = 306) stated that production type is a risk factor, while 38.8 % (n = 194) did not, the risk factor showed a significant association with odds ratio of 25.470 and *p*- value of .000. About 22.2 % (n = 111) stated that mixed species is a risk factor, while 77.8% (n = 389) did not, the risk factor showed an insignificant association with odds ratio of 9.426 and *p*- value of .051. About 49 % (n = 245) stated that housing is a risk factor, while 51% (n = 255) did not, the risk factor showed an insignificant association with odds ratio of 2.561 and *p*- value of .634. About 51.6 % (n = 258) stated that watering is a risk factor, while 48.4% (n = 242) did not, the risk factor showed an insignificant association with odds ratio of 4.052 and *p*- value of .399. About 24.2 % (n = 121) stated that communal dipping is a risk factor, while 75.8% (n = 379) did not, the risk factor showed an insignificant association with odds ratio of 7.240 and *p*- value of .124. About 74.8 % (n = 374) stated that migration is a risk factor, while 25.2 % (n = 126) did not, the risk factor showed a significant association with odds ratio of 9.910 and *p*- value of .042. About 50.0 % (n = 250) stated that animal movement is a risk factor, while 50.0 % (n = 250) did not, the risk factor showed a significant association with odds ratio of 122.640 and *p*- value

of .000. About 47.2 % (n = 236) stated that vaccination is a risk factor, while 52.8 % (n = 264) did not, the risk factor showed a significant association with odds ratio of 12.070 and *p*- value of .017. About 52 % (n = 260) stated that disease history is a risk factor, while 48% (n = 240) did not, the risk factor showed a significant association with odds ratio of 26.282 and *p*- value of .000.

Table (10) summarized the responses of sheep owners and herders on the potential risk factors associated with PPR infection at area level in Sinnar, Gadarif, Kassala, River Nile and White Nile states. About 84.8 % (n = 424) stated that livestock density is a risk factor, while 15.2% (n = 76) did not, the risk factor showed a significant association with odds ratio of 23.492 and *p*- value of .000. About 50.0 % (n = 250) stated that climate: temperature, rain-fall, seasons is a risk factor, while 50.0% (n = 250) did not, the risk factor showed a significant association with odds ratio of 10.560 and *p*- value of .032. Nobody of the owners and herders 100 % (n = 500) stated that elevation is a risk factor. About 79.2 % (n = 396) stated that livestock marketing system is a risk factor, while 20.8 % (n = 104) did not, the risk factor showed an insignificant association with odds ratio of 6.240 and *p*- value of .182. About 47.2 % (n = 263) stated that veterinary service provision (surveillance, control) is a risk factor, while 52.8 % (n = 264) did not, the risk factor showed a significant association with odds ratio of 12.070 and *p*- value of .017. About 3.4 % (n = 17) stated that susceptible wildlife is a risk factor, while 96.6% (n = 483) did

not, the risk factor showed a significant association with odds ratio of 70.393 and *p*- value of .000.

Table (9): Number and frequencies of responses of sheep owners and herders (n = 500) on the potential risk factors associated with PPR infection at herd level in Sinnar, Gadarif, Kassala, River Nile and White Nile States

Risk Factorswith Levels	Number	%	Chi. value	*p*- value
Herd size:			0.275	0.991
Yes	276	55.2		
No	224	44.8		
Production type:			25.470	0.000
Sedentary	306	61.2		
Semi-sedentary	194	38.8		
Mixed species:			9.426	0.051
Yes	111	22.2		
No	389	77.8		
Housing:			2.561	0.634
Yes	245	49.0		
No	255	51.0		
Watering:			4.052	0.399
Yes	258	51.6		
No	242	48.4		
Communal dipping:			7.240	0.124
Yes	121	24.2		
No	379	75.8		
Migration:			9.910	0.042
Yes	374	74.8		
No	126	25.2		
Animal movement:			122.640	0.000
Yes	250	50.0		
No	250	50.0		
Vaccinations:			12.070	0.017
Yes	236	47.2		
No	264	52.8		
Disease history:			26.282	0.000
Yes	260	52.0		
No	240	48.0		

Table (10): Number and frequencies of responses of sheep owners and herders (n = 500) on the potential risk factors associated with PPR infection at area level in Sinnar, Gadarif, Kassala, River Nile and White Nile States

Risk Factorswith Levels	Number	%	Chi. value	*p*- value
Density:			23.492	0.000
Yes	424	84.8		
No	76	15.2		
Climate: temperature, rain-fall, seasons:			10.560	0.032
Yes	250	50.0		
No	250	50.0		
Elevation:			-	-
Yes	0	0		
No	500	100.0		
Livestock marketing system:			6.240	0.182
Yes	396	79.2		
No	104	20.8		
Veterinary service provision: surveillance, control:			12.070	0.017
Yes	236	47.2		
No	264	52.8		
Susceptible wildlife:			70.393	0.000
Yes	17	3.4		
No	483	96.6		

3. 2 Veterinarians Questionnaire Outcome

A total number of 100 veterinarians were questionnaired about PPR in the five surveyed study States, only 96 veterinarians were responsed. The technical veterinary staffs were asked to provide information on the occurrence of the disease, its pattern, seasonality, economic importance, devastating effects, control strategies, management systems, vaccination, comments and advices to authorities in Sinnar, Gadarif, Kassala, River Nile and White Nile states. Summary of general information of responders veterinarians (96%) is presented in table (11).

Table (11): Number and frequency of veterinarians (n = 96) general information in Sinnar, Gadarif, Kassala, River Nile and White Nile states

Variable with Levels	Veterinarians	%
State		
Sinnar	18	18.80
Gadarif	19	19.80
Kassala	19	20.80
River Nile	20	19.80
White Nile	20	20.80
Sex		
Male	24	25.0
Female	72	75.0
Years of Experience		
≤5	25	26.0
>5 - 10	42	43.8
>10 - 15	19	19.8
>15	8	8.3
No Answer	2	2.1

Table (12) showed the responses of veterinarians on farming systems, migratory routes of nomads and the economically important animal diseases in Sinnar, Gadarif, Kassala, River Nile and White Nile states. The most practiced farming system in the study areas was nomadic and as such identified by 71.9 % of the veterinarians; 3.1 % sedentary, 15.6% semi-nomadic system and 9.4 % semi-Sedentary/ nomadic farming systems was practiced. About 36.5 % indicated the migratory route for the nomads while 63.5 % did not. Veterinarians mentioned the most economically important diseases of animals in their areas in decreasing order. PPR (36.5 %), sheep pox (24%), blood parasites (22.9%) and botulism (16.6 %). The remaining diseases and conditions took low ranks.

Table (12): Number and frequencies of responses of veterinarians (n = 96) on farming systems, migratory routes of nomads and the economically important animal diseases in Sinnar, Gadarif, Kassala, River Nile and White Nile states

Variable with Levels	Veterinarians	%
Farming system		
Sedentary	3	3.1
Nomadic (Free range of grazing)	69	71.9
Semi-Nomadic	15	15.6
Semi-Sedentary/ Nomadic	9	9.4
Migratory route		
Indicated	35	36.5
Not indicated	61	63.5
Economically important animal diseases		
PPR	35	36.5
Sheep pox	23	24
Blood parasites	22	22.9
Botulism	16	16.6

Table (13) showed the responses of veterinarians on the last occurrence of PPR and its pattern, seasonality and sources of PPRV outbreaks in Sinnar, Gadarif, Kassala, River Nile and White Nile states. Concerning occurrence of PPR, 55.2% (n = 53) of the veterinarians mentioned that the last outbreak of PPR in their localities was in 2019, 14.6 % reported it is occurrence between 2016 and 2018, 14.6 % reported the occurrence between 2013 and 2015, 10.4 % reported it is occurrence before 2013 and 5.2 % not sure. As far as seasonality and pattern of occurrence of PPR, 68.8 % of the veterinarians reported that outbreaks were not specifically associated with seasons, 21.9 % of them linked outbreaks with the cold season, but 6.2 % noticed the disease occurrence in hot season. Only 3.1 % of veterinarians had no respective opinion. When an outbreak of PPR occurs, 54.2 % of the veterinarians suggested that communal points like watering points and pasture are the sources of the disese, 31.2% moving animals and 14.6 % introduction of new animal(s) into flocks. Wild animals were given no role at all.

Table (14) summarized the responses of veterinarians on the most susceptible species, susceptible breed, most susceptible age group and sex to PPRV infection in Sinnar, Gadarif, Kassala, River Nile and White Nile states. The majority of veterinarians (81.2 %) suggested that sheep as most susceptible species, but 18.8% goats. Regarding breeds, most of veterinarians (54.2%) suggested that Kawahla breed is the most susceptible breed to PPR, Baladi breed was suggested by 24%, Hamari breed was suggested by 10.4 % as most susceptible, and 15.6% mentioned

crosses of local breeds. All sheep breeds equally susceptible to PPR were suggested by 7.3 and 2.1% had no opinion on sheep breed susceptibility.

Animals within the age group ≤ 1 year were perceived by 60.4 % as most susceptible to PPRV, 14.6 % suggested the age between 1 and 2 years old. About 24 % perceived there was no difference between age groups in regards to susceptibility to PPRV, and 1% were not sure. By far the majority of veterinarians (78.1 %) reported males and females are equally susceptible to PPR, but 15.6 % reported females as most susceptible, 6.3 % were unsure, but none of the veterinarians mentioned males as the most susceptible to PPRV.

Table (13): Number and frequencies of responses of veterinarians (n = 96) on the last occurrence of PPR, seasonality and sources of PPRV outbreaks in Sinnar, Gadarif, Kassala, River Nile and White Nile states

Risk Factors with Levels	Number	%
Last Outbreak of PPR		
Before 2013	10	10.4
From 2013 to 2015	14	14.6
From 2016 to 2018	14	14.6
2019	53	55.2
Not Sure	5	5.2
Season of Outbreaks		
Cold season	21	21.9
Hot season	6	6.2
Not associated	66	68.8
No Answer	3	3.1
Source of PPR outbreaks		
Introduction of new animal(s)	14	14.6
Contact at communal points	52	54.2
Movement of animal(s)	30	31.2

Table (14): Number and frequencies of responses of veterinarians (n = 96) on susceptible species, susceptiblebreed, susceptible age group and sex to PPRV infection in Sinnar, Gadarif, Kassala, River Nile and White Nile states

Risk Factorswith Levels	Number	%
Susceptible Species		
Sheep	78	81.2
Goats	18	18.8
Susceptible Breed		
Kawahla	39	40.6
Baladi	23	24.0
Hamari	10	10.4
Crosses of local breeds	15	15.6
No difference	7	7.3
No Answer	2	2.10
Susceptible Age Group (years)		
≤1	58	60.4
>1 - 2	14	14.6
No difference	23	24.0
No Answer	1	1.0
Susceptible Sex		
Females	15	15.6
Equally Susceptible	75	78.1
Not Sure	6	6.3

Table (15) showed major clinical signs of PPR seen frequently by veterinarians in Sinnar, Gadarif, Kassala, River Nile and White Nile states. In descending order, the major clinical signs reported for the study states were: mucoid or bloody tinged diarrhoea (19.8 %), mucopurulent occulonasal discharges (16.7 %), respiratory distress (14.6 %), stomatitis (13.5%), high morbidity (10.4 %), high mortality in young animals (8.3 %), loss of milk production (4.1%), loss of weight, weakness and emaciation perceived (3.1 %), dyspnea and coughing (3.1 %), abortion (2.1 %), erosions in the vulva or prepuce (2.1%) and lacrimation (1.1 %).

Table (15): Number and frequencies of responses of veterinarians (n = 96) on the major clinical signs of PPRV infection seen frequently in Sinnar, Gadarif, Kassala, River Nile and White Nile states

Clinical Signs of PPR	Number	%
Respiratory distress	14	14.60
Dyspnea and coughing	3	3.10
Occulonasal discharges	16	16.70
Stomatitis	13	13.50
Mucoid or bloody diarrhoea	19	19.80
Erosions in the vulva/prepuce	2	2.10
High morbidity	10	10.40
High mortality in young	8	8.30
High mortality in adults	0	0.00
Abortion	2	2.10
Weakness and emaciation	3	3.10
Loss of milk production	4	4.10
Lacrimation	1	1.10
No answer	1	1.10

Table (16) showed veterinarians responses to questions on routine diagnosis, control practices and measures taken and vaccination for the ranked diseases. Both clinical and laboratory diagnoses were perceived to be the routine practices of diagnosis for the ranked diseases by 63.5 % (n = 61) of the veterinarians, while just clinical diagnosis 34.4% and 2.1 % did not give an answer. No veterinarian saw any value in laboratory diagnosis alone as a routine practice. Treatment was emphasized by 29.2% as primary measure to be taken against the ranked diseases when diagnosed, vaccination used by 21.9 %; but only 5.2 % suggested isolation and quarantine as useful routine practice, while the majority (43.7 %) suggested all this choices is the routine protocol for PPR control. In regards to vaccination

schemes in the states, their opinion of vaccination of animals was prcticeed for PPR (36.5 %), sheep pox (39.6 %), HS (12.5 %), anthrax (8.3%) and botulism (3.1 %).

Table (16): Number and frequencies of responses of veterinarians (n = 96) on routine diagnosis, control practices and control measures taken and vaccination for the ranked diseases in Sinnar, Gadarif, Kassala, River Nile and White Nile states

Variable with Levels	Number	%
Diagnosis of ranked diseases		
Clinical	33	34.4
Laboratory	0	0
Both	61	63.5
No Answer	2	2.1
Control of ranked diseases		
Treatment	28	29.2
Vaccination	21	21.9
Quarantine/ Isolation	5	5.2
All	42	43.7
Vaccination against ranked diseases		
PPR	35	36.5
SPP	38	39.6
HS	12	12.5
Anthrax	8	8.3
Botulism	3	3.1

Table (17) showed responses of veterinarians on the diagnosis, control measures taken against PPRV and quarantine period practiced in Sinnar, Gadarif, Kassala, River Nile and White Nile states. For the diagnosis of PPRV, clinical diagnosis was perceived to be the routine practice of diagnosis for PPRV by 27.1 % (n = 26), while both clinical and laboratory diagnoses were perceived by 64.6 % (n = 62). Laboratory diagnosis alone was perceived as a routine practice by 7.3 % (n = 7),

and 1 % (n = 1) did not give an answer. But for its control, treatment was perceived by 30.2 % (n = 29), vaccination 50 % (n = 48), isolation and quarantine 6.3 % (n = 6); public education 13.5 % (n = 13). About 78.1 % reported that in case of PPR no quarantine was practiced in their localities. Only 4 veterinarians reported a possible quarantine for 3 weeks and 2 veterinarians reported a possible quarantine for 1 month. Fivteen point six percent of veterinarians could not develop an opinion on quarantine; they failed to give any answer.

Table (17): Number and frequencies of responses of veterinarians (n = 96) on diagnosis, control measures taken against PPRV and quarantine period practiced in Sinnar, Gadarif, Kassala, River Nile and White Nile states

Risk Factors with Levels	Number	%
Diagnosis of PPR		
Clinical	26	27.1
Laboratory	7	7.3
Both	62	64.6
No Answer	1	1.0
Control measures for PPR		
Treatment	29	30.2
Isolation/Quarantine	6	6.3
Vaccination	48	50.0
Public Education	13	13.5
Quarantine period		
3 weeks	4	4.2
1month	2	2.1
Not practiced	75	78.1
No Answer	15	15.6

Table (18) summarized responses of veterinarians on vaccination period, last vaccination against PPRV, number of vaccinated animals and vaccine protectivty in Sinnar, Gadarif, Kassala, River Nile and White Nile states. In regards to

vaccination period, 53.1% (n = 51) stated that they had PPR vaccination in their flocks every year, while 46.9%, stated that they vaccinated their flocks only in response to outbreaks. About 65.6 % stated that the last vaccination against PPRV in different localities had occurred in 2019, 15.6 % between 2016 to 2018; 11.5% between 2013 to 2015, but 7.3% failed to give an answer. About 9.4 % thought that the number of vaccinated animals was ≤ 1000 animals, 17.7 % >1000 _ 2000 animals, 8.3 % > 4000, while 50% not sure about the number of vaccinated animals and 14.6% have no answer to give. Half of veterinarians (50 %) found that the PPR vaccine is protective, while 29.2 % has no protectivity, although 17.7% found the PPR vaccine is protective to some extend and 3.1% did not know.

Table (19) summeized the opinions of veterinarians on problems facing disease control programs including controlling PPR in Sinnar, Gadarif, Kassala, River Nile and White Nile states. Ignorance of animal owners, not wanting to vaccinate and not being aware of the vaccine benefits was seen as the major problem (18.3%). Uncontrolled use of drugs by the owners/ herders of animals (12.6%), continuous uncontrolled movement of sheep and other animals from and into the study areas (12.6%), logistical and regulatory issues like problems such as insufficient vaccine supplies (3.7%) and the fact that vaccination certificates were not issued sometimes and usually owners do not keep them (10.2%) are further problems adds to unimplement meaningful control programmes. Owners/herders do often report outbreaks to the veterinary authorities too late (7.3%). Difficulty of diagnosis was

perceived as a problem by 8.1% of the veterinarians. Compared to these major problems, improper vaccine preparation and dosage (2.0%), large number of animals to be vaccinated (4.5%) and the inefficient recording system (2.0%) each are seen as relatively minor problems. No problems basically arise from insufficient cold chains and vaccine storage problems (2.8%). But 4.5 % of veterinarians did prefer not to answer these questions.

Table (18): Number and frequencies of responses of veterinarians (n = 96) on vaccination period, last vaccination against PPRV, number of vaccinated animals and vaccine protectivty in Sinnar, Gadarif, Kassala, River Nile and White Nile states

Risk Factorswith Levels	Number	%
Vaccination period		
Every year	51	53.1
Only in response to outbreaks	45	46.9
Last Vaccination		
From 2013 to 2015	11	11.5
From 2016 to 2018	15	15.6
2019	63	65.6
No Answer	7	7.30
Number Vaccinated		
≤1000	9	9.40
>1000 - 2000	17	17.7
>4000	8	8.30
Not Sure	48	50.0
No Answer	14	14.6
Vaccine protectivity		
Yes	48	50.0
No	28	29.2
To some extend	17	17.7
Don't know	3	3.10

Table (19): Number and frequencies of veterinarians (n = 96) on problems facing disease control programs including controlling PPR in Sinnar, Gadarif, Kassala, River Nile and White Nile states

Problems Faced	Number	%
Difficulty of Diagnosis	20	8.1
Insufficient Logistics	28	11.4
Lack of Desire to Vaccinate	45	18.3
Vaccine Storage Problems	7	2.8
Insufficient Vaccine Supply	9	3.7
Improper Preparation and Dosage of Vaccines	5	2.0
Uncontrolled Movement	31	12.6
Uncontrolled use of Drugs	31	12.6
Huge Number of Animals Issuing	11	4.5
VaccinationCertificates	25	10.2
Late Reporting of Outbreaks	18	7.3
Inefficient Recording System	5	2.0
No Answer	11	4.5

Table (20) summerized veterinarians comments, advises, additional information they desire to find response from the MARF/Public/Policy makers concerning control of PPR in their localities. Making vaccines available and enforcing routine vaccination by law were given the highest priority (27.2%), followed by the need to reduce contact of animals and regulate the animal movements from and to different areas by law 16.7 % and promotion of extension and public education (12.5%) equally with provide more logistics (12.5%). Training, including that of para _ vets was recommended by 9.2 % and construction of equipped laboratories recommended by (7.5 %). About (6.3%) reported the needs to proper reporting systems; establish check points, intensive follow up. About (3.0%) recommended to make cold chains available and (1.3%) seen a need to improve pastures and

water supply. The quality of vaccines was given good marks. Only 0.4 % of veterinarians reported the needs to improve the preparation of vaccines. Whereas 14 (3.4 %) of veterinarians had no advice.

Table (20): Number and frequencies of veterinarians (n = 96) comments, advises, additional information to MARF/ Public/ Policy makers concerning control of PPR in Sinnar, Gadarif, Kassala, River Nile and White Nile states

Advices	Number	%
Construct equipped labs	18	7.5
Availability of Vaccines and Enforce Vaccination by Law	65	27.0
Promote Extension	30	12.4
Regulate Movements by Law	41	17.0
Proper Reporting Systems	15	6.2
Make Logistic Available	30	12.4
Make Cold Chain Available	7	2.9
Training including Para-Vets	22	9.1
Improve on Pastures and Water	4	1.7
Good Preparation of Vaccines	1	0.4
Nothing to say	8	3.3

CHAPTER FOUR

DISCUSSION

The results of the present study have increased knowledge on the epidemiology of PPRV in sheep in Sinnar, Gadarif, Kassala, River Nile and White Nile states of the Sudan, by using questionnaires and personal interview. It showed that the knowledge and perceptions of PPRV was considerably high in the five studied states. While many studies have been conducted on PPR in the Sudan, only few, if any at all, did include investigations on potential risk factors contributing to the occurrence and spread of PPRV amid small ruminants populations. Very few studies also included knowledge and perceptions which sheep owners and herders have on PPR. In total, knowledge on these aspects of PPR in the Sudan is still fragmentary and far from being complete; it might be entirely lacking in most parts of the country. Therefore, this study was conducted to investigate potential risk factors associated with the occurrence of PPRV, and to study the knowledge and perceptions of sheep herders and owners on PPRV infection in the Sinnar, Gadarif, Kassala, River Nile and White Nile states.

Traditional owners and herders are said to have animmense and good practical knowledge, experience, and understanding in their farming fields and businesses. This knowledge is very helpful when information about susceptibilities of breeds, age groups and sexes to a certain disease of interest or where information

on disease patterns in different production systems, communities and value chains, treatments and local control strategies is needed (Tun 2007; Shuaib, 2011). The amount of peoples' knowledge on a particular farming sector is usually related to the kind of their economic activity. Community knowledge related to animal health has been termed existing veterinary knowledge or indigenous ethno-veterinary medicine (Tun 2007; Shuaib, 2011). Over the last few decades, the gathering of existing veterinary knowledge or indigenous ethno-veterinary medicine through surveys has become an important method to identify animal health problems within communities (Tun, 2007, Shuaib, 2011).

However, existing veterinary knowledge or indigenous ethno-veterinary medicine can be further used to design better animal health projects and programs, to improve surveillance, to establish more efficient reporting systems, and to foster control and management strategies (Tun 2007: Shuaib, 2011).

The results of the questionnaires administered to owners and herders showed that all responders were males and the majority of them were uneducated. Therefore, avoiding vaccination, taking no actions when diseases of animals, including PPR, break out and practicing communal grazing and watering could be related to their poor educational status.

The majority of the owners and herders did perceive contact with infected animals, contact of animals at communal points like watering points and pastures as the essential source of PPR outbreaks. This observation could be related to the fact

that substantial amounts of PPRV are found in the secretions and excretion of infected animals (Chauhan *et al.,* 2009; Abu bakar *et al.,* 2011) and hence pastures and water sources are heavily contaminated. Susceptible animals pick up the virus there and become infected. Surprisingly, a considerable number of the owners and herders did perceive vaccination is the essential source of PPR outbreaks that explain their unwillingness to vaccinate their animals and their avoiding communicating with the veterinary authorities. On the other hand the majority of them saw mix of these reasons as likely sourceof PPR outbreaks.

The owners and herders were well known that PPR is a fatal disease affected sheep and goats and not just result of seasonal case. The majority of the owners and herders perceived that outbreaks were not specifically associated with season. This is in disagreement with the reports of Abubakar *et al.* (2011), and Sarker and Hemayeatul (2011) and agrees with Shuaib (2011). On the other hand, the majority reported that last PPR outbreaks occur in 2019 and it occurred annually. If so, this annual occurrence of PPR in most of the herds would suggest that PPR has taken an endemic pattern of occurrence or has reached the endemic stability state. Observations of Banyard *et al.* (2010) also point in this direction; they state that PPR is endemic across the majority of East Africa countries.

Concerning sheep age groups, the majority of owners and herders perceived animals ≤ 1 year to be the most susceptible age group to PPRV. This result would confirm findings of most studies carried out on PPRV, like that of El-Rasih (1992),

Saliki *et al.* (1993), Srinivas and Gopal (1996), Abubakar *et al.* (2011) and Shuaib (2011), who all did confirm a distinction in the susceptibility and the level of antibodies to PPRV in different age groups.

It is well possible that this reflects the experience most owners and herders claimed to have had with PPR outbreaks. In the investigation of Wifag (2009) on herders' perception of disease, 7%, 20.9% and 11.6% selected adults, youngs and youngs as well as adults as most susceptible age groups, respectively. Ozkul *et al.* (2002); Singh *et al.* (2004) and Abd El-Rahim *et al.* (2010) indicated that young animals, both sheep and goats, after losing maternal immunity become at higher risk than adults and have better chance to become affected by PPR. Therefore, the higher the number of young animals is in herds, the more do sources of PPRV exist.

The majority of the owners and herders perceived both sexes (males and females) to be equally susceptible to PPR. Obviously both sexes are seen as subject to the same risk and source of virus at e.g. communal points, this agrees with Shuaib (2011) although Sarker and Hemayeatul (2011) came to a different conclusion.

The majority of the owners and herders perceived the frequent animal-to-animal transmission this agrees with finding of (Abubakar *et al.,* 2011). Direct contact happening on pastures and at watering points with secretions and excretions of infected animals was scored highest by owners and herders. The survival period

of the virus is an issue in this context, as PPRV might live longer in drinking water, considering its survival at 60˚C for 60 seconds and its stability between pH 4.0 and pH 10.0, as reported by OIE (2008). Indirect transmission was perceived by considerable number of owners and herders, although close contact is the most important way of transmitting the disease, it is suspected that contaminated materials can also turning them into additional sources of infection this is in disagreement with (Gopilo, 2005; Abubakar *et al.,* 2011) who found that indirect transmission seems to be unlikely in view of the low resistance of the virus in the environment and its sensitivity to lipid solvents.

The majority of the owners and herders indicated that they were known the clinical symptoms of PPRV infection. Wifag (2009) found that only about 50% of owners and herders knew some clinical symptoms of PPRV infection, while the other half were unaware of the major clinical symptoms. This disagreement could be related to the dissimilarity of the number of questionnaires admitted to the owners and herders. In this study, owners and herders indicated they were known the following clinical symptoms of PPRV infection: respiratory distress, dyspnea and coughing, Serous or mucopurulant occulonasal discharges, stomatitis, mucoid or blood tinged diarrohea, erosions in the vulva or prepuce and mucous membranes, abortions, high mortality in young, high mortality in adults, high morbidity, loss of weight, weakness and emaciation, low milk production, loss of

appetite fever, restless and depression, erection of hair and rough coat, lacrimation, breath putrid odor and conjunctivitis.

More than half of the owners and herders who have had experience of PPR outbreaks in their flocks stated that the incubation period is 3 to 4 days after natural infection of the virus, this is agrees with finding of (Roeder and Obi, 1999; Diallo, 2000; DEFRA, 2001; Diallo, 2004).

More than half of the owners and herders answered that they had not vaccinated their animals against PPRV. The majority of owners and herders have negative attitude to vaccination and do reject vaccination because they think that vaccination causes the disease rather than protecting their animals against it and this rejection extend to not vaccinate the born in herd/ brought in animals. It also is possible that a considerable number of owners and herders does not vaccinate because they have to pay vaccination fees sometimes. Wifag (2009) and Shuaib (2011) also reported only one-third of owners and herders vaccinating against PRRV.

More than half of the owners and herders who vaccinated their animals did so in the year 2019, rather than in previous years. The number of vaccinated animals is very small. It is obvious that this low number of vaccinated animals against PPRV in the Sudan will not lead to effective containment and control of PPRV due to the fact that the Sudan has millions of susceptible host animals. Vaccination campaigns further on are not well organized since they have been

established in 2002 (Intisar *et al.,* 2009). The educational status of the owners and herders, their unawareness of the benefits of vaccination and the fees of vaccination could all be probable explanations why only very small numbers of animals are vaccinated. Also, vaccine availability plays an essential role. More than half of the owners and herders who had not vaccinated their animals before indicated that vaccine was unavailable.

During a PPR outbreak, owners and herders take some protective measures like stop moving, preventing contact with other herd or animals, reporting to veterinary authorities. Others though do not take any action. Local disease control measures, if implemented, could be a valuable result of the long experience owners and herders have with many infectious animal diseases. FAO (1999); Saliki (2010); Abubakar *et al.* (2011) and Baron *et al.* (2011) confirm the existence of such local measures. Moreover, Al-Majali (2008) reported that visiting the live animal market is seen as a risk factor for PPRV transmission. The same might be true for visiting herds at pasture. As some of the owners and herders were known this fact, they do prevent people from visiting their herds and take some control measures such like isolation of infected animals, treatment, vaccination and burn and burial the dead animals after infection. Other owners/herders are less serious: they have very little knowledge of PPR and neglect its devastating effects, in consequence, do not take any action when PPR breaks out in their area and left the dead animals behind and are not impacted by positive actions of owners and herders who have had negative

experience with PPR. Those who do not take positive action may do so because the disease had never occurred in their herd. The majority of the owners and herders who had experience with PPR though stated that it had occurred during the last 5 years, indicating that the disease has been circulating recently.

The majority of veterinarians confirm that they are confronted with a traditional nomadic system. Scarce feed and water are the determining factors of this system. The majority of owners and herders move freely from one place to another looking for pasture and water for their animals. This system did also prevail in the investigations of Wifag (2009) and Shuaib (2011). Surprisingly then is the fact that almost all veterinarians were unable to identify the migratory route(s) of the nomads. In absence of movement regulations and laws, this area is of no concern to the veterinary services, Shuaib (2011) agrees with this.

For occurrence of PPR, the majority of the interviewed veterinarians reported that the last outbreak of PPR in their locality was in 2019. This confirmation of outbreaks in 2019 supports the idea that PPR has recently been circulating in the surveyed localities. The widely practiced communal grazing and watering by almost all owners and herders, resulting in healthy animals coming in contact with infected ones specially when introduce new animals to the herd, supports this hypothesis. Free movement of animals from one place to another also plays a significant role in disseminating the disease, in addition to the huge number of susceptible animals existing in the Sudan. Moreover, lack of knowledge by owners

and herders how PPRV is being transmitted could be another reason, in addition to the very small number of vaccinated animals (AHEDC, 2019). Al-Majali (2008) and Wifag (2009) support these underlying facilitating factors from their investigations. Furthermore, the same explanations can apply to the seasonality or the pattern of occurrence of PPR, again supported by the expertise of the majority of veterinarians who did not associate PPR outbreaks with any particular season. Abubakar *et al.* (2011) and Sarker and Hemayeatul (2011) and Shuaib (2011) in principle come to the same conclusion of a non-seasonality of PPR. When outbreaks of PPRV occur, veterinarians saw the likely sources were contact at communal points like watering points and pasture, movement of animal(s) and introduction of new animal(s).

The majority of veterinarians also confirm that sheep are more susceptible to PPRV than goats. Further to a particular effect of the species itself, variation in the husbandry and production systems of sheep and goats in the Sudan make differences in disease occurrence in both species likely. Sheep flocks are, in most parts of the Sudan, kept away from home for grazing and watering, while goats are raised at home and do graze not very far from home. In addition, goat flocks always consist of a smaller number of animals in comparison to sheep herds this agreed with findings of Shuaib (2011). Abubakar *et al.* (2009) do not support the effects of husbandry and herd size they emphasize the species variation in the susceptibility

to PPRV infection and indicate that PPR is more severe in goats than sheep, based on serological investigations and clinical observations.

Kawahla breed was perceived by the majority of the veterinarians in regards to susceptibility to PPRV. This finding is in disagreement with Shuaib (2011) who found that no difference between animal breeds and suggested that PPR has taken an endemic course of occurrence in the Sudan; this would result in very little difference in the susceptibility of different breeds. While Abu bakar *et al.* (2011) emphasize that PPR is significantly associated with breeds, where by prevalence in indigenous breeds of Bengali goats is higher than in exotic breeds of goats; also, the Guinean breeds are recognized as being highly susceptible (Abu bakar *et al.*, 2011).

Most veterinarians consider the age group ≤ 1 year as most susceptible to PPRV. An explanation can be sought in the immunity of different age groups. Older animals are probably been exposed to PPRV many times and as result they develop immunity against severe infection and vaccination of new born animals against PPRV is not practiced. The reverse may be true for younger animals after losing their maternal immunity. This agrees with reports of Saliki *et al.* (1993), Srinivas and Gopal (1996), Ozkul *et al.*(2002), Singh *et al.*(2004), Waret-Szkuta *et al.* (2008) and Abd El-Rahim *et al.* (2010).

Most veterinarians consider both males and females equally susceptible to PPRV, which seen to be subjected to the same risk and source of PPRV,

contradicting reports of Waret-Szkuta *et al.* (2008), Abubakar *et al.* (2011) and Sarker and Hemayeatul (2011) and Shuaib (2011).

The major clinical signs of PPRV infection seen frequently by veterinarians in the study states were mucoid or bloody tinged diarrhoea, mucopurulant occulonasal discharges, respiratory distress, stomatitis, high morbidity, high mortality in young animals, loss of milk production, loss of weight, weakness and emaciation perceived, dyspnea and coughing, abortion, erosions in the vulva or prepuce and lacrimation. This wide spectrum of clinical signs almost copies compiled lists of signs in veterinary textbooks (Radostits *et al.*, 2007).

For the diagnosis of ranked diseases, particularly PPR, the minority of veterinarians saw clinical diagnosis as sufficient for routine practice. The majority underlined the necessity of both clinical and laboratory diagnoses. In absence of a functioning laboratory within reach, most of the outbreaks or cases of the ranked diseases and PPR consequently are not diagnosed in the correct way. Shuaib (2011) also found that samples have to be sent to the Soba Veterinary Research Institute for confirmation of the tentative diagnosis. However, Wifag (2009) reported that the available vehicles and other facilities identified in her study are principally suitable for an on-going control program against epidemic diseases in the White Nile state. However, running budgets are insufficient to maintain this infrastructure (Wifag, 2009).

Treatment, isolation and quarantine, public education and vaccination were perceived by many of the veterinarians as necessary measures against the ranked diseases. However, chemotherapy and vaccination are the easiest measures to be taken against animal diseases in the Sudan and most of the ranked diseases are seen as being most effectively addressed by using drugs (chemotherapy) Shuaib (2011). Even for those diseases which cannot be treated by drugs, drugs can be used prophylactically or curatively for secondary infections; overall, the severity of diseases and resultant economic losses can be reduced. Most veterinarians were reported that they vaccinated against ranked diseases, needed vaccines are produced locally for many of the ranked diseases like PPR, sheep pox, HS, and Anthrax, with the exception of vaccine against Botulism which has to be imported. On the other hand, veterinarians ranked PPR as most economically important disease, followed by sheep pox and blood parasites. This is in agreement with the findings of ILRI (2009), where PPR was ranked as number 1 important sheep disease in the Eastern region, while information about its ranking in Western region was not available. For sheep pox rank the result also is in agreement with the findings of ILRI (2009), where sheep pox was ranked number 1 important sheep disease in Western region, while information about its ranking in the Eastern region was not available. PPR and SPP being ranked as most important sheep diseases without doubt reflects their alarming picture in the Sudan and their coverage of almost all states.

The majority of the veterinarians answering the questionnaire reported that quarantine is not practiced in the Sudan. This finding can be related to lack of laws and legislations, the vast areas of the Sudan and having no specific routes for animal movements. Shortage of technical staff is another problem even if check points are established. FAO (1999), Abubakar *et al.* (2011) and Baron *et al.* (2011) nevertheless point to the fact that control of PPR outbreaks can at least be essentially supported by movement control and quarantine.

Majority of veterinarians stated that they had PPR vaccination in their flocks every year as routine for vaccination period, while the rest of them stated that they vaccinated their flocks only in response to outbreaks.

The last vaccination against PPR in the surveyed localities was perceived by almost all veterinarians to have been in 2019. Larger scale frank outbreaks of PPR in all likelihood occurred just a short time ago. On the other hand, the number of vaccinated animals (> 4000) from the questionnaire survey is very small. AHEDC (2019) also reported only a small number of vaccinated animals (1,656,000 Head) comparing with actual animal population in the studied states. Ignorance of owners and herders to vaccinate their animals, vaccination fees, and also vaccine shortage all will have contributed to this unsatisfactory vaccination coverage, reported also for another state in the Sudan in previous years (Wifag, 2009). Surprisingly, only half of veterinarians believe on PPR vaccine productivity, while the rest of them

were not saw this productivity or found the PPR vaccine is productive to some extend, this could be due to lack of vaccination campaigns in their localities.

Veterinarians face a multitude of frustrating problems and drawbacks when they attempt to apply a disease control program. Questionnaire results list these drawbacks as ranging from difficulty of diagnosis, insufficient logistics, owners' unwillingness to vaccinate animals due to their unawareness of vaccination benefits, insufficient cold chains and vaccine storage problems, insufficient vaccine supply, improper vaccine preparation and dosage, uncontrolled movement of sheep and other animals from and into areas, uncontrolled use of drugs, huge number of animals to be vaccinated, vaccination certificates not being issued sometimes and owners not keeping them, late reporting of outbreaks to veterinary authorities and the inefficient recording system.

Some solutions to the problems were suggested by the veterinarians to improve the quality of veterinary services in the study states and in the Sudan. Suggestions range from constructing well equipped laboratories, making vaccines available and enforcing routine vaccination by law, promotion of extension and public education, reduction of contact of animals and regulation of movements to and from areas by law, intensive follow ups and proper reporting systems, making logistics available, making cold chains available, training, including the para_vets, improvements of pastures and water supply and better preparation of vaccines. The biggest problem seems to be that the veterinary services are not well connected

with the animal keeping communities and that communication between them is only fragmentary, Shuaib (2011) agrees with this.

Few studies in the Sudan have addressed risk factors associated with PPRV outbreaks (Al-Majali *et al.*, 2008); Shuaib, 2011; Huyam, (2014)). In the current study, univariate analysis using chi square, with a confidence interval of 95% and at a *p*-value of ≤ 0.05 was used to identify potential risk factors associated with PPRV infection.

At the individual animal level, species and having a PPR infection was significant in the univariate analysis with odds ratio of 29.161 and *p*- value of .004; it is in agreement with findings of Abd El-Rahim *et al.* (2010) and Abubakar *et al.* (2009) who found that goats is more susceptible to have PPR infection than sheep and Saeed *et al.* (2010) and Gopilo (2005) found that sheep is more susceptible to have PPR infection than goats.

Age and having a PPR infection were insignificant in the univariate analysis with odds ratio of 4.128 and *p*- value of .845; it is in disagreement with findings of Waret-Szkuta *et al.* (2008); Al-Majali *et al.* (2008); Banyard *et al.* (2010); Abubakar *et al.* (2011) and Shuaib (2011). The insignificant association of age with PPRV infection indicates that antibodies occur in all age groups and that the virus also is in constant circulation in sheep of all ages. This can be elucidated by the fact that animals of the most vulnerable age group (lambs) do die as soon as they contract the virus and only those animals with some resistance do survive. This

disagreement with Ozkul *et al.* (2002), Singh *et al.* (2004), Waret-Szkuta *et al.* (2008), Abd El-Rahim *et al.* (2010) and Shuaib (2011), who found such age dependencies.

In the combination of factors, no significant association between being PPR affected and sex was established with odds ratio of 4.675 and *p*- value of .792, this is in agreement with result of Sarker and Hemayeatul (2011), found that no difference between sexes. However, it is disagreement with results of Shuaib (2011) and Abdalla *et al* (2012), who found female more affected with PPR, considered that females are subject to more stressing factors like pregnancy and lactation; in addition, the productive life span of females is longer than that of males in addition to higher number of females in herds in comparison to males. But it disagree with Sarker and Islam (2011) who stated according to his results, that males are more affected may be due to genetic factors.

When individual risk factors are combined, associations between breeds and being PPR affected no longer exist with odds ratio of 8.648 and *p*- value of .373. Gopilo (2005) also found no association of PPR status and breeds, while in contrast, results of Abu bakar *et al.* (2011) shows that some breeds have resistance to PPRV infection.

At the herd level, the insignificant association of herd size to being PPRV affected with odds ratio of 0.275and *p*- value of .991 could be due to the fact that all owners and herders, with small or large numbers of animals, do practice

communal grazing and/or watering; therefore, all animals at these times are at similar risk to be infected with PPRV by coming in contact with infected animals.

There was a significant association between being PPR affected and the production system with odds ratio of 25.470 and *p*- value of .000. The animals owned by nomadic pastoralists were at high risk for PPR comparing to the other systems. This could be due to vulnerability of small ruminant herds in pastoralists and open grazing systems to infected herds in pastures and water points, these herds could be from other Sudan states or from a neighboring countries, in particular in state at borders like Sinnar and Gadarif, the same observation was mentioned by Kihu *et al* (2010), Huyam, (2014).

No significant association between being PPRV affected and where herds get mixed with mixed species could be established with odds ratio of 9.426 and *p*-value of .051, this agrees with Shuaib, (2011). This could be related to the fact that PPR is transmitted from infected animals to susceptible ones by contact, whether the contact happens at watering points, pastures or at both.

The analysis further showed that there was insignificant association between housing categories and PPR occurrence with odds ratio of 2.561 and *p*- value of .634; this is in disagreement with Shuaib, (2011) and Huyam, (2014) who found that housing categories have association with PPR occurrence, where animals in free grazing system were more affected followed by animals in semi_sedentary system and the low occurrence in animals kept sedentary system.

The analysis further showed that there was insignificant association between being PPR affected and water and communal dipping. This finding is in disagreement with results of Shuaib (2011) and Salih *et al.* (2014), who found increase the probability of spreading PPR through the common pastures and water sources.

The analysis further showed that there was a significant association between being PPR affected and the animal movement and migration. Stress of animal from movement, coupled with low environmental temperature, and bolstered by humidity and nutritional deficiency may contribute to the occurrence of PPR disease (Abd El-Rahim *et al.,* 2010).

Surprisely, the analysis showed an association between being affected by PPRV infection and vaccination with odds ratio of 12.070 and *p*- value of .017. Although RPV vaccine has been used for PPRV control in the Sudan for many years in the past and it is considered as the most effective way of controlling PPR (Kumar *et al.,* 2014), but the owners and herders still could not accept vaccination as method of control and this reflect their belief in it is disease causality, this is in disagreement with Huyam (2014).

There was a significant association between being affected by PPRV infection and diseases history with odds ratio of 26.282 and *p*- value of .000. Some authors suggested that a more severe disease results from mixed infection of bacteria and viruses than a single infection. Nutritional and environmental factors

have important effect on the appearance of PPR disease in a flock of animals, on the other hand Saliki (1998) previously reported that poor nutrition status, stress of movement and concurrent parasitic and bacterial infections enhance the severity of clinical signs (Osman *et al*, 2009).

At the area level, this analysis showed an association between being affected by PPRV infection and density with odds ratio of 23.492 and *p*- value of .000. This is in agreement with Singh (2011) who stated that; the higher population density of animals' results in increased levels of contact between them and this helps to maintain the PPR virus within the environment.

The climatic factors were found associated with PPR occurrence with odds ratio of 10.560 and *p*- value of .032; states with high rain fall and high wind speed were found to have the highest PPR occurrence. Animals in these states were more affected significantly than those in states with low rain fall and slow wind speed. High rainfall rates lead to cold weather and that is contributing to PPR spread and this agree with Elnoman *et al* (2011), Elhassan *et al* (1994) and with Saeed *et al* (2010), Huyam (2014).

No association was found with PPR occurrence and elevation. Despite that the change of humidity and ambient temperature might have contributed to the maintenance of the outbreak (Elhassan *et al*, 1994).

The analysis further showed that there was insignificant association between being PPR affected and the livestock marketing system with odds ratio of 6.240

and *p*- value of .182, but trade of live animals is one of the important risk factors in spreading PPR in Africa as mentioned by Kaukarbayevich (2009) and Singh (2011).

The analysis showed that there was significant association between being PPR affected and the veterinary service provision (surveillance, control) with odds ratio of 12.070 and *p*- value of .017. There is no regular application for bio-security measures which considered risk that increase the disease transmission. The primary quarantine or vaccination and inspection centers were found to be far away. Majority of primary and secondary livestock markets are lacking for separated pens (ElDirani *et al.*, 2009).

The analysis further showed that there was a significant association between being PPR affected and the wildlife with odds ratio of 70.393 and *p*- value of .000. Development of trade relations, transport, tourism and migration of wildlife animals susceptible to PPR contribute to the spread of the disease beyond the boundaries of Western Africa. Also the interaction between sheep and goats in pastoralist system with wild small ruminants in pasture especially in states with high density of wild life like Sinnar could affect the PPR occurrence; as the infectivity and role of PPR transmission through wild ruminants is mentioned by Housawi *et al* (2004), Zahur *et al* (2008) and Gopilo (2005).

CONCLUSIONS

From the results of the study it can be concluded that PPR according to knowledge and perceptions of sheep owners/ herders and veterinarians is prevailing endemic spreading occurrence all over sheep in Sinnar, Gadarif, Kassala, River Nile and White Nile states. Pastoralists and open grazing among the different husbandry systems were most important for PPR occurrence.

Many outbreaks occurred in 2019 indicated that vaccination programs against PPR were not well organized and implemented. Number of vaccinated animals is insignificantly small compared to the large number of susceptible animals existing in the region. The sheep owners and herders have little knowledge about the benefits of vaccination and consider it as source of infection and risk factor.

Sheep owners and herders have a good knowledge of patterns of PPRV infection, its clinical signs, seasons of occurrence, sources of infection, economic impact and the disease picture in different age groups, breeds and sexes. PPR, Sheep pox, blood parasites and botulism in this order are diseases of economic importance for the sheep owners and herders in Sinnar, Gadarif, Kassala, River Nile and White Nile states.

Vaccination and treatment are major control measures taken against PPR and many other diseases in the Sudan. In contrast, movement control and quarantine,

very important strategies in controlling PPRV as recommended by OIE, are not practiced.

Risk factors associated with PPRV were found to be species at animal level and production system, migration, animal movement, vaccination and disease history at herd level, while livestock density, climatic changes, veterinary services and wildlife were identified as risk factors at area level. In contrast, age, sex and breed at animal level and herd size, mixed species, housing, water, communal dipping at herd level, and elevation, livestock marketing system at area level were found not to be significantly associated with the occurrence of PPRV outbreaks.

The results of the study suggest that PPRV no longer shows features of epidemic disease; rather, an endemic pattern of occurrence seems to have been reached.

RECOMMENDATIONS

The study shows need for:

1. Implementation of National program for control and eradication of PPR involved all stakeholders in Sudan and in collaboration with region countries.
2. Communication and awareness programs should be started to enable sheep and other livestock owners to understand the importance of vaccination in control and eradication of PPRV and other infectious diseases and to comprehend the risks to their animals by practicing communal grazing and watering and free movement from one place to another.
3. An appropriate strategy is needed to help increase the capacity of vaccine production amount and in time and application of a risk- based vaccination strategy.
4. To reduce the costs of vaccination, it would be advisable to not only use a thermo-resistant vaccine but also a polyvalent vaccine for the control of other important disease together with PPRV; this may incourage sheep owners/ herders to vaccinate their animals.
5. Legislation should be improved, updated and enforced to ensure that sheep and other livestock movements are controlled through the implementation of a permit system for livestock movement and road check points within states

and between Sudan and neighboring countries. In addition, all sheep owners and herders should compulsorily vaccinate their animals annually.

6. Strengthening the existing information and reporting systems and a vaccinated animals identification and traceability system are needed.
7. Fund raising at national and regional level to assist Sudan to commitment to the Global Strategy For The Progressive Control of PPR developed by FAO with OIE 2013.
8. Establishment of well-equipped laboratories can handle dangerous pathogens without posing risks to humans and animals at least at state, if not at locality level.
9. The socio-economic impact of PPRV and vaccination cost-benefit ratio should be understood.
10. Capacity building (institutional and personnel).

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APPENDIXES

Appendix1 _ A: PPR Questionnaire Format for Owners and Herders

DATA COLLECTION FORMAT

No. **Date: / /**

State: **Locality/site:**

1. <u>General information:</u>

1. Sex:
    a. Male
    b. Female
2. Age (In Years):
    a. 5 _ 14
    b. 15 _ 29
    c. 30 _ 45
    d. > 45
3. Educational level:
    a. Uneducated
    b. Primary School
    c. Secondary school
    d. Graduate
    e. Professional training
4. Number of years of experience in animal business: .....

2. <u>Management and knowledge of participant to the case and host range:</u>

1. Animal Husbandry
    a. Sedentary
    b. Semi-sedentary
    c. Nomadic (Free range or grazing)

- If nomadic please indicate the migratory route? ……..

2. Herd origin:.....
3. Where is the herd kept?……
4. How many animals are there? Sheep: Goats: Total:
5. Action when introducing new animals into the herd
    a. Quarantine and vaccination
    b. Mixing them with the old ones
6. Do animals in the herd have identification numbers? a. Yes b. No
7. Do you mix different species? a. Yes b. No
8. When was the last outbreak of PPR occurrence in your herd? .....
9. Source of infection:
    a. Contact with infected animals
    b. Contaminated water

c. Contaminated feeds
d. Contaminated troughs
e. Vaccination
f. Mixed

10. Can sheep or goat get PPR disease: a. Yes b. No
11. Cause of PPR disease:
    a. Disease
    b. Seasonal case
    c. Stress
    d. Starvation and thirst
12. Species affected:
    a. Sheep
    b. Goat
    c. Cattle
    d. Camel
    e. Sheep, Goat
    f. Wild animal
    g. All
13. Age affected:
    a. < 1 year
    b. 1-2 year
    c. 2-3 year
    d. > 4 year
14. The most sex affected:
    a. Males
    b. Females
    c. Both equally
    d. Do not know
15. Season of occurrence:
    a. Dry season
    b. Rainy season
    c. Hot season
    d. Cold season
    e. Rainy and Cold
    f. Not specifically associated with season

3. <u>Participant knowledge onmode of transmission, symptoms and incubation period:</u>

1. Transmit from animal to animal: a. Yes b. No
2. Mode of transmission:
    a. Direct contact
    b. In Direct contact
    c. All

d. Don’t know

3. Mode of direct contact transmission:
    a. Loose faeces
    b. Droplet from cough or sneeze
    c. Saliva, discharge from eyes, nose and mouth.
    d. Contact with infected animals
    e. All
4. Mode of indirect contact transmission:
    a. Contaminated materials
    b. Insects
    c. All
5. Is PPR disease fatal?
    a. Yes
    b. No
    c. I don’t know
6. Signs and symptoms:
    a. Respiratory distress
    b. Dyspnea and coughing
    c. Serous or mucopurulant occulonasal discharges
    d. Stomatitis
    e. Mucoid or blood tinged diarrohea
    f. Erosions in the vulva or prepuce
    g. Abortions
    h. High mortality in youngs
    i. High mortality in adults
    j. High morbidity
    k. Loss of weight, weakness and emaciation
    l. Loss of milk production
    m. Others (indicate)…….……
7. Incubation period:
    a. Immediately
    b. 3-4 days
    c. 8-13 days
    d. I don’t know

4. <u>Practices and Attitude to prevent and control PPR infection:</u>

1. Attitude to vaccine:
    a. Positive
    b. Negative
2. Vaccinations born in herd/ brought in: a. Yes b. No
3. Do you vaccinate against the following?
    a. Sheep pox Yes No
    b. PPR Yes No

c. Anthrax Yes No
d. HS Yes No
e. Botulism Yes No

4. When was the last time you vaccinated your animals against PPR? .....
5. How many animals were vaccinated? Sheep: ..... Goats:.... Total…..
    a. ≤1000
    b. >1000 - 2000
    c. >2000 - 3000
    d. >3000 - 4000
    e. >4000
6. Action after infection:
    a. Isolation of infected animals
    b. Treatment
    c. Vaccination
    d. All
    e. Don't know
7. Action taking to dead animals
    a. Left behind
    b. Burn
    c. Burial
    d. Burn and Burial
8. Action when an outbreak of PPR or any other disease occurs in the next herd
    a. Stop movement
    b. Prevent contact with other herd or animals
    c. Prevent humans from contact with animals
    d. Report to the authorities
    e. Do not Take Action

5. <u>Potential Risk factors associated with infection:</u>

I. <u>At animal level:</u>

1. Species:
    a. Sheep
    b. Goat
    c. Cattle
    d. Camel
    e. Sheep, Goat
    f. Wild animal
    g. All
2. Age:
    a. < 1 year
    b. 1-2 year
    c. 2-3 year
    d. > 4 year

e. Do not know

3. Sex:
    a. Males
    b. Females
    c. Both equally
    d. Do not know
4. Breed:
    a. Local
    b. Imported
    c. Cross

II. <u>At herd level:</u>

1.	Herd size:	a. Yes	b. No
2.	Production type:	a. Yes	b. No
3.	Mixed species:	a. Yes	b. No
4.	Housing:	a. Yes	b. No
5.	Watering:	a. Yes	b. No
6.	Communal dipping:	a. Yes	b. No
7.	Animal movement:	a. Yes	b. No
8.	Migration:	a. Yes	b. No
9.	Vaccinations:	a. Yes	b. No
10.	Disease history:	a. Yes	b. No

III. <u>At area-level:</u>

1.	Livestock density:	a. Yes	b. No
2.	Climate: temperature, rain-fall, seasons:	a. Yes	b. No
3.	Elevation:	a. Yes	b. No
4.	Livestock marketing system:	a. Yes	b. No
5.	Veterinary service provision: surveillance, control:	a. Yes	b. No
6.	Susceptible wildlife:	a. Yes	b. No

Appendix 1 - B: مرض طاعون المجترات الصغيرةإستبيان الرعاة وملاك الحيوانات

إستبيان رقم: ..... **التاريخ:** .....

الولاية: ..... **المحلية/ الموقع:** .....

1. **<u>بيانات عامة:</u>**

1) الجنس : (أ) ذكر (ب) أنثي

2) العمر: (أ) 5- 14سنة (ب)15 – 29 سنة (ج) 30 – 45 (د) أكبر من 45 سنة

3) المستوى التعليمى: (أ) غير متعلم (ب) تعليم إبتدائي (ج) تعليم ثانوى (د) خريج (هـ) تعليم متخصص

4) عدد سنوات الخبرة فى مجال التعامل مع الحيوانات:.....

2. **<u>الإدارة ومدى المعرفة بالمرض والعائل:</u>**

1) نمط التربية : (أ) مستقر (ب) شبه مستقر (ج) رُحّل

- إذا رُحّل الرجاء توضيح المسار: .....

2) من أين يتم جلبالقطيع:..... **3) أين يتم الإحتفاظ بالقطيع:**.....

4) الحيوانات الموجودة: الضأن: (.....) رأس الماعز: (.....) رأس الجملة:(.....) رأس

5) الإجراءات المتبعة عند إدخال قطيع جديد للمزرعة: (أ) حجر بيطري وتطعيم (ب) خلط الحيوانات الجديدة مع القديمة

6) هل الحيوانات الموجودة بالمزرعة بها علامات رقمية تعريفية: (أ) نعم (ب) لا

7) هل تخلط جميع الحيوانات بالمزرعة مع بعضها البعض:(أ) نعم (ب) لا

8) متى كان آخروباء لمرض طاعون المجترات الصغيرة بالقطيع:.....

9) مصدر العدوى:(أ) إحتكاك مع حيوانات مصابة(ب) ماء ملوث(ج) غذاء ملوث(د) أحواض ملوثة(هـ) التطعيم(و) أسباب مختلفة

10) هل يصاب الضأن والماعز بالمرض: (أ) نعم (ب) لا

11) سبب حدوث مرض طاعون المجترات الصغيرة:(أ) مرض (ب) حالة موسمية (ج) إجهاد (د) الجوع والعطش

12) الأنواع المصابة:(أ) الضأن (ب) الماعز(ج) الأبقار (د) الجمال (هـ) الضأن والماعز (و) الحيوانات البرية (ز) الكل

13) الأعمار المعرضة للإصابة: (أ) أصغر من عام (ب) 1 -2 سنة (ج) 2 – 3 سنة (د) أربعة سنوات فما فوق

14) الجنس المعرض للإصابة: (أ) الذكور (ب) الإناث (ج) الإثنين معاً (د) لا أعلم

15) الفصل الذى تحدث فيه الإصابة: (أ) فصل الجفاف(ب) الخريف(ج) الشتاء(د) الصيف (هـ) الخريف والشتاء (و) غير محدد بفصل

3. **<u>مدى المعرفة بطريقة الانتقال، العلامات، الأعراض والعلاج:</u>**

1) إنتقال المرض من حيوان إلى حيوان: (أ) نعم (ب) لا

2) طريقة الإنتقال: (أ) إنتقال مباشر (ب) إنتقال غير مباشر (ج) معاً (د) لا أعرف

3) طرق الإنتقال المباشرة: (أ) البراز الملوث (ب) رزاز السعال أو العطس (ج) إفرازات العينين والأنف والفم (د) الاتصال مع الحيوانات المصابة (هـ) الكل

4) طرق الإنتقال غيرالمباشرة: (أ) المواد الملوثة (ب) الحشرات (ج) معاً

5) **هل تعتقد أن مرض طاعون المجترات الصغيرة مرض قاتل:** (أ) نعم (ب) لا (ج) لا أعرف

6) **العلامات والأعراض:** (أ) ضيق التنفس. (ب) السعال (ج) مخاط مصلى أو صديدى من الأنف (د) إلتهاب الفم (هـ) إسهال دموى أو مخاطى (و) تآكل في الفرج أو القلفة (ز) إجهاض (ح) إرتفاع معدل الوفيات فى الصغار (ح) إرتفاع معدل الوفيات فى الكبار (ط) إرتفاع معدل الوفيات عامةً (ى) ضعف وهزال (ك)قلة إنتاج الحليب ل) أخرى: .....

7) **فترة حضانة المرض:** (أ) مباشرة بعد الإصابة (ب) 3 – 4 أيام (ج) 8 – 13 يوم (د) لا أعرف

4. **<u>الممارسات والسلوك لمنع ومكافحة العدوى بمرض طاعون المجترات الصغيرة:</u>**

1) **السلوك تجاه التطعيم:** (أ) إيجابي (ب) سلبي

2) **تطعيم المواليد الجديدة أو التى تم إدخالها في القطيع :** (أ) نعم (ب) لا

3) **هل قمت بالتطعيم ضد الأمراض التالية :**

جدرى الضأن والماعز	(أ) نعم	(ب) لا
طاعون المجترات الصغيرة	(أ) نعم	(ب) لا
الحمى الفحمية	(أ) نعم	(ب) لا
التسمم الدموى	(أ) نعم	(ب) لا
التسمم الوشيجى	(أ) نعم	(ب) لا

4) **متى كانت آخر مرة تم تطعيم الحيوانات الخاصة بك ضد مرض طاعون المجترات الصغيرة:** .....

5) **كم عدد الحيوانات التي تم تطعيمها:**الضأن: (.....) رأس الماعز: (.....) رأس الجملة: (.....)رأس

6) **الإجراءات المتبعة بعد الإصابة:**(أ) عزل الحيوانات المصابة(ب) العلاج (ج) التطعيم(د)الكل (هـ) لا أعرف

7) الإجراءات **المتخذة تجاه الحيوانات الميتة:** (أ) تترك كما هى (ب) الحرق (ج) الدفن (د) الحرق والدفن

8) **ماذا تفعل فى حالة الإصابة بمرض طاعون المجترات الصغيرةأو أي مرض آخر فى القطيع المجاور :**

(أ) إيقاف حركة الحيوان (ب) منع تداخل الحيوانات مع الحيوانات الأخرى(ج) منع البشرمن الإتصال مع الحيوانات (د) إبلاغ السلطات البيطرية (هـ) تدابير أخرى

5. **<u>عوامل الخطر المحتملة المرتبطة بالعدوى:</u>**

I. **<u>عوامل الخطر المحتملة على مستوى الحيوان:</u>**

1) **النوع:** (أ) الضأن(ب) الماعز (ج) الأبقار (د) الجمال(هـ) الضأن والماعز(د) الحيوانات البرية(و) الكل

2) **العمر:** (أ) أصغر من عام (ب) 1 -2 عام (ج) 2 – 3 عام (د) أربعة سنوات فما فوق

3) **الجنس:** (أ) الذكور (ب) الإناث

4) **السلالة:** (أ) المحلية (ب) المستورد (ج) الهجين

II. **<u>عوامل الخطر المحتملة على مستوى القطيع:</u>**

1) عدد القطيع:	(أ) نعم	(ب) لا	
2) نمط التربية:	(أ) مستقر	(ب) شبه مستقر	(ج) رُحّل
3) الأنواع المختلطة:	(أ) نعم	(ب) لا	
4) السكن:	(أ) نعم	(ب) لا	
5) شرب المياه:	(أ) نعم	(ب) لا	

6) التغطيس الجماعى: (أ) نعم (ب) لا

7) حركة الحيوان: (أ) نعم (ب) لا

8) هجرة الحيوانات: (أ) نعم (ب) لا

9) التطعيم: (أ) نعم (ب) لا

10) التاريخ المرضى: (أ) نعم (ب) لا

III. <u>عوامل الخطر المحتملة على مستوى المنطقة:</u>

1) كثافةالثروة الحيوانية: (أ) نعم (ب) لا

2) المناخ: درجة الحرارة، هطول الأمطار، الفصول: (أ) نعم (ب) لا

3) الإرتفاع: (أ) نعم (ب) لا

4) نظام تسويق الثروة الحيوانية: (أ) نعم (ب) لا

5) تقديم الخدمات البيطرية (المراقبة والسيطرة): (أ) نعم (ب) لا

6) الحيوانات البرية القابلة للإصابة بالمرض: (أ) نعم (ب) لا

Appendixe 2_ A: PPR Questionnaire Format for Veterinarians

DATA COLLECTION FORMAT

No. Date: / /

State: Locality/site:

1. General information
   a. Gender:
   b. Age:
   c. Number of years of experience:……
      1. ≤5
      2. >5 – 10
      3. >10 – 15
      4. >15
2. Which farming system is being practiced for production of sheep and goats in your locality?
   a. Sedentary
   b. Semi-sedentary
   c. Nomadic (Free range or grazing)
   d. Mixed (Livestock/Crop)
   e. Ranching
   f. Semi-Nomadic
   g. Semi-Sedentary/ Nomadic
   - If nomadic please indicate the migratory route?……
3. Please mention the most economically important diseases of sheep and goats in your locality beginning with the most important in decreasing order:
   a. …… c. ……..
   b. …… d. .....
4. When was the last outbreak of PPR occurrence in your locality?
   a. Before 2013
   b. 2013 to 2015
   c. 2016 to 2018
   d. 2019
   e. Had never occurred
5. When PPR outbreaks occur, in which season are they occurring mostly?
   a. Dry season
   b. Rainy season
   c. Cold season
   d. Hot season
   e. Cold and rainy seasons
   f. Not specifically associated with season

6. When an outbreak of PPR occurs in your locality, the likely source is:
    a. Introduction of new animal(s)
    b. Contact at communal points (indicate)
    c. Contact with wild animals
    d. Movement of animal(s)
    e. Other
       (indicate)……
7. Which animal species (sheep or goats) is the most affected by PPR in your locality?
    a. Sheep
    b. Goats
    c. Equally
    d. Do not know
8. Which animal breeds (sheep or goats) is the most affected by PPR in your locality?
    a. Kabashi
    b. Hamari
    c. Dubaasy
    d. Kawahla
    e. Baladi
    f. Rufaa
    g. Crosses of local breeds
    h. No difference
9. Which age group is the most affected by PPR in your locality?
    a. Less than one year
    b. One to two years
    c. Two to four years
    d. More than four years
    e. No difference between age groups
10. Which sex is most affected?
    a. Males
    b. Females
    c. Both equally
    d. Do not know
11. What are the major symptoms observed usually in PPR infected animals in your locality? Please tick
    n. Respiratory distress
    o. Dyspnea and coughing
    p. Serous or mucopurulant occulonasal discharges
    q. Stomatitis
    r. Mucoid or blood tinged diarrohea
    s. Erosions in the vulva or prepuce

t. Abortions
u. High mortality in youngs
v. High mortality in adults
w. High morbidity
x. Loss of weight, weakness and emaciation
y. Loss of milk production
z. Others (indicate)…….....

12. What is the basis of diagnosis for the above mentioned diseases?
    a. Clinical
    b. Laboratory
    c. Both
13. What measures are taken when the diseases in 3 above are diagnosed?
    a. Treatment
    b. Vaccination
    c. Both
    d. Others (indicate)
14. If vaccination, for which disease(s) do you vaccinate?
    a. ……..
    b. ……..
    c. ……
    d. ……..
15. How those PPR outbreaks are being diagnosed in your locality and by whom?
    a. Clinically
    b. Laboratory
    c. Quarantine/ Stop moving
    d. All
16. What control measures are undertaken when an outbreak of PPR occurs?
    a. Vaccination
    b. Quarantine
    c. Public education
    d. Treatment
    e. Others (indicate)……
17. For how long do quarantine measures last, if undertaken?
    a. 3 weeks
    b. 1 month
    c. 1 - 2 months
    d. 2 - 4 months
    e. 4 - 6 months
    f. > 6 months
    g. Not practiced

18. Vaccination of sheep and goats against PPR in your locality is done:
    a. Every 6 months
    b. Every year
    c. Every 2 years
    d. Only in response to outbreaks
    e. Other(indicate)……
19. When was the last vaccination against PPR carried out in your locality?
    a. Before 2013
    b. 2013 to 2015
    c. 2016 to 2018
    d. 2019
20. How many animals were vaccinated? .....
    a. ≤ 1000
    b. > 1000 – 2000
    c. > 2000 – 3000
    d. > 4000
21. Was the vaccine protective?
    a. Yes
    b. No
    c. To some extend
    d. Don't know
22. What problems are you facing when implementing generally a disease control programme in your locality and specifically when controlling PPR?

……

23. Give any comments, advice or additional information you would like to give to the MAR/Public/Policy makers concerning the control of PPR in your locality.

.....

مرض طاعون المجترات الصغيرةإستبيان للأطباء البيطريين : Appendix2 - B

إستبيان رقم: ..... **التاريخ: .....**

الولاية: ..... **المحلية/ الموقع: .....**

1. **بيانات عامة:**
   أ. الجنس: .....
   ب. العمر: .....
   ج. سنين الخبرة فى المجال: .....
2. **نمط التربية للضأن والماعز الممارس فى المحلية:** (أ) مستقر(ب) شبه مستقر(ج) رُحّل (دمزرعة (هـ) مختلط (و) شبهرُحّل
   - إذا رُحّل الرجاء توضيح المسار: .....
3. **أكثر الأمراض ذات الأهمية الإقتصادية التى تصيب الضأن والماعز فى المحلية إبتداءاً من الأكثر أهمية:**
   أ. ..... هـ. .....
   ب. ..... و. .....
   ج. ..... ز. .....
   د. ..... ح. .....
4. **متى كان آخر حدوث لوباء مرض طاعون المجترات الصغيرة فى المحلية؟**
   أ. قبل 2013. ب. 2013 - 2015.
   ج. 2016 - 2018. د. 2019.
   هـ. لم يحدث إطلاقاً.
5. **فى أى فصل يحدث وباء مرض طاعون المجترات الصغيرة؟**
   أ. الجفاف. ب. الخريف. ج. الشتاء. د. الصيف. هـ. الشتاء والخريف و. غير محدد حدوثه بفصل معين.
6. **عند حدوث وباء لمرض طاعون المجترات الصغيرة بالمحلية ما هو مصدر العدوي؟**
   أ. إدخال حيوانات جديدة. ب. الإختلاط بالقطعان الأخرى. ج.الإختلاط بالحيوانات البرية.
   د. حركة الحيوانات. هـ. أخرى: .....
7. **أى الأنواع أكثر إصابةً بمرض طاعون المجترات الصغيرة بالمحلية؟**
   أ. الضأن. ب. الماعز. ج. الإثنين معاً. د. لا أعرف.
8. **ما هى سلالات الضأن والماعز الأكثر إصابة بمرض طاعون المجتران الصغيرة بالمحلية؟**
   أ. الكباشى. ب. الحمربج. الدباسى د. الكواهلى هـ. بلدى و. رفاعة ذ. الهجين ح. لا يوجد إختلاف فى الإصابة
9. **ماهو العمر الأكثر إصابةً بمرض طاعون المجترات الصغيرة بالمحلية؟**
   أ. أقل من عمر سنة. ب. 1 - 2 سنة. ج. 2 - 4 سنة. د. أكثر من 4 سنة. هـ. لا يوجد إختلاف فى الأعمار للإصابة. و. لا أعرف

10. ماهو الجنس الأكثر إصابةً بمرض طاعون المجترات الصغيرة بالمحلية؟

أ. الذكور. ب. الإناث. ج. الإثنين معاً. د.لا أعرف.

11. ما هى الأعراض الملاحظة عند إصابة الحيوانات بمرض طاعون المجترات الصغيرة؟

أ. ضيق التنفس.

ب. سعال.

ج. مخاط مصلى أو صديدى من الأنف.

د. إلتهاب الفم.

هـ. إسهال دموى أو مخاطى.

و. تآكل في الفرج أو القلفة.

ز. إجهاض.

ح. إرتفاع معدل الوفيات فى الصغار.

ط. إرتفاع معدل الوفيات فى الكبار.

ي. إرتفاع معدل الوفيات عامةً.

ك. ضعف وهزال.

ل. قلة إنتاج الحليب.

م. أخرى: .....

12. ما هو أساس التشخيص للأمراض المذكورة أعلاه؟

أ. تشخيص سريرى. ب. تشخيص معملى. ج. الإثنين معاً.

13. ما هي التدابير التي يتم إتخاذها عندما يتم تشخيص الأمراض في السؤال رقم 3 أعلاه:

د. العلاج. ب. التطعيم. ج. الحجر والعزل. د. كل ما ذكر.

14. فى حالة التطعيم، ما هى الأمراض التى تطعم ضدها؟

أ. ..... هـ. .....

ب. ..... و. .....

ج. ..... ز. .....

د. ..... ح. .....

15. كيف يتم تشخيص حالات وباء مرض طاعون المجترات الصغيرة في المحلية؟

أ. تشخيص سريرى

ب. تشخيص معملى

ج. الإثنين معاً

16. ما هي تدابير السيطرة التي يتم إتخاذها عندما يحدث وباء بمرض طاعون المجترات الصغيرة؟

أ. التطعيم. ب. الحجر البيطرى. ج. العلاج. د. توعية وإرشاد

هـ. أخرى: .....

17. فترة الحجر البيطرى، إذا تم القيام بها؟

أ. 3 أسابيع. ب. شهر.ج. 1 - 2 شهر. د. 2 - 4 أشهر. هـ. 4 - 6 أشهر.و. أكثر من 6 أشهر. ز. غير ممارس

18. يتم تطعيم الضأن والماعز ضد مرض طاعون المجترات الصغيرة في المحلية كل:

د. 6 أشهر. ب. 1 سنة. ج. 2 سنة. ج. فقط كإستجابة عند حدوث وباء .د. أخرى: .....

19. متى كان آخر تطعيم ضد طاعون المجترات الصغيرة نفذ في محليتك أو موقعك؟

أ. قبل 2013. ب. 2013 - 2015. ج. 2016 - 2018. د. 2019.

20. كم عدد الحيوانات التي تم تطعيمها: .....

21. هل كان اللقاح واقياً: (أ) نعم (ب) لا (ج) إلى حد ما (د) لا أعرف

22. ما هي المشاكل التي تواجهها عند تنفيذ برنامج مكافحة الأمراض بشكل عام في الموقع الخاص بك وتحديداً عند السيطرة على مرض طاعون المجترات الصغيرة؟

.....

23. هل عندك أي تعليقات أو مشورة أو معلومات إضافية ترغب في إعطاؤها للمركز / وزارة الثروة الحيوانية / صانعي السياسات فيما يتعلق بمكافحة مرض طاعون المجترات الصغيرة في الموقع الخاص بك؟

.....