Introduction

Foot and Mouth Disease, Fiebre Aftosa (Sp), Fievre Aphteuse (Fr), Maul-und Klauenseuche (Gr) **(***Corrie, B., et al., 2008***)**.

Back ground:

FMD is an acute infection of cattle, sheep, pigs, goats, buffalo and many species of cloven-hoofed wildlife, caused by a single-stranded RNA virus belonging to the genus **Aphthovirus**, in the family **Picornaviridae**. There are 7 distinct serotypes of FMD virus, and within each serotype there are numerous strains. Infections in humans are very rare and of minor clinical significance. *(Pharo, H.J. et al., 2002).*

There are seven serotypes of FMD virus (FMDV), namely, O, A, C, SAT 1, SAT 2, SAT 3 and Asia 1. The genome of the virus is over 8 kb in length and encodes four structural proteins (SPs, VP1, VP2, VP3 and VP4) that form an icosahedral capsid , and a total of ten mature non-structural proteins (NSPs) (L, 2A, 2B, 2C, 3A, 3B, 3C, 3D, 3AB or 3ABC). *(Yao –Zhong, D., et al., 2013).*

Infection with any one serotype does not confer immunity against another. Within serotypes, many strains can be identified by biochemical and immunological tests. Of the domesticated species, cattle, pigs, sheep, goats, and water buffalo (Bubalus bubalis) are susceptible to FMD. Many species of cloven-hoofed wildlife may become infected, and the virus has occasionally been recovered from other species as well. Amongst the camelidae, Bactrian camels and new world camelids have been shown to be susceptible.

(OIE Terrestrial Manual 2012).

FMD is endemic in large areas of Africa, Asia and South America and has shown an extraordinary ability to cross international boundaries and cause epidemics in previously free areas, as illustrated by the 2001 epidemic in the UK and continental Europe, as well as the outbreaks in the year 2000 in Japan and South Korea *(Alexandersen , S. et al., 2003).*

In Africa, SAT serotypes of FMD viruses are often maintained by African buffalo (Syncerus caffer). There is periodic spillover of infection into livestock or sympatric cloven-hoofed wildlife. Elsewhere in the world cattle are usually the main reservoir for FMD viruses, although in some instances the viruses involved appear to be specifically adapted to pigs. Small ruminants can play an important role in the spread of FMDV, but it is not clear whether the virus can be maintained in these species for long periods in the absence of infection of cattle. Strains of FMDV that infect cattle have been isolated from wild pigs, antelope and deer. Infection of susceptible animals with FMDV can lead to the appearance of vesicles on the feet, in and around the oral cavity, and on the mammary glands of females. The vesicles rupture and then heal whilst coronary band lesions may give rise to growth arrest lines that grow down the side of the hoof. The age of lesions can be estimated from these changes as they provide an indicator of the time since infection occurred. Mastitis is a common sequel of FMD in dairy cattle. Vesicles can also occur at other sites, such as inside the nostrils and at pressure points on the limbs – especially in pigs. The severity of clinical signs varies with the strain of virus, the exposure dose, the age and breed of animal, the host species and the immunity of the animal. The signs can range from a mild or in apparent infection to one that is severe. Death may result in some cases. Mortality from a multifocal myocarditis is most commonly seen in young animals. In animals

with a history of vesicular disease, the detection of FMDV in samples of vesicular fluid, epithelial tissue, oesophageal–pharyngeal (OP) sample, milk, or blood is sufficient to establish a diagnosis. Diagnosis may also be established by the detection of FMDV in the blood, heart or other organs of fatal cases. A myocarditis may be seen macroscopically (the so-called “tiger heart”) in a proportion of fatal cases. FMD viruses may occur in all the secretions and excretions of acutely infected animals, including expired air. Transmission is generally effected by direct contact between infected and susceptible animals or, more rarely, indirect exposure of susceptible animals to the excretions and secretions of acutely infected animals or uncooked meat products. Following recovery from the acute stage of infection, infectious virus disappears with the exception of low levels that may persist in the oropharynx of some ruminants. The carrier state in cattle usually does not persist for more than 6 months, although in a small proportion, it may last up to 3 years. Sheep and goats do not usually carry FMD viruses for more than a few months, whilst there is little information on the duration of the carrier state in Asian buffalo species and subspecies. There are a number of commercially available diagnostic test kits, for the detection of virus antigens or antibodies**.** *(OIE Terrestrial Manual 2012)*.

In the Sudan, FMD is endemic, and FMD outbreaks occur annually; the first record of the disease in the Sudan was in **1903**, and four FMD serotypes out of the seven have been reported in the country. These are O, A, SAT 1 and SAT 2**.** Serotype O was isolated first, then serotype SAT 1 before 1952, serotype (A) in 1957, and lastly, serotype (SAT 2) in 1977**.** Antibodies to these

four FMDV serotypes were detected in cattle, sheep and goat sera, but their prevalence rate was quite different from species to species. Camel sera were screened by the agar gel immune diffusion test (AGID) for the presence of antibodies against FMD virus infection associated (VIA) antigen and proved to be negative**.** However, efforts have been recently renewed; a serosurvey has been conducted in Khartoum state and samples of suspected FMD outbreaks have been sent more regularly to the World Reference Laboratory (WRL) at Pirbright in the UK.

(Habiela,M. et al., 2010).

Type O was the first FMD virus serotype to be recovered in the Sudan (Anon., 1938). It is the most frequent and most widespread. It caused 55% of the total positively-typed samples (1952-1981).

(ABU ELZEIN, E. M. E. 1983).

The first record of **type A** in the Sudan was made in 1957. Its incidence was sporadic. It constituted 20% of the total positively-typed samples during1952-1982. Serological differentiation of type A virus isolates in Sudan (1967-1981) showed that early isolates were similar to those of the A 2 2 subgroup in the Middle East.

(ABU ELZEIN, E. M. E. 1983).

WRL records show that **SAT 1** in the Sudan was recorded before 1952. Two strains, designated as ≪ Wad Medani ≫ and ≪ Khartoum North ≫, were typed as SAT 1 before 1952 and were sent back to WRL, at Pirbright, in 1952 for retyping by Dr. Leach.

Infection with type SAT 1 in the Sudan appears to take place in cycles with a frequency range from one to five years. Type SAT 1 constituted 20% of the total positively-typed FMD samples from Sudan, during the period reviewed (1952-1981). *(ABU ELZEIN, E. M. E. 1983).*

This type has been only recently recorded for the first time in the Sudan. The outbreak involved cattle in the Kadaro quarantine, Khartoum province. That outbreak died out and **SAT 2** was not reported from elsewhere in the country. Strain differentiation study on the Sudan SAT 2 isolate indicated that it was different from current isolates from Botswana and Southern Africa but most similar to isolates from Niger (1973) and Tanzania (1975) which are equally interrelated. *(ABU ELZEIN, E. M. E. 1983).*

Justification for the research

Sudan is a vast country with a massive population of animals. Cattle mounts to **29618000** head, sheep **39296000** head, goats to around **30649000** head and camels about**4715000** head and a considerable mass of wild livestock of diverse population. *(FMARF.ISO (21). 2012).* FMD is probably one of the most important livestock diseases in the world in terms of economic impact. The disease (FMD) is endemic in the Sudan with higher prevalence. The economic potentiality of livestock is far from being fully exploited. FMD cause significant loss of direct

production effects, death in young ruminants, comparatively low milk production in farm animal, weight gain, loss of markets, reproductive inefficiencies, and affected animals cannot work lands accounting for further economic losses. The disease is affect directly in the export of cloven-hoofed domestic and wild animals. Foot and mouth disease (FMD) cause direct effect on animal health, animal trade, and on animal productivity. FMD has been a public health problem (Plesters).

Objectives:

The aims of this study were to:

(1) Estimate the prevalence of Foot and Mouth Disease of cattle in Khartoum State, Sudan.

(2) Determine the Risk Factors which could be associated with Foot and Mouth Disease of cattle in Khartoum State – Sudan.

CHAPTER ONE

LITERATURE REVIEW

1.1. Definition

Foot-and-mouth disease (FMD) has been considered a sufficiently serious infectious animal health problem for most developed countries to have expended a

great deal of effort on its eradication. FMDV infects cattle, buffalo, pigs, sheep, goats, and various wildlife species and is a major cause of productivity loss. It exists as seven serotypes that do not engender cross-protective immunity, as well as many intra- serotypic strains that may also incompletely cross-protect.
(Paton, D.J.et al., 2009).

The disease is highly contagious and causes formation of vesicles on the mouth and the coronary band of feet in all cloven-hoofed animals. FMD is a transboundary animal disease and is economically very important to countries which export and import animals or animal products. *(Frank, N.M.et al., 2010*).

Although adult animals generally recover, the morbidity rate is very high in naïve populations, and significant pain and distress occur in some species. Squeal may include decreased milk yield, permanent hoof damage, and chronic mastitis. High mortality rates can be seen in young animals. Although foot and mouth disease was once found worldwide, it has been eradicated from some regions including North America and most of Europe. Where it is endemic, this disease is a major constraint to the international livestock trade. *(Fiebre, A. 2007).*

1.2. Etiology:

Foot-and-mouth disease virus (FMDV), a member of the **Aphthovirus** genus within the **Picornaviridae** family, is the causative agent of foot-and-mouth disease (FMD), one of the world's most important infectious animal diseases, responsible for huge global losses of livestock production and trade, as well as frequent and highly disruptive large-scale epidemics. **(***Margo, E. T.et al., 2013*).

There are seven immunologically distinct serotypes - O, A, C, SAT 1, SAT 2, SAT 3 and Asia 1 - and over 60 strains within these serotypes. New strains

occasionally develop spontaneously. FMDV serotypes and strains vary within each geographic region. Serotype O is the most common serotype worldwide. *(Fiebre, A. 2007).*

The viral particle, or vision, contains a single-stranded RNA of positive polarity, approximately 8500 nucleotides long. It is an icosahedra particle with a smooth surface and a diameter of about 30 nm. There are 60 copies of each of the structural protein VP1, VP2, VP3, and VP4. The genome of FMDV is about 8.5 Kb in length enclosed within a protein capsid. **(***Neeta, L.et al., 2011*).

Infection with one serotype does not confer immune protection against another. Within serotypes many subtypes can be identified by biochemical and immunological tests**.** *(Esayas, G.et al., 2009).*

1.3. Species Affected:

FMDV can infect most or all members of the order Artiodactyla (cloven-hooved mammals), as well as a few species in other orders. On most continents, cattle are usually the most important maintenance hosts for FMDV, but some virus strains are primarily found in pigs, sheep, or goats. *(Fiebre, A. 2007*). Infection with FMD has been reported in cattle, sheep, goats, swine, and antelopes, as well as many wild animal species. *(Habiela,M. et al., 2010).*

The species affected can markedly influence spread. Pigs, for example, liberate vast quantities of airborne virus in their breath - one pig is capable of excreting 400 million infectious units of virus per day. By contrast ruminants excrete a maximum of around 120000 infectious units per day (Sellers and Parker 1969; Donaldson et al. 1982a). The topic of airborne spread of FMD is considered in more detail in a following section. After recovery from FMD, up to 80070 of ruminant species may become persistently infected. These carriers can irritate fresh outbreaks when brought into contact with fully susceptible animals. Pigs do not become carriers and cease excreting virus within 3-4 weeks after infection.

(Copland, W.et al., 1993).

1.4 .Geographic Distribution:

Foot and mouth disease is endemic in parts of Asia, Africa, the Middle East, and South America. North America, New Zealand, Australia, Greenland, Iceland, and most of Europe are free of this disease. Sporadic outbreaks have occurred in disease-free countries, with the exception of New Zealand, Greenland, Iceland and the smaller islands of Oceania. *(Fiebre, A. 2007).*

The cumulative incidence of FMD serotypes show that six of the seven serotypes of FMD (O, A, C, SAT-1, SAT-2, SAT-3) have occurred in Africa, while Asia contends with four sero-types (O, A, C, Asia-1), and South America with only three (O, A, C). Periodically there have been incursions of Types SAT-1 and SAT-2 from Africa into the Middle East. (*Rweyemamu, M .et al., 2008*).

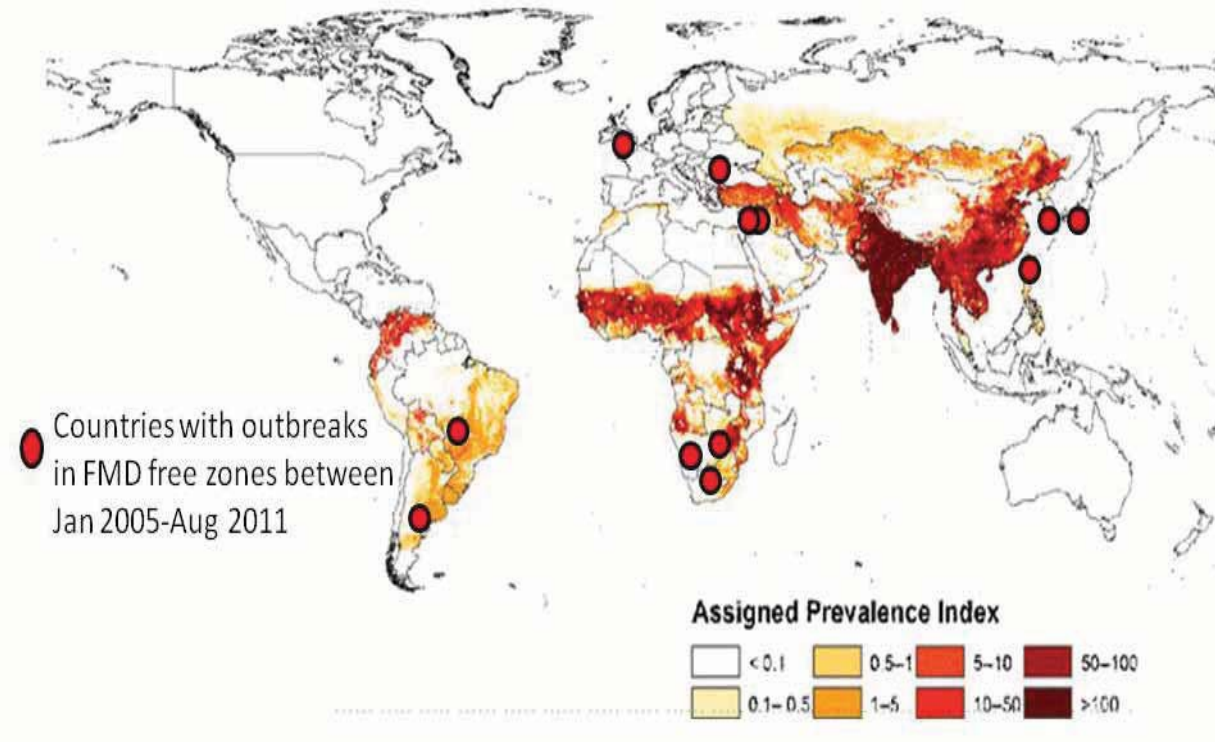

Figure (1): Distribution of Foot and Mouth Disease in the world - 2011

(*Jonathan, R and Theo. K.J. 2012*)

1.5. Transmission:

The virus spreads rapidly by multiple routes and is difficult and expensive to control. Susceptible livestock are most commonly infected by FMDV through the

oropharynx, although the virus can also enter through abrasions in the skin. After replication at the portal of entry, the virus drains to the local lymph nodes and then the bloodstream leading to viraemia, widespread dissemination throughout the body and viral shedding in many bodily secretions. The virus reaches high titers in the stratified epithelia of the mouth, feet, and udder associated with the development of painful vesicles that rupture and release large amounts of virus into the surrounding environment. (*Jonathan, R and Theo. K.J. 2012*).

Transmission can occur by direct or indirect contact with infected animals and contaminated fomites; routes of spread include inhalation of aerosolized virus, ingestion of contaminated feed, and entry of the virus through skin abrasions or mucous membranes. The importance of each of these routes varies with the species. Sexual transmission could be a significant route of spread for the SAT type viruses in African buffalo populations. Some animals carry FMDV for prolonged periods after recovering from acute disease. Animals with natural or vaccine-induced immunity can also become carriers if they are later exposed to virus; these animals can remain asymptomatic. Most cattle carry this virus for six months or less, but some animals remain persistently infected for up to 3.5 years. *(Fiebre, A. 2007).*

Most commonly the movement of infected animals spreads FMD. Contact between infected and susceptible animals results in aerogenous transmission of infectious droplets and droplet nuclei. These particles originate mainly from the respiratory tract and are exhaled in the breath of infected animals. The next most common mechanism of spread is by the movement of contaminated animal products such as meat, milk etc. FMD virus can also be transmitted mechanically e.g. by contaminated vehicles and by people. In addition, FMD can be spread by the wind. *(Mikkelsen T.et al., 2003).*

1.6. Incubation Period:

FMD has one of the shortest incubation periods of any major infectious disease known. In most situations, the incubation period for clinical signs is usually 3-5

days. Experimentally, clinical signs can be seen as early as12 hours post exposure. (*Corrie ,B., et al., 2008*).

In cattle, the incubation period varies from two to 14 days, depending on the dose of the virus and route of infection. Incubation periods as short as 24 hours and as long as 12 days have been reported in this species after experimental infection. *(Fiebre, A. 2007).*

1.7. Clinical Signs:

Typical cases of FMD are characterized by a vesicular condition of the feet, buccal mucosa and, in females, the mammary glands. Clinical signs can vary from mild to severe, and fatalities may occur, especially in young animals. In some species the infection may be subclinical, e.g. African buffalo (Syncerus caffer). *(OIE Terrestrial Manual 2012)*.

Affected animals will initially exhibit pyrexia, lasting for one or two days, followed by development of vesicles on the tongue, hard palate, dental pad, lips, gums, muzzle, coronary band and interdigital space. Infected animals have excessive salivation and a nasal discharge. Signs of lameness are exhibited by frequent stamping of the feet. Depending on the severity of the disease and the host susceptibility, lactating animals can develop vesicles on the teats. This makes milking painful and the ruptured vesicles can become infected leading to secondary mastitis. There is a significant drop in milk production. The vesicles in the mouth usually rupture within 24 hours of formation, leaving shallow erosions surrounded by shreds of epithelium .Healing of oral lesions is usually rapid, in contrast to those

on the feet . Clinical signs are more apparent in cattle as compared to other domestic species. **(***Kinzang, D., 2011*).

FMD is rarely fatal to adult livestock, but causes blisters on the mouth and feet (hence the name) and a deterioration of condition, often leading to a dramatic decline in milk production in dairy cattle and very slow weight gain in other livestock. **(***Matt, J. K., 2014*).

Vesicles often rupture rapidly, becoming erosions. Pain and discomfort from the lesions leads to a variety of symptoms including depression, anorexia, excessive salivation, lameness, and reluctance to move or rise. Lesions on the coronary band may cause growth arrest lines on the hoof. In severe cases, the hooves may be sloughed. Although FMDV does not cross the placenta, abortion may occur in pregnant animals. Most adults recover in two to three weeks, although secondary infections may lead to a longer recovery time. *(Fiebre, A. 2007).*

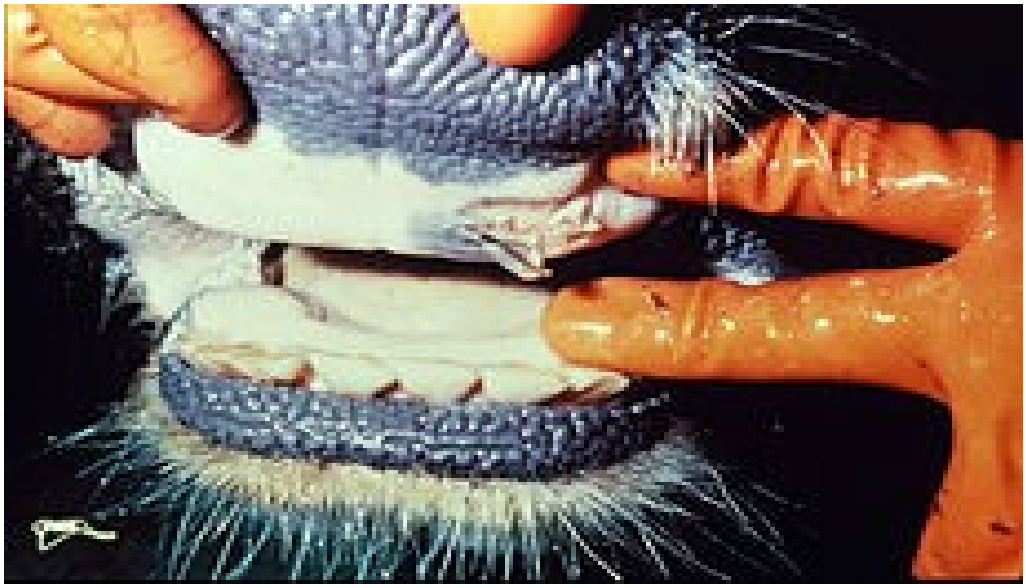

Figure (2): Signs of foot-and-mouth disease includes Vesicle.
(DAFWA. 2013).

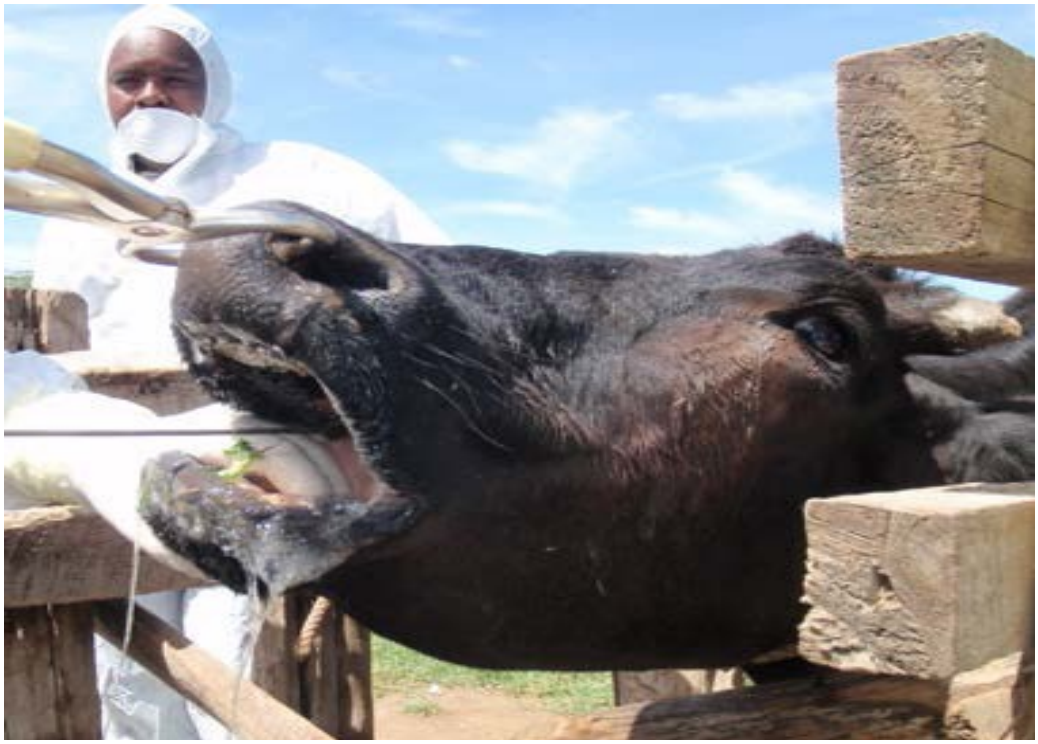

Figure (3): Signs of foot-and-mouth disease include drooling (DAFWA. 2013)

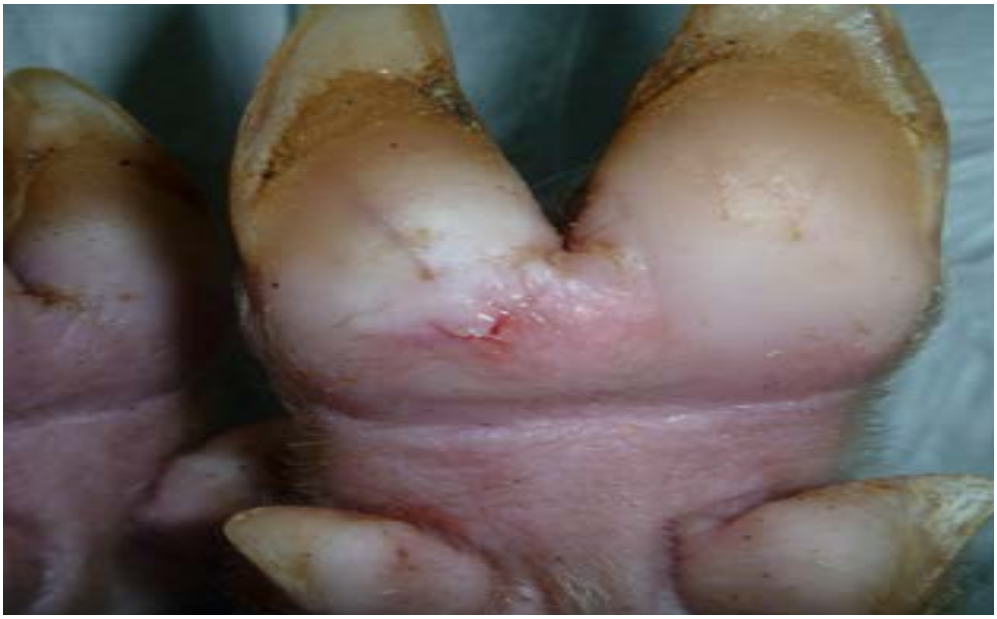

Figure (4): Signs of foot-and-mouth disease includes blisters on feet. (DAFWA. 2013)

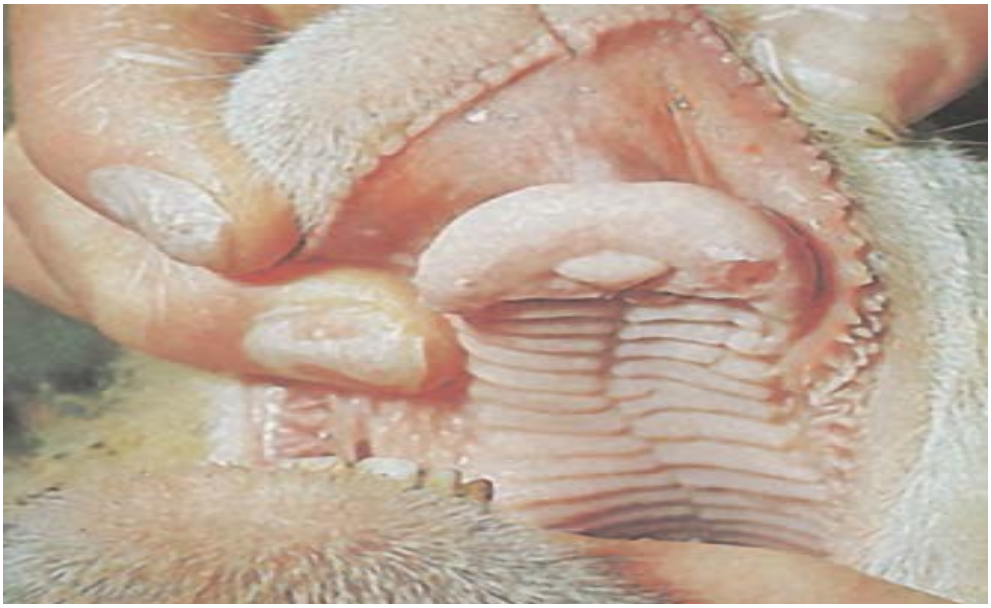

Figure (5): signs of foot-and-mouth disease includes blisters on tongue.

(DAFWA. 2013)

1.8. Post Mortem Lesions:

The characteristic lesions of foot and mouth disease are single or multiple, fluid-filled vesicles or bullae from 2 mm to 10 cm in diameter. The earliest lesions can appear as small pale areas or vesicles. Some vesicles may coalesce to form bullae. Vesicles are generally present for only a short period. Once they rupture, red, eroded areas or ulcers will be seen. These erosions may be covered with a gray fibrinous coating, and a demarcation line of newly developing epithelium may be noted. *(Fiebre, A. 2007).*

The diagnostic lesions are single or multiple vesicles ranging from 5mm to10cm. These can occur in all sites of predilection. Occasionally dry FMD lesions develop in the tongue .Instead of forming a vesicles, the fluid is apparently lost as it forms and the upper layers of the epithelium become necrotic and discolored .The lesion therefore appears necrotic rather than vesicular. The

vesicle in the interdigital space is usually large because of the stress on the epithelium caused by movement and weight. The lesion at the coronary band at first appears blanched then; there is separation of the skin and horn. When healing occurs, new horn is formed but a line resulting from the coronitis is seen on the wall of the hoof. Animals that die may have grayish or yellowish streaking in the myocardium due to degeneration and necrosis. These finding are known as tiger heart, but are histologically no different from any other acute myodegeneration or viral inflammation of heart muscle. Skeletal muscles lesions occur but are rare. Occasional erosions are observed on the epithelium of the rumen pillars.

(*Corrie, B.*, 2008).

1.9. Morbidity and Mortality:

The disease morbidity can reach up to 100%, especially in a non-immune population; however, mortality is usually restricted to young animals that can develop viral myocarditis. In adult cattle, mortality is normally below 5% whereas calves can have a mortality of up to 50%. (*Kinzang, D.*, *2011*).

Morbidity is usually very high (close to 100%) in fully susceptible cloven-hoofed domestic animals. However, it does depend on the conditions under which the animals are kept. Consequently, sheep kept under intensive conditions indoors may have a high morbidity, while sheep kept under low-intensity conditions outside may have a much lower morbidity.

In tropical areas, some cattle that have recovered from acute FMD suffer from a wasting syndrome in which they have a staring coat (a dry hair coat lacking in luster, usually carrying dandruff, or scurf) and dyspnea. They have been called "hairy panters." The underlying pathology has not been determined, but its link to hyperactive thyroid-adrenal function has been hypothesized.

Mortality in adult animals is usually low to negligible. Up to 50% of calves may die due to cardiac involvement and complications such as secondary infection, exposure, or malnutrition. *(CFIA.2013).*

1.10. Diagnosis:

The accurate diagnosis of infection with FMDV is of prime most importance for both control and eradication campaigns in FMD endemic areas and as a supportive measure to the stamping out policy in FMD-free areas.

(*Neeta,L.***,** *2011*).

1.10.1 .Clinical:

The presence of a vesicular disease should be suspected any time that there are

Vesicular lesions in cloven – hoofed domestic or wild animals. Due to the in ability to distinguish clinically among the different vesicular disease, it is absolutely necessary to submit samples to competent laboratory. The fact that FMD virus spread extremely fast and that there are serious trade consequences if FMD is diagnosed in any country in the world means that prompt submission of quality samples for laboratory diagnosis is a must. **(***Corrie, B.***,** 2008).

1.10.2. Differential diagnosis:

The differential diagnosis of diseases causing oral lesions in cattle can pose problems both clinically and at necropsy. Several diseases can be associated with crusting of the muzzle, and erosion, ulceration, necrosis and, occasionally, vesiculation of the oral mucosa. Few signs or lesions associated with oral infection are pathognomonic and an aetiological diagnosis based solely on clinical observation is often not possible. **(***Andrew, H.***,** *2005*).

Sometimes, a differentiation from FMD is not possible on the basis of clinical signs and gross lesions, necessitating further laboratory investigations. This applies in particular to cases caused by the agents of vesicular stomatitis (VS) and swine vesicular disease (SVD). Additionally, other infectious agents can cause stomatitis, e.g. the viruses of mucosal disease (MD), malignant catarrhal fever (MCF), rinderpest, papular stomatitis, orf, blue tongue (BT) and epizootic haemorrhagic disease (EHD). **(***Teikfke, J.P. et al., 2012*).

1.10.3. Laboratory tests:

FMD will be confirmed through the use of internationally recognised and validated tests carried out at the national reference laboratory. There are three types of laboratory test: two detect the presence of virus (antigen ELISA and virus isolation and PCR type tests) and one detects the presence of antibody produced by an infected animal in response to infection. *(Defra.2011).*

FMDV is identified using enzyme-linked immune sorbent assay (ELISA), complement fixation, or reverse transcription polymerase chain reaction (RT-PCR) tests. Serological tests can be used for diagnosis as well as to certify animals for export. Antibodies to FMDV structural proteins are used to diagnose previous or current infections in unvaccinated animals. These tests include ELISAs and virus neutralization tests, and are serotype specific. Serological tests that detect antibodies to nonstructural proteins (NSP) can diagnose previous or current infections in vaccinated animals. Anti-NSP tests include ELISAs, and are not serotype specific. *(Fiebre, A. 2007).*

1.11. Samples to collect:

Before collecting or sending any samples from vesicular disease suspects, the proper authorities should be contacted. Samples should only be sent under secure conditions and to authorized laboratories to prevent spread of the disease. Since vesicular diseases cannot be distinguished clinically, and some are zoonotic, samples should be collected and handled with all appropriate precautions.

(Fiebre, A. 2007).

Blood samples should be collected under sterile conditions and mixed as soon as possible with the anticoagulant heparin (0.1-0.2 mg per ml of whole blood). Sequestrene EDT A can be used as an alternative anticoagulant (30 mg of Sequestrene EDT A in one ml of 0.7% aqueous solution sodium chloride per 20 ml of whole blood). The sample should be kept at 4°C until dispatched to the World Reference Laboratory. Serum, rather than whole blood, must be submitted. A minimum of 4 ml is essential. Should lesser amounts be submitted there is a risk that re-sampling may be required with subsequent delay.

It is essential that sterile containers be used. If sera have been collected under sterile conditions they can normally travel satisfactorily without refrigeration. *(Kitching, R.P. et al., 1987*).

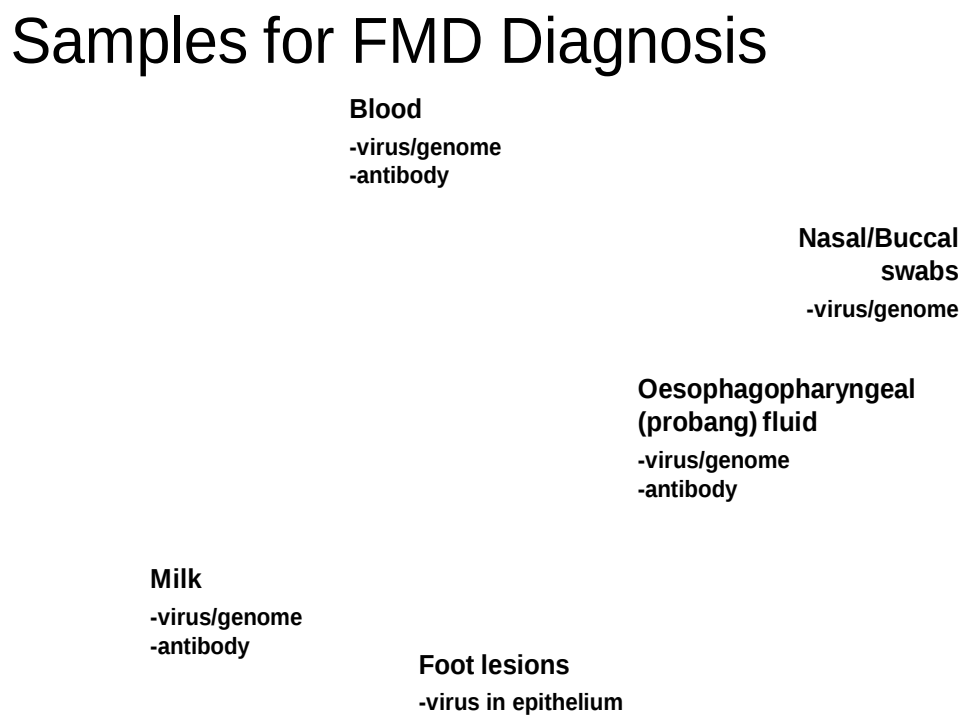

Figure (6): Samples for FMD Diagnosis

1.12. Recommended actions if foot and mouth disease is suspected

1.12.1. Notification of authorities:

The disease is notifiable: if you suspect the disease, **you must immediately notify the duty vet in your** local Animal Health Veterinary Laboratories Agency (AHVLA) office. (*Defra.2013*).

1.13. Control:

The initial measures in the global strategy for dealing with FMD are early detection and warning systems and prevention and rapid response measures and mechanisms in place. This contributes to monitoring the occurrence, prevalence and characterization of FMD viruses. Protection of FMD free countries, areas, or zones is

enhanced with stringent import and cross-border animal movement controls and surveillance. It is essential for livestock owners and producers to maintain sound biosecurity practices to prevent introduction/spread of the virus. Measures that are recommended at the farm level include:

- Control the introduction of new animals to existing stock.
- Control over access to livestock by people and equipment.
- Maintain sanitation of livestock pens, buildings, vehicles and equipment .
- Monitor and report illness.
- Appropriate disposal of manure and dead carcasses.

Contingency planning for potential outbreaks will identify the elements included in a response effort to eradicate the disease, such as:

- Humane destruction of all infected, recovered and FMD-susceptible contact animals.
- Appropriate disposal of carcasses and all animal products.
- Surveillance and tracing of potentially infected or exposed livestock.
- Strict quarantine and controls on movement of livestock, equipment, vehicles, and;

thorough disinfection of premises and all infected material (implements, cars, clothes, etc.)

In endemic areas, culling may be complemented by vaccination for susceptible livestock. Vaccines used must protect against the particular virus strain prevalent in the area. *(OIE Terrestrial Manual.2014).*

1.14. Public Health:

FMD is not considered zoonotic at the exposure levels that would be experienced by response personnel. In 1968, the World Health Organization (WHO) dropped FMD from its list of zoonoses, and it is considered a rare human disease, rather than a public health problem.

FMDV infections in humans are very rare, with about 40 cases reported in the literature since 1921. The majorities of these cases were diagnosed without laboratory confirmation and are thus viewed with scepticism by some FMD researchers. Most of these cases existed as subclinical infections. Humans are believed to become infected through skin wounds or through the mucosa by handling infected livestock, contacting the virus in the laboratory, or drinking infected milk. Infection does not occur through eating cooked or normally prepared meats. These rare infections are temporary and mild, and FMD is not considered a public health problem*. (CFIA.2013).*

1.15. Economic:

The most direct economic impact of FMD in endemic countries is the loss or reduced efficiency of production, which lowers farmers' income. The impact of reduced productivity of animals can be prolonged, and diseases can have lasting effects on livestock output in a number of ‘hidden’ ways such as delays in reproduction leading to fewer offspring, resulting in a reduced livestock population. *(Tariku, J. et al., 2013).*

1.15.1. Direct impacts:

1.15.1.1. Visible losses:

Production losses due directly to FMD include:

– reduced milk production.

– reduced livestock growth.
– Mortality in young stock.
– Loss of traction power where draught animals are used.
– Abortion.
–Although FMD typically has a short-term effect on an animal's health, chronic FMD typically reduces milk yields by 80%. *(Jonathan, R .et al., 2012).*

The economic impact of an outbreak of foot and mouth disease that took place during 2002 was assessed in dairy farms of Khartoum state, Sudan .The overall cost to the dairy farmers in the state was estimated USD 1 771 924 with the loss in milk production constituting the main component in this cost.
(El-Hussein, A. M .et al., 2012).

1.15.1.2. Invisible losses:

FMD causes problems with fertility, the most obvious are the abortion losses explained above, but there are longer lasting impacts of this loss of both fetus and a reduced probability of conception. These both translate into the need to have a greater proportion of breeding animals in a population implying that for every kilo of meat or milk produced there is an additional fixed cost to cover more breeding stock. *(Jonathan, R .et al., 2012).*

1.15.2 Indirect impacts: (Additional costs)

1.15.2 .1.Control costs

The cost of control measures carried out by the state veterinary services, such as vaccination, outbreak control and sometimes culling and compensation are borne by the tax payer.

– An estimated 2.6 billion doses of FMD vaccine are administered annually. Estimated global FMD vaccine use:

Region	Million doses/year	Comments
China	1.6 billion doses	5 government
South America	500	Brazil: 350 million doses
Asia (excluding China)	200	India: 150 million doses
Middle East	20	
European region	15	Mainly Turkey
Africa	15	

– Some national FMD vaccination programmes vaccinate all bovines three times a year this limits resources available to combat other diseases.

– In endemic settings significant amounts are spent on privately funded vaccination and control.

– In some areas wildlife are kept out of FMD free zones with extensive fencing at great financial cost not to mention the impact this restriction has on wildlife.

In Africa it has been estimated that more is spent controlling FMD than any other veterinary disease**.** Even if a country is FMD free there are ongoing costs due to:

– Efforts to reduce the chance of disease re-introduction, including border and import controls and inspections and sometimes vaccination.

– Efforts to maintain the capability for early detection and control of FMD, including surveillance, ensuring sufficient organizational capacity in the veterinary services which are tested by outbreak simulation exercises (ref, outbreak exercises) and permanent restrictions on the livestock sector (such as post movement standstills).

– Dealing with outbreaks, which may involve culling, movement restrictions and vaccination. Outbreaks in animals lacking prior immunity to FMD are particularly dramatic:

i) Control measures can affect other industries.

ii)The impact of culling based control measures can have other non-financial impacts. Culling healthy animals is a politically sensitive issue and is seen as unnecessary and inhumane by much of the wider public.

iii) Movement restrictions disrupt production and may even lead to welfare problems that lead to further culling.

1.15.2 .2. Market access: (Revenue foregone)

– Livestock trade is limited; those affected by FMD receive lower prices for their stock, those wishing to purchase animals from FMD free herds face a restricted supply.

– Countries infected with FMD cannot trade live animals with FMD free countries.

– The trade of livestock products is also restricted, if regular outbreaks occur only processed, tinned products can be exported to free countries; if FMD is effectively controlled with vaccination by a competent veterinary services able to detect outbreaks then deboned meat can be exported.

– Trade of fruit and vegetables can also be affected by FMD status.

– The FMD status of nations that a country trades with also affects a country's ability to trade with FMD free countries irrespective of its own status.

– Lack of access to lucrative markets restricts the development of commercial farming, consequently employment and tax revenue from this area is limited by FMD status.

– Investment in the livestock sector is limited if there is a perceived risk that FMD may occur. *(Jonathan, R .et al., 2012).*

FMD Impact

Indirect		**Direct**	
Revenue Foregone	Additional Cost	Invisible Losses	Visible Losses
• Use of suboptimal breeds	• Vaccines	• Lower fertility	• Loss of milk production
•Denied access to markets both local and international	• Vaccine delivery	• Change in the herd or flock Structure	• Loss of draught power
	• Movement control		• Lower weight gains
	• Diagnostic tests		•Dead animals

The direct and indirect impacts of foot and mouth disease

(Jonathan, R .et al., 2012).

1.16. Vaccination:

The aim of vaccination is to protect animals against the production losses which FMD may cause. To be effective the vaccine must be potent, safe, antigenic ally matched against the strains of virus circulating or likely to pose a threat, and properly administered so as to provide an optimal response.

) Copland, J.W.et al., 2009).

Vaccines are widely employed to control FMD. The vaccines currently available are inactivated and contain whole virus in a semi-purified state. Vaccines may include one or several of the serotypes but the strain used should match the field strains that are causing the disease. Most vaccines contain aluminum hydroxide as an adjuvant. A high level of immunity can be induced by potent vaccines within a few days in both cattle and pigs, but the interval between vaccination and protection may be some 14 days with the usual commercial vaccines. The current generation of FMD vaccines protects animals for periods up to 12 months. *) Zinna.et al., 2002).*

1.17. Treatment:

No. Affected animals will recover. Vaccines can protect against the disease but do not necessarily prevent animals from being infected. Vaccination is used in many countries to control the disease in an endemic situation. In order for a country to regain FMD-free status and limit the economic impacts, it is important to eradicate the virus as quickly as possible. Movement controls and removal of infected animals (along with other complementary control measures such as

cleaning and disinfection) are essential to eradicate this disease. Vaccination can be an important tool to assist in containing and eradicating FMD, but its use will have trade implications.

1.18. Prevalence of FMD in the world:

In Somalia Regional State (Awbere and Babille Districts) Western, Ethiopia a cross-sectional seroprevalence study of cattle foot and mouth disease (FMD) was conducted. 384 blood samples were collected in the period of October 2009 to March 2010 from 384 animals and tested for antibodies against non-structural protein of FMD virus by using the 3ABC-ELISA. The overall individual animal antibody seroprevalence was 14.05% (95% CI = 11.2 to 18.13%). Statistically no significant variation ($P > 0.05$) was observed in the prevalence of FMD in Awbere (14.2%) and Babille (15.1%) Districts. Similarly there was no significant variation ($P>0.05$) in seroprevalence among male (19.4%) and female (13.6%) animals. Seroposetivity recorded for calves (Zero), young (13.2%) and adult (18.9%) age groups of animals showed a significance variation ($\chi 2 = 8.45$, DF = 2, $P = 0.01$). (*Abdulahi, M. et al., 2011*).

Another cross sectional study was conducted during November 2007 to April 2008 in three districts of Bale Zone, Oromiya regional state to determine seroprevalence of Foot and Mouth Disease virus and to obtain local perception regarding the disease in the study area. A total of 301 bovine serum samples were collected from two districts and one dairy farm (Sinana 172, Goba 109 and Agarfa dairy farm 20). Semi structured questionnaire format was prepared and 80 informants were interviewed. Out of 301 serum samples examined at National Veterinary Institute by 3ABC ELISA 65 (21.59%) were positive for the disease FMD. The highest prevalence was observed at Sinana (24.41) followed by Goba (20.18%) and Agarfa dairy Farm (5%). The difference in prevalence between these

sites was statistically non-significant (P= 0.066). The prevalence among age category and breed type was calculated and there is no significant difference (P=0.539 and P= 0.599 respectively). Semi structured interview result showed that out of 80 informants, 74 have described a consistent and valid clinical picture of FMD and other epidemiological information similar with other scientific literatures. *(Misgana, D. et al., 2013*).

In another study aimed to determine the prevalence of Foot and Mouth Disease (FMD) of cattle in Kenya especially in the Somali Eco-system (SES) in Kenya with 499 sera collected from January 2007 to December 2008. The samples were screened against the five serotypes of FMD known to be in circulation in Kenya i.e., FMD O. A, C, SAT1, SAT2 and measured by micro neutralization assay. The overall sero-prevalence of FMD in the Somali-ecosystem was found to be 45.3% (95% CI = 40.96 to 49.66%). Twenty seven percent of all animals sampled tested positive for only one serotype while17.6% tested positive for multiple serotypes. There was a high prevalence (p#0.05) in the circulation of serotype O (23 and 95% CI = 20.13-27.57%) as compared with the other serotypes, while the prevalence of serotype C was significantly lower (p#0.05) compared to the other four serotypes (1.6 and 95% CI = 0.82-3.12). Wajir district recorded the highest prevalence (24.8 and 95% CI = 16.71 to 27.54) while Garissa district recorded the least (6.2%). There was no significant sero-prevalence variation in relation to sex while old animals had higher sero-prevalences. The pastoral mode of livestock production, porous borders and wildlife inter-phase are significant factors that need consideration for effective control programmes. *(Chepkwony , E.C. et al., 2012*).

In Nigeria with the objective of determining the seroprevalence of foot and mouth disease (FMD) in cattle, a serological survey was conducted between 2009 and 2011 in six Border States and two other states that lie on the major cattle trek routes.. Four hundred and forty-eight (448) sera were screened for FMD antibodies using the Enzyme-linked immunosorbent assay (ELISA) including samples collected during suspected field outbreaks. Statistics was conducted by using the

modified Wald method and two-by-two contingency table. Higher seroprevalence was recorded in cattle samples from Yobe State (82%), followed by those from Plateau (80%), Ogun (77.77%), Taraba (73.50%), Adamawa (68%), Borno (67%), Sokoto (63%) cattle and Bauchi (27.84%). There is no difference in seropositivity between cattle sampled at the border and those from the trek routes.
(Lazarus, D. D. et al., 2012).

Another cross sectional study was conducted on serum from 39 counties in Kenya in order to determine the prevalence of foot and mouth disease in bovine species. From the serology results, the national prevalence of foot and mouth disease in bovines was 52.5% (CI = 95). Of the 3709 samples subjected to Nonstructural protein (NSP) enzyme linked immune sorbent assay (ELISA) screening test, 1,947 of those were interpreted as positive representing 52.5% (1947/3709) while the other 1,762 samples turned negative representing 47.5% (n = 1,762). There was significant association between seropositivity and age groups (p = 0.002) and vaccination status (p = 0.048) but no association between the seropositivity and sex (p = 0.063). *(Kibore, B. et al., 2013*).

An Epidemiological study was conducted in Rajshahi, between July 2010 and February 2011 with the objective of determining the prevalence of Foot- and –mouth disease (FMD) in cattle to identifying the potential risk factors associated with the disease. In total, 347 skin diseased cattle were examined in the Veterinary Clinic of the University of Rajshahi. Among them, 154 were males and 139 were females. The overall prevalence of FMD in Rajshahi was found to be 25.07% (n=87). From the various risk factors analyzed, age categories of animal, farming system, sex, breed and seasonal influence were found to be significantly associated ($p < 0.01$) with the prevalence of FMD. Finding suggested that the seasonal influence on outbreaks of this disease was significantly higher. The clinical prevalence of FMD was higher in the month of November (35.59%) and December (37.14%). The influence of sex of FMD outbreaks was estimated to be significantly ($p < 0.01$) higher in males than females cattle. As regards to age, FMD was

significantly ($p < 0.01$) higher in old (36.53%) compared to adult (22.22%) and young (8.08%). Given the higher prevalence (41.46%) of FMD in indigenous breed, it is advisable to establish appropriate FMD control measures in cattle. *(Sarker, S. et al., 2011*).

By using non structural protein 3ABC ELISA kit, a cross sectional study was conducted to estimate the seroprevalence of Foot and Mouth Disease in cattle from November 2010 to March 2011 at Dire Dawa and its surroundings. The overall prevalence of Foot and Mouth Disease was 8.01 % (79/986). There was a statistically significant difference observed in the prevalence of FMD with the origin ($p= 0.004$) and the age of the animals ($p= 0.006$). There is a tendency of progressively increased prevalence with increasing age and the odds of animals in age band of 3 to 4 years and above 4 years of age was 3.46 and 2.43 times at more risk of infection than young animals (age group less than 3 years). However, there was no statistically significant difference observed in the case of sex of the study animals ($p>0.05$). *(Fufa , A. et al., 2013*).

In Southwestern Ethiopia between November 2007 and February 2008 , a cross-sectional sero-epidemological study was conducted in two districts of the Bench Maji Zone, with the objective of determining the seroprevalence of Foot and Mouth Disease (FMD) in cattle and identifying the potential risk factors associated with the disease. Sera samples were collected from a total of 273 cattle in 98 herds. The sera were submitted to the National Veterinary Institute (NVI), Debre zeit, Ethiopia for screening using the3ABC-ELISA. The overall seroprevalence of FMD was 12.08% (n=273). Significantly higher seroprevalence (20%) was recorded in the Surma district compared to the Semen Bench district (5.88%). Peasant associations (equivalent to villages in a district) had prevalence rates of 25, 20, 15, 8.16, 5.66 and 3.92% for Kibish, Tulgit, Koka, Aman, Mizan and Temenja-yasz respectively. From the various risk factors analyzed peasant associations, cross boundary movement and herd size were seen to be statistically associated ($p<0.05$) with the

seroprevalence of FMD. There was no significant variation in seroprevalence among sex, age and herd type. *(Esayas , G. et al., 2009*).

In this study the authors investigated antibodies against FMD virus (FMDV) in cattle in surrounding areas of Lake Mburo National Park in South-Western Uganda. 2011 serum samples from 23 cattle herds were examined for the presence of antibodies against FMDV non-structural proteins and structural proteins.

Furthermore, serotype-specific antibodies against the seven serotypes of FMDV were determined. Of the sera tested, 42.7% (90/211) were positive in the ELISA for antibodies against non-structural proteins, while 75.4% (159/211) had antibodies against the structural proteins of FMDV serotype O. Titres of ≥ 1:160 of serotype-specific antibodies in SPBEs were identified in 61% (19/31), 33% (5/15), 6%7 (20/30), 37% (10/27) and 12% (4/33) of the investigated samples for serotypes O, A, SAT 1, SAT 2 and SAT 3, respectively. This study indicates that most of the FMD outbreaks in the cattle herds in the investigated area were probably caused by FMDV serotype O, A and/ or SAT-serotype(s). *(Frank, N. M.et al., 2010*).

A cross sectional study using3ABC- ELISA technique was conducted on Borana plateau and Guji highlands of southern Ethiopia to determine the prevalence of Foot and Mouth Disease (FMD) in bovine species. The result indicated that the overall prevalence of Foot and Mouth Disease was 24.6 %(113/460). Significantly higher prevalence was recorded in Borana 53.6 %(82/153) compared to Guji 10.1 % (31/307). From the various risk factors, geographical distribution ($\div^2$=104.26, P<0.05) and age ($\div^2$=6.68, P<0.05) were seen to be significantly associated with the seroprevalence. The result of this study indicated that FMD is highly prevalent in lowland area (Borana) than highland (Guji) due to contact of different origin cattle in search of feed and water. *(Habtamu, M. et al., 2011*).

In Northeast Ethiopia, during October 2007 to April 2008 a cross sectional study was conducted to determine seroprevalence and associated risk factors for seropositivity of FMD. Antibodies against non-structural protein of FMD virus (using 3ABC ELISA) were measured as indicator of exposure to the virus. An

overall seroprevalence of 5.6% (48.4% at herd level) for FMD was found. Differences in geographical locations, age groups and herd sizes were risk factors found statistically ($p<0.05$) associated with the occurrence of FMD.
(Shiferaw, T. J. et al., 2011).

Another cross sectional serological surveys was conducted between March and December 2009 to determine the distribution of foot-and-mouth disease and also to validate the current passive surveillance system in Bhutan. A total of 1909 sera collected from cattle, goats, sheep, and pigs, from 485 herds in 106 villages, were tested using a foot-and-mouth disease non-structural protein 3ABC ELISA. The true prevalence at the animal-level for all species was 15% (95% CI: 13.5, 16.7) using the sensitivity (97.2%) and specificity (99.5%) for cattle. The true prevalence for cattle was 17.6 (95% CI: 15.6, 19.5).

The sub-districts that shared border with India had significantly ($p = 0.03$) higher seroprevalence than the interior sub-districts. Villages located in the sub-tropical zone had significantly ($p < 0.0001$) higher seroprevalence than those located at high altitude zones. Herds with known outbreaks of FMD were 3.6 times more likely ($p < 0.001$) to be seropositive than those with no history of outbreaks of FMD.
(Kinzang, D. et al., 2011).

The present study is carried out in two district of Rwanda, yagatare district from Eastern Province where FMD outbreak occurred in 2009, and Gisagara district, from Southern Province where FMD was declared in last two years. The serum samples were tested using the FMD non-structural protein ELISA to determine if animals in the herd had been recently infected with FMD virus/es (*O* and SAT-2), thereby estimating the seroprevalence in the district. In Nyagatare district prevalence FMD is 53.3% (n=195), this is comparable to the 23.85% prevalence reported in Gishwati-grazing area in Nyabihu district. The prevalence in Gisagara district is 10.8% where FMD outbreaks occurred in last 2 years and the difference was statistically significant ($P<0.05$). This is comparable with 13.6% prevalence rate observed among cattle in Rusizi district and confirms recent FMD infection.

*(UWIZEYE, A. et al.*2010).

The aim of this study was to determine the seroprevalence and serotype-specificity of the circulating antibodies against Foot-and-Mouth Disease Virus (FMDV) in cattle in Kasese and Bushenyi districts in Uganda. A total of 309 serum samples were collected and tested for antibodies against Non-Structural (NS) and Structural Proteins (SP) using Ceditest® FMDV-NS and C editest® FMDV type O test kits. Seroprevalences were much higher in Kasese in both tests (61 and 43%, respectively) than in Bushenyi (3 and 4%, respectively). A high proportion of sera, that tested positive in the NSP test, were subjected to seven serotype specific blocking ELISAs for antibodies against the seven FMDV serotypes (O, A, C, Asia 1, SAT 1, SAT 2 and SAT3). The study showed presence of antibodies against four FMDV serotypes with decreasing magnitude as follows: O> SAT 1> SAT 3/SAT 2. *(Mwiine, et al., 2010*).

In Saudi Arabia An immune diffusion test using foot and mouth disease (FMD) virus infection-associated (VIA) antigen was used to detect precipitating antibodies in serum samples collected from non-vaccinated indigenous ruminants raised in different regions of Saudi Arabia. Of 1,052 cattle sera precipitating activity was detected in 172 (16%) samples. In addition, 100 sera showing precipitating activity against VIA antigen originating from 13 different regions were tested for the presence of naturally-occurring neutralizing antibodies against the four serotypes of FMD virus (O, A, Asia 1, and C) currently prevalent in the region and incorporated in the vaccine being used. The results obtained are interpreted with regard to the geographical distribution and epizootiology of FMD in Saudi Arabia.
(HAFEZ, et al., 1994).

A serological survey to investigate risk factors for Foot and Mouth Disease (FMD) occurrence was conducted between October 2007 and March 2008 in Southern Ethiopia. Antibodies against non-structural protein of FMD virus (using 3abc ELISA) were measured as indicator of exposure to the virus. The seroprevalence of FMD was 9.5% (95%CI=7.7 – 11.3, n=1020) and 48.1% (95%

CI=36.8 – 59.4%, n=79), respectively at animal and herd levels. Within herd seropositivity was ranged from 6.7 to 46.7% with 18.6% (95%CI=14.6 – 22.5%) risk of being seropositive for an animal in positive herds. The most important herd level risk factors identified were pastoral system (OR=16.3, 95% CI=2.0 -133.7) compared to sedentary, low altitude (OR=7.5, 95% CI 1.4 -40.7) compared to high altitude, keeping cattle with small ruminants (OR=5.1, 95%CI 1.0 -25.2) when compared to one species or alone. Seroprevalence was significantly higher (P <0.05) in South Omo than Sidama and Gamo Gofa areas. The odds of seropositivity were 2.8 and 2.3 times higher in the adult (>4 years) and maturing animals (3–4 years) compared to young age category (<3 years). Both multivariable logistic and negative binomial regressions depicted that production system was the major risk factor for FMD seropositivity. *(Megersa, et al., 2009*).

In Sudan, A screening format of serum neutralization (SN) test was used to screen Sudanese cattle sera against current infection of type "O" and "SAT2" foot-and-mouth disease (FMD) viruses. The format was easy to perform; reading of results was objective and it detected high seropositivity in distinct test groups of cattle; as high as 82.6% and 43.7% for types "O" and "SAT2" respectively. Similar figures to these have been reported using the sensitive liquid-phase blocking ELISA (LPBE) in recent different occasions. Results obtained by the screening format confirmed recent serological findings obtained by the LPBE. Serotype specific antibodies against types "O" and "SAT2" were significantly higher in tested cattle (63.15% and 20.63% respectively). Seroprevalence of antibodies to the long known predominant type "O", unlike seroprevalence of type "SAT2" antibodies, was markedly lower in local (33.3%) than in cross (63.15%) tested cattle breeds. In Western Sudan, where local breeds of cattle prevail, seroprevalence of antibody to the moderately prevalent type "SAT2" (40%) even surpassed that of antibody to type "O" (25%).
(Raouf, Y.A. et al., 2012).

The objectives of the study reported here were to identify current FMD virus strains circulating in cattle herds and to identify exposure factors associated with a

seropositive diagnosis of FMD in cattle herds in Nigeria. Cattle herds in a neighborhood affected with FMD had higher odds of being classified as seropositive to FMD, compared to herds that were in a neighborhood not affected with FMD (OR=16.27; 95% CI=3.61, 18.74; P<0.01). Cattle herds that share water points along the trek routes with other cattle herds had higher odds of being classified as seropositive to FMD (adjusted OR=4.15; 95% CI=0.92, 18.74; P<0.06).
(Fasina , F.O. et al., 2012).

Prevalence of antibody against types “O”, “A” and “SAT2” of foot-and-mouth disease virus (FMDV) was studied in cattle sera collected in the year 2005 from Khartoum State at central Sudan, using the liquid-phase blocking ELISA (LPBE). Results showed high prevalence of type “A” antibody (85.65%) followed by that of type “O” (81%) then “SAT2” antibody (65.78%). Apart from an observed natural resistance in local breeds to type “O” infection, no epidemiological factor seemed to affect separately the prevalence’s of each of the three serotypes; prevalence rates of the serotype-specific antibody increased or decreased simultaneously in different locations. Prevalence was higher in the west and south than in the east and north of the State, coinciding with the known direction of animal movements in Sudan, and higher near traffic lines than in milking farms, where sedentary type of management prevails. The result indicated the maintained activity of three serotypes of FMDV at central Sudan. Prevalence of type “O” antibody was similar to that previously reported in Sudanese cattle and that of “SAT2” was coinciding with the history of its introduction in Sudan. The much higher prevalence of type “A” antibody than the earlier report was likely to be due to testing of sera at low dilution (1/32) in the present LPBE in comparison to high dilutions (1/100 to 1/200) in previous work. This is apparently more to be relevant since the present LPBE distinguished positivity to type “A” from that to type “O” and “SAT2” by lower number of strong positive sera and more sharp decline of their titration curves, consistent with the known antigenic diversity of this virus type. *(Raouf, Y. A. et al., 2011*).

A total of 1,069 sera were collected from cattle, sheep, goats, and camel, from seven states in the Sudan, for the detection of antibodies to FMDV. Application of liquid phase blocking (LPB) ELISA revealed that antibodies to four serotypes were present in ruminants; namely O, A, SAT 1 and SAT 2. No antibodies to FMDV were detected in camel sera. The results differed from early reports regarding the prevalence of serotype specific c antibodies in different species; for instance, in cattle, the antibodies to type A (78.13%) surpassed that of type O (69.39%) and the antibodies to type SAT 2 (44%) surpassed that of type SAT 1 (20.2%).
(Mohammed, et al., 2010).

Serological evidence of exposure to foot and mouth disease virus (FMDV) was assessed in traditionally managed cattle in 21 districts of East and West Hararghe zones in Oromiya State, Ethiopia, through a cross-sectional survey conducted between November 2008 and March 2009. Sera collected from 504 cattle were tested for antibodies against FMDV using a commercial ELISA. Antibodies to FMDV were detected at an overall prevalence rate of 11.6% [95% confidence interval (95CI): 8.6–14.5%]. In West Hararghe the seroprevalence was significantly ($p < 0.05$) higher (25.7%; 95CI: 19.6–31.9%) than in East Hararghe (1.4%; 95CI: 0.0–3.3%). Location [odds ratio (OR) 0.87], altitude (OR 0.62), and age (OR 1.12) were found to be significant infection risk factors. Cattle sampled in the lowlands had a significantly ($p < 0.05$) higher FMDV seroprevalence (36.2%) than those in the highlands (3.4%). Furthermore, cattle in districts dominated by agropastoralists and those closer to the pastoral and agropastoral communities of Somali (6.4%) and Afar (21.3–46.1%) regional states showed higher seropositivity. The study found that FMDV circulated in the areas at a relatively low frequency, which may however increase because of unrestricted movement of animals within the region and across borders. *(Yahya, M. et al., 2013*).

The prevalence of antibodies to foot-and-mouth disease (FMD) virus was determined in 1611 sera collected in 1979 and 1980 from cattle, sheep and goats in Sudan, using the enzyme-linked immune sorbent assay (ELISA) and serum

neutralization (SN) tests. The double immune diffusion (DID) test was used to detect antibodies against the virus infection associated antigen (VIA). Antibodies against VIA antigen, indicating infection with FMD virus was detected in 53 p. 100 of the cattle. 2 D. 100 of the sheep and 4 D. 1OWof the goats tested. Antibodies to ty& 0 were predomi-riant and 'were tested in-47 p. 100 of a11 animals tested. Antibodies to types A and SAT 1 were detected in28 p. 100 and 25 p. 100, respectively, of a11 animals examined. Type SAT 2 antibodies were detected onlv in cattle in one location. The highest incidence of type 6 antibodies was demonstrated in cattle, whereas that of type SAT 1 was detected in goats and that of type (A) in sheep. *(Abu Elzein, E. M. E. et al., 1987).*

During February and March 2007, a sero surveillance was conducted in Amman, Jordan. Clinical specimens were collected from 258 cattle in different provinces of Jordan, in which the history of FMD vaccination was known. Three vaccinated cattle herds and one vaccinated mixed herds for sheep, goat and cattle had reported outbreaks of disease two to three months previously. Out of total 258 cattle, 160 cattle were sampled from 4 vaccinated farms where clinical lesions were observed whereas 98 cattle from five vaccinated herds were sampled from no outbreak area to find out the tests. The overall sero-prevalence for vaccinated cattle varied with different NSP tests from 30% to 82% with a tests specificity of 92% to 97%.
(*Amareen, S. et al., 2008).*

CHAPTER TWO

MATERIALS AND METHODS

2.1. Description of the Study Area

The study was conducted in Khartoum State. The State lies between longitude 31.5 -34 east and latitude 15-16 north in an area about 28.165 square kilometers. It is bordered to the north and the east side by the River Nile State, to North Western by the Northern State, and to the east and south-eastern and south by Kassala, Gedaref and Gezira state respectively and to west by North Kordofan . Most of the Khartoum state lies in the climatic semi-desert region, while northern areas lie in desert zones. The climate of the state is ranging from hot to very hot. The weather is rainy in summers, cold and dry in winters. Average rainfall reaches 100-200 mm in the north-eastern areas and 200-300 mm in the North Western areas. Temperature ranges in summer between 25-40 degrees in the months from April to June, and 20-35 in the months from July to October. In winter, however, temperatures continue to decline between November to March from 25-15degrees.

Geographically, Khartoum state is divided into three blocks: -

A / first block: it starts from the Mugran, i.e. the confluence of the two rivers (the blue and white Niles). Being confined between them, this block extends southwards to the boundaries of the Gezira state. Administratively, it is divided into two localities, Khartoum and Jabel awlya localities.

B/ second block: is limited between the Blue Nile and the River Nile. It includes the localities of Khartoum North and East of the Nile, North or Khartoum North represents a largest one of the towns of this block.

C / third block: namely, the one located west of the White Nile and the River Nile and includes three localities, which are: Omdurman, Om bada and Karari localities. (FMARF, 2014).

Figure (7): Map of the study area Khartoum state in Sudan (FMARF, 2014)

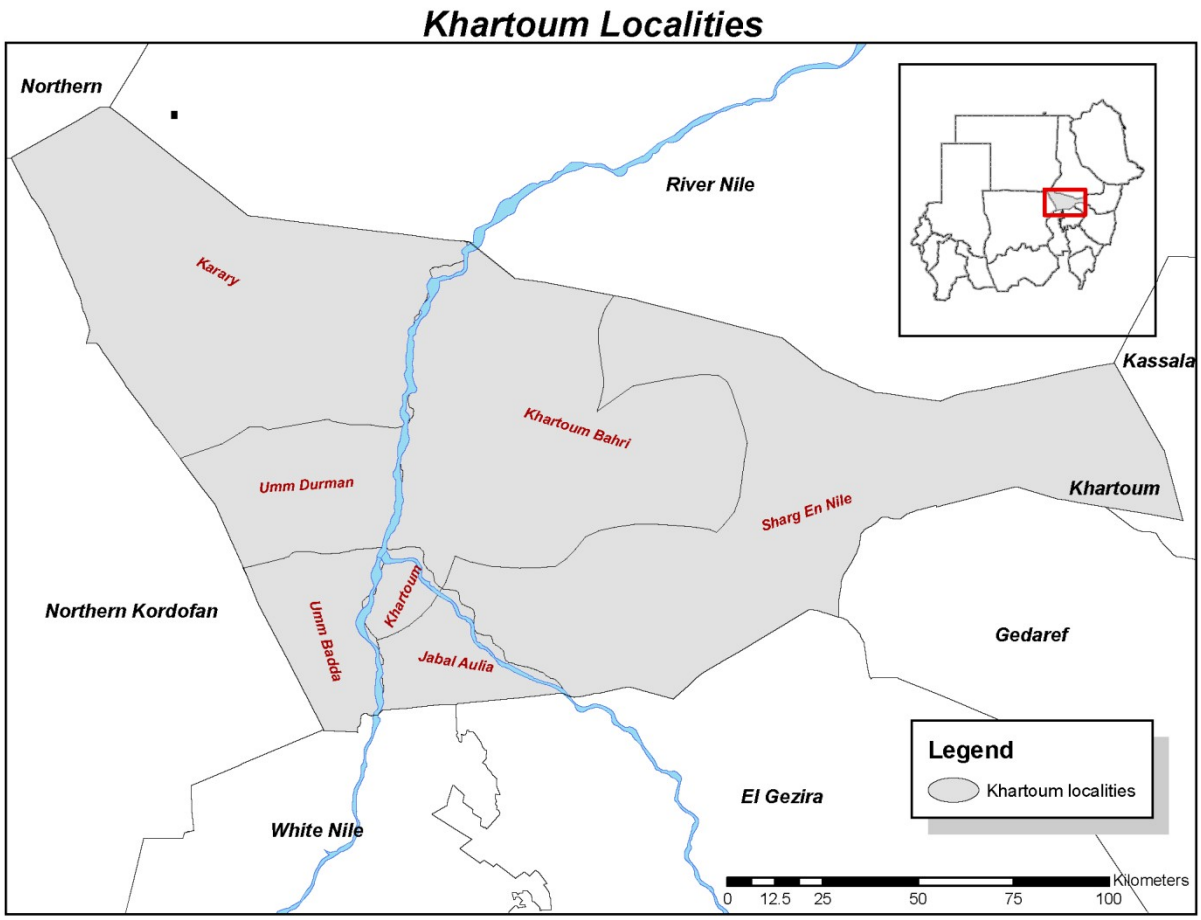

Figure (8): Map of the localities of Khartoum state (FMARF, 2014)

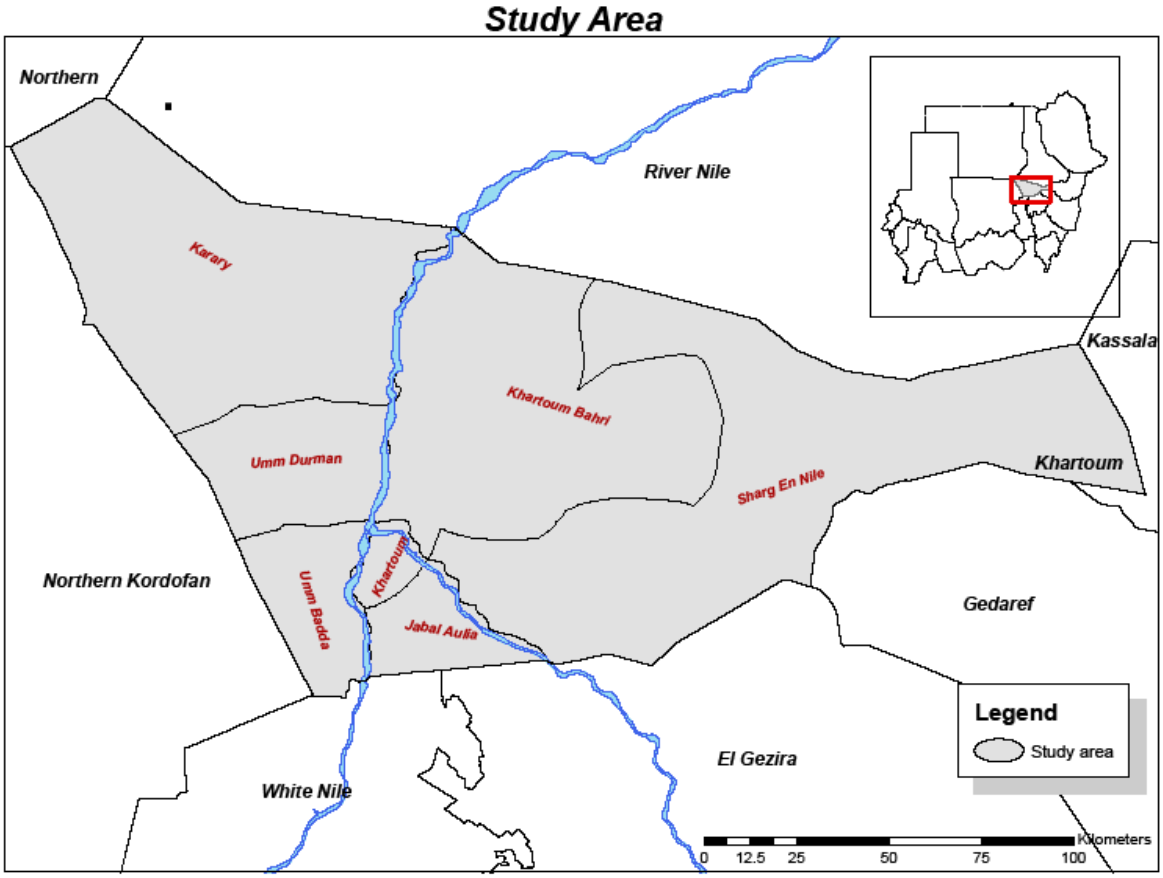

Figure (9): Map of the selected study area (FMARF, 2014)

2.2. Description of the Study Population:

The study population consists of cattle at different breeds, ages, sex, Body Condition, Previous history of FMD and Previous history of other diseases in the study area. The livestock population for the year 2012 in Khartoum state:-

Camel	Sheep	Goat	Cattle	Total
6601	444170	647083	242868	134072

(FMARF.2012).

2.3. Description of the Study Design:

The study design was a cross sectional study which provides snapshot information on occurrence of a disease (*Martin, S. W. et al, 1987*). A cross-sectional study was conducted in Khartoum State - Sudan by using the probability sampling method for selected animals, to estimate the prevalence of FMD, and to investigate the risk factors which could be associated with the disease of cattle. Sample was collected from all Khartoum Localities and data were collected by filling out the questionnaire.

2.4. Sampling:

By using the probability sampling methods to select the cattle, multistage sampling was used. Three blocks of Khartoum state (Omdurman, Khartoum and Bahry) Figure (9) were selected. Khartoum is first block; it is divided into two localities, Khartoum and Jabel awlya localities. Bahry is the second block; it includes the localities of Khartoum North and East of the Nile. Third block is Omdurman, includes three localities, which are: Omdurman, Om bada and Karary localities.

From the three blocks of the state, seven localities were selected. Then from each locality by random sample, two locations were selected and farms were selected randomly from each location. Within individual animal selected the cattle were selected randomly. (Simple Random Sampling) and the number of study cattle was one hundred thirty two. 14 serum samples were collected from Khartoum, 45from Bahry and 73from Omdurman as shown in table 1.

2.4.1. Sampling Method:

The animals in each farm were selected by random sampling method. Each selected animal was given number.

2.4.2. Sample Size Determination:

For calculation the minimum number required for sample size of FMD of cattle to determine the prevalence, the expected prevalence was taken from the study in Southern Ethiopia (Study on the Risk Factors of Foot and Mouth Disease in Selected Districts of Afar Pastoral Area, Northeast Ethiopia). In which the prevalence of FMD of cattle was 5.6 %(*Shiferaw, T.J. et al. 2011*). The precision was decided to be 2.5% at 95% confidence level. According to the following formula by Martin, S.W. et al., *(1987)* sample size was calculated.

$$N = \frac{(1.96)^2 * P\hat{}Q\hat{}}{L2}$$

Where:

N= sample size

P= expected prevalence

L= desired absolute precision (0.05)

Q= (1-P). *(Martin et al. 1987.)*

Prevalence rate = $\frac{\text{No. of cattle with FMD} * 100}{\text{Total no. of cattle at a particular point in time}}$

Accordingly, the following calculation was made:

P^ = 5.6 %(0.0056) Q^= 0.944

L= 0.0025

$$N = \frac{4*(0.056)*(0.944)}{(0.0025)} = \textbf{85 animals}$$

Eighty five animals is the minimum sample size required for the study, but one hundred thirty two cattle from Khartoum state were be considered to increase precision of the results. (*Thursfield, M. 2007*).

2.4.3 .Blood Samples Collection:-

Blood sample were collected in the period from June 2013 to July 2013. One Blood sample, about (10ml) was taken from each cattle using sterile vacutaioner tubes and disposable syringes from the Jugular vein. Then, vacutaioner were allowed to clot by placing it overnight at room temperature and thereafter the serum

was separated. The separated sera were transferred to sterile Ependorff tube and labeled with specific laboratory number. Samples were kept at -20°C at Veterinary Research Institute (VRI) for test and *analysis (Habtamu, M. et al. 2011).* Samples were tested and analyzed, as shown in table (1).

Table (1) Blood samples taken from farms in different localities of Khartoum State

Locality	Location	Breed	Housing	Hygiene Practice	No. of sera
Jabel Awlya	Alzarayb	Cross	Close	Bad	**5**
Jabel Awlya	Alshigelab	Cross	Close	Good	**1**
Khartoum	Juref-West	Cross	Close	Bad	**8**
Bahry	Alkadaro	Local	Close	Bad	**10**
East Nile	Alshigla	Cross	Close	Bad	**19**
East Nile	Hilat Koko(10)	Cross	Close	Bad	**16**
Ombada	Alrodwan	Cross	Close	Bad	**24**
Omdurman	Almowailih	Local	Close	Bad	**14**
Karary	Alsarha	Cross	Close	Bad	**35**

2.5. Virus neutralization test for detection

The plates were used in this test to detect the CytoPathic Effect (CPE) on the BHK-21 kidney cells by known dilution virus. Stock virus is grown in cell monolayers and stored at –20°C after the addition of 50% glycerol. (Virus has been found to be stable under these conditions for at least 1 year).

(OIE Terrestrial Manual 2012).

2.6. Description and Principle:

2.6.1. Positive and negative control

Appropriate volume of serum with Specific type of FMD tested positive was used as positive control and same to negative control was done.

2.6.2. Preparation of Benzyl Penicillin solution

Tow million units of Benzyl Benicillince were diluted in (3) ml laboratory grade distils water, and mixed well. Then added 3ml laboratory grade distils water to one vial of Streptomycin, and mixed well. Mix tow solutions together and added (2) ml laboratory grade distils water, and mixed well. Total volume of solution about (10ml) was store in refrigerator.

2.6.3. Preparation of Gentamycine solution

Prepared by added (80) milligrams (2) ml Gentamycine to (5) ml laboratory grade distils water and mixed well. Washed the Gentamycine Ampula by added (1) ml laboratory grade distils water. Added washed solution to the prepared solution. (Total volume of solution about (8ml) was store in refrigerator.

2.6.4. Preparation of Phosphate Diluents Saline (PD)

Dissolved (8) grams of Nacl (Natrium Chloride – Cell Culture Grade), (, 2) gram of Kcl (Potassium Chloride - Cell Culture Grade), (1, 15) grams of Di-Natrium hydrogen Phosphate (Molecular biology grade) and (, 2) gram of Potasium dihydrogen Phosphate (Cell Culture Grade) in about 200 ml deionizer distal water. Complete the volume to one litter by added 800ml deionizer distal water and autoclaved at 121ºC. Stored at 4ºC, after reached room temperature.

2.6.5. Preparation of Trypsine 2.5% (1 litter)

Dissolved (25) grams of Trypsine powder in one litter of deionizer distal water. Sterilized by filtration. Stored at -20ºC, after reached room temperature.

2.6.6. Preparation of Versine 5 %(100ml)

Dissolved (5) grams of Versine powder in100 ml of PD (Phosphate Diluents Saline). Autoclaved. Stored at 4ºC, after reached room temperature.

2.6.7. Preparation of Trypsine – Versine Solution

Six mls of prepared Trypsine were added to (4ml) of prepared Versine. Complete the volume to 100 ml by adding 90 ml of PD (Phosphate Diluents Saline). One drop of Phenole red 1% was added. Some drops of PD were added until the color change to light purple. Stored at 4ºC.

2.6.8. Preparation of Tryptose Phosphate Broth (TPB)

Dissolved (30) grams of Tryptose Phosphate Broth Powder in one litter of deionizer distal water. Autoclaved and stored at 4ºC, after reached room temperature.

2.6.9. Preparation of Bi carb(Na^2HCO^3)

To prepare 50 ml dissolved (3.75) grams of Na^2HCO^3 in 50 ml of deionizer distal water. (Use to be cells grown slowly.)

2.6.10. Preparation of Glasgow Minimum Essential Media (GMEM) 1- Fold

To prepare one litter of Glasgow Minimum Essential Media (GMEM) 1- Fold, added (1) ml of prepared Gentamycine solution, (1) ml of Benzyl Penicillin solution, (1) ml of Amphotercine (Anti-fungal), (6.3) ml of Na^2HCO^3 to (200) ml of Glasgow Minimum Essential Media (GMEM) 5- Fold. Added (100) ml (10%) of Tryptose Phosphate Broth (TPB), then mixed well. Complete the volume by added (800) ml deionizer distal water.

2.6.11. Preparation of Buffer diluents (100 ML)

Added (90) ml (90%) of prepared Glasgow Minimum Essential Media (GMEM) to (10) ml (105) of prepared Tris.

2.6.12. Preparation of Crystal Violet

Dissolved (8) grams of Nacl (Sodiun Chloride – Cell Culture Grade) in one litter of deionizer distal water. Discharge 100 (10%) ml of the solution .Added 100 ml (10%) of Formaldyhyde solution for fixation .Added (1) gram of Crystal Violet powder and dissolved.

2.6.13 .Preparation of Serums for use

The sera were inactivated at 56°C for30 minutes before testing. After one hour added 6 µl of prepared Benzyl Penicillin solution and same volume of Gentamycine solution for de contamination. Stored at -20ºC.

2.6.14 .Preparation of Sub Culture

All components were used for preparation(Media, Negative Calve serum, Trypsine-Versine and PD) must be put in water bath until reached room temperature to be sure about the cells health . Discharge the Media by the side of the cells growth. Added (2) ml of Trypsine-versine Solution by the side of the cells growth, then shacked well and see it under Microscope. Remove the solution by the side of the cells growth to another vial contain (2) ml of Negative Calve serum, then mixed well and covered. Washed the cells vial by added (4) ml of (PD), then added the washed solution to the vial which was contain (2) ml of Negative Calve serum, (2) ml of Trypsine-Versine and cells and (4) ml of (PD). Vigorous shacked by using 2 ml pupate and rubber must be done to be sure that all cells became alone in a circle shape.

For sub culture in avail (100) ml, needed (10%) (10) ml Negative Calve serum, (8 ml) volume of above solution and complete the volume to 100ml by added Glasgow Minimum Essential Media (GMEM) (about 82 ml).

2.6.15 .Preparation of Cells for use

All components were used for preparation(Media , Negative Calve serum, Trypsine-Versine and PD) must be put in water bath until reached room temperature to be sure about the cells health .See the Cell culture vial under Microscope to be sure about the proper grown of the cells (Spaces& Shape). Discharge the Media by the side of the cells growth. Washed the vial well tow times by used (PD), and discharge the washed solution. Added (2) ml of Trypsine – Versine Solution then shacked well and see it under Microscope. Added some volume of Negative Calve serum to tube and added the solution of cells to it. Washed the vial of cells well and added the washed solution to another tube. Mixed the solutions of tow tubes well, put the total solution in same volumes in tow tubes then closed the tubes well. Centrifuged tow tubes for (5) minutes. Discharge the supernatant of tow tubes and added some volume of Calve serum to one tube, then mixed it well. Added the solution to the second tube and added some volume of (PD). Vigorous shacked by

using 2 ml pupate and rubber must be done. Removed the solution by using 5 ml pupate to another vial (250 ml) and make Vigorous pupating for about (10) minutes.

To prepared cells solution for one plate, need 4800 µl about (5) ml. The volume prepared by added (3) ml (60%) of buffer diluents, (1) ml (20%) of cells solutions, (.5) ml (10%) of Negative calve serum and (.5) ml (10%) of Gentamysine.

2.6.16. Preparation of Virus Solution

Firstly added (.5) ml by using (2) ml pupate to (10) ml of buffer solution (1:10). Vortex must be done. Secondly (.5) ml of solution added to (10) ml of buffer solution (1:10) to get new dilution. Vortex must be done. (.5) ml of solution added to (10) ml of buffer solution (1:10) to get final required dilution. Vortex must be done. (Note: The final required dilution for serotype (O) was **-2.2** and (SAT 2) was **-3)**.

2.6.17 .Test Procedure:

- 94 µl buffer diluents were added to all well in line A, C, E and G of Serum Neutralization plate (figure -10).
- 50 µl buffer diluents were added to all well in line B, D, F and H of Serum Neutralization plate (figure -10).
- 6 µl Serum was added to well A1 and A2 (figure -1). (Done for all Samples).
- 6 µl of positive control was added to well A11 and A12.
- 6 µl of Negative control was added to well C11 and C12.
- 6 µl of buffer diluents was added to well E11 and E12 to complete the volume to 100 µl.
- 6 µl of buffer diluents was added to well G11 and G12 to complete the volume to 100 µl.
- Mixed solution in the wells in line (A) probably by using multi pupate with50 µl tips.
- Pupate 50 µl of solution from wells in line (A) and added to same wells in line (B).
- Mixed solution in the wells in line (B) probably, and discharge 50 µl of solution.

- Last three steps must do in every tow lines in the plate prospectively (C&D, E&F and G7H).
- 50 µl buffer diluents were added to all well in line G11, G12, H11 andH12 to complete the volume to 100 µl.
- Covered the plate by using cover slip.
- Added 50 µl of prepared dilution of virus solution to all wells, except wells G11, G12, H11 andH12 (Cells Control).
- Covered the plate and shacked 600 round for (10) minutes.
- Waiting for one hour.
- Removed the cover slip and added 50 µl of prepared cells solution to all wells in the plate.
- Checked the volume (100 µl) in all wells in the plate (by four sides) to be soured, and then covered with cover slip.
- Inculpated plate for (3) Days at 37ºC.
- After two days, plate must be diagnosed by using Microscope for the present of (CPE) and registered the first result.
- In days three, plate diagnosed by using Microscope and registered the result.
- In the last step in the test drops of prepared Crystal Violet was added to the plate for (30) minutes, then the plates were washed and the final results were reported (figure 10).

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
A	S1	S1	S2	S2	S3	S3	S4	S4	S5	S5	**C-**	**C-**
B	S1	S1	S2	S2	S3	S3	S4	S4	S5	S5	**C-**	**C-**
C	S6	S6	S7	S7	S8	S8	S9	S9	S10	S10	**C+**	**C+**
D	S6	S6	S7	S7	S8	S8	S9	S9	S10	S10	**C+**	**C+**
E	S11	S11	S12	S12	S13	S13	S14	S14	S15	S15	**Virus**	**Virus**
F	S11	S11	S12	S12	S13	S13	S14	S14	S15	S15	**Virus**	**Virus**
G	S16	S16	S17	S17	S18	S18	S19	S19	S20	S20	**Cells**	**Cells**
H	S16	S16	S17	S17	S18	S18	S19	S19	S20	S20	**Cells**	**Cells**

Controls

Figure (10): Micro Neutralization Plate

C+ = Positive Control

C- = Negative Control

S = Sample

Virus = Virus Control

Cells = Cells Control

2.7. Interpretation of results:

A result was considered Negative when there was degree of Cyto Pathic Effect (CPE) shown in all serum dilution in the serum/virus mixture wells, (Where the virus has been complete damaged of the cells or part of cells, also when wells showed with effects of fixation). The absence of Cyto Pathic Effect (CPE) of all serum dilution in the serum/virus mixture or absence of first dilution in the serum/virus mixture was considered as positive (where viruses has connected with the antibodies in the serum/virus mixture and give antigen antibodies complex. Also result will be considered positive when effect of fixation was not showed.

2.8. Data collection

The data were collected through observations, structured questionnaires that target the key persons in the farms selected. Moreover, the samples (132) were collected using probability random sampling techniques

2.9. Questionnaire Survey:-

A structured questionnaire with the primary objective of elucidating the multi factorial background of FMD in cattle was conducted in an interactive manner at every farm. Nine farms were visited in all localities and just (9) structured questionnaire were filled out by asking the owner. The form included sex, breed,

body condition, and age. The general management factors included locality, herd size, hygienic practices , water source, manure disposal, previous history of FMD, previous history of other disease, housing, separation , concentrate feeding, green fodder, milking techniques, grazing, feeding and drinking equipment , and distance from other farms .

2.10. Data Management and Analysis

All collected data of individual animals and localities during sampling and the laboratory results were entered, coded, and stored electronically in a Microsoft® Excel for Windows® 2007 data base. The Statistical Package for Social Sciences (SPSS) for Windows® version 16.0 was used for all appropriate statistical analysis.

Descriptive statistics of the variables were obtained. For each variable (age, breed, and locations), frequencies (number of observations within variable) and prevalence rates by cross-tabulation (number of positive valid samples/number of individuals sampled in the category) were obtained.

Hypothesis testing for association between disease and potential risk factors were first tested by the univariate analysis by means of the 2-tailed Chi-square test. Risk factors found associated with the disease at a significance level of P-value ≤ 0.25 were entered to the multivariate analysis. In a second step, a logistic regression model was used to assess the association between the potential risk factors, and the disease. Associations in the logistic regression model were deemed significant when $p \leq 0.05$.

Chloropleth maps were produced using Arc GIS version 9.2 (ESRI, Redlands, California) to show:

i) Selected study state within the country.

ii) Selected study localities within the state.

iii) Selected study area within the state.

CHAPTER THREE

RESULTS

3.1. Serum Neutralization Results:

FMDV Serotype (O):

The result showed that high prevalence (82.6%) of FMD antibodies for serotype (O) in tested sera (132) collected from cattle in Khartoum state as shown in table (3.1.1).

Table 3.1.1: Frequency table for distribution of FMDV serotype (O) among 132 cattle tested in Khartoum state:

FMDV	Frequency	Percent (%)	Relative Percent (%)	Cumulative Percent (%)
- ve	23	17.4(%)	17.4(%)	17.4(%)
+ ve	109	82.6(%)	82.6(%)	**100(%)**
Total	**132**	**100(%)**	**100(%)**	

3.2. Descriptive statistical analysis frequency tables:

Frequency of FMDV serotype (O) in result was shown in table (3.1.1) distribution of FMDV serotype (O) antibodies in Khartoum state.23 of cattle were negative (17.4%) and 109 of cattle were positive (82.6%).

3.3. Analysis of risk factor for FMDV serotype (O)

3.3.1. Localities:

Result of frequency of FMDV in Localities is shown in table (3.1.3). **14** cattle from Khartoum, **45** from Bahry and **73** from Omdurman. Infection was found to be 86.30 %(63/73) in Omdurman, in Khartoum rate of infection about 78.57 % (11/14), and Bahry 77.78% (35/45). (Table 3.1.3).

The results of association between localities and FMDV serotype (O) (chi- square test), showed no significant association (p-value = 0.454). (Table 3.1.4).

3.3.2. Age of animals:

One hundred thirty two cattle of various ages were tested in this study. The result showed the age distribution of cattle, 7 of the cattle were less than or equal to one year (young) , 64 of cattle were more than or equal to 5 years (medium) and 61 of cattle were more than 5 years (old) ,(Table 3.1.2). Among young animals 4 animals were found infected. Rate of infection within young animals was 57.14% (4/7). Among medium animals 48 animals were found infected. Rate of infection within medium animals was 75% (48/64). Among old animals 57animals were found infected. Rate of infection within old animals was 93.44% (57/61).
(Table 3.1.3).

The Chi- square test showed there is high significant association between the infection of FMDV serotype (O) and age of animals (p-value = 0.005), (Table 3.1.4).

3.3.3. Sex of animals:

The result of present of antibodies of FMDV serotype (O) in this study, showed the distribution of 132 cattle tested for FMDV serotype (O) according to sex. Total number of male examined was 7 animals, while the total number of female examined was125 (table 3.1.2). Among males, 4 animals were found infected. Rate of infection within males was 57.14% (4/7), while among females, 105 animals were found infected. The rate of infection within females was 84% (105/125). (Table 3.1.3).

The Chi-square test showed there is no significant association between FMDV serotype (O) infection and sex of animals (p-value = 0.068). (Table 3.1.4).

3.3.4 .Breed of animals:

According to breed, the result of study showed distribution of FMDV serotype (O) infection in Khartoum state. Total number of local breed was 24 animal. Among these 24 animals, 20 were found infected. The rate of infection was 83.33% (20/24). Total number of cross breed examined was 108. Among these, 89 were found infected. The rate of infection was 82.41% (89/108). (Table 3.1.3).

The chi- square test showed no significant association between the infection of FMDV serotype (O) and type of breed (p-value = 0.914). (Table 3.1.4).

3.3.5. Body condition:

The body condition of animals and the presence of antibodies of FMDV serotype (O) in all tested sera were analyzed. One hundred and eighty of cattle were found to be in good condition, while 24 of cattle were found to be in bad condition (table 3.1.2). Among good animals, 89 were found infected. The rate of infection within good condition animals was 82.41% (89/108). However 20 animals were found infected among bad animals. The rate of infection within bad animals was 83.33 % (20/24). (Table 3.1.3).

The chi- square test showed no significant association between the infection of FMD and body condition (p-value = 0.914). (Table 3.1.4).

3.3.6. Grazing type:

All tested animals in this study were found to be in close grazing type .The grazing type of animals in Khartoum state is close system. In this study the grazing type of animals and the presence of FMDV serotype (O) were analyzed, but there is no statistics are computed because the grazing type of animals is constant. However 109 animals were found infected and on the other hand there was no infection found in 23 animals. The rate of infection of FMDV serotype (O) was showed about 82.57% (109/132). (Table 3.1.2).

3.3.7. Herd Size:

One hundred thirty two cattle were tested in this study. The result showed the herd size distribution of cattle, 9 of the cattle were found in small farms (less than or equal to fifty cattle), 77 of cattle were found in medium farms (more than fifty or equal to 100 cattle) and 46 of cattle were found in large farms (more than 100 cattle), (table 3.1.2). Among small farms 7 animals were found infected. Rate of infection within small farm was 77.78% (7/9). Among medium farms 66 animals were found infected. Rate of infection within medium farm was 85.71% (66/77). Among large farms 36animals were found infected. Rate of infection within large farms was 78.26% (36/46). (Table 3.1.3).

The Chi- square test showed there is no significant association between the infection of FMDV serotype (O) and herd size (p-value = 0.531). (Table 3.1.4).

3.3.8. Previous history of FMD in the farm:

The previous history of the infection of FMD in the farm and the presence of antibodies of FMDV serotype (O) in all tested animals in this study were analyzed. All tested animals in this study were found to be in farms with previous history of the infection of FMD. There is no statistics are computed because the previous history of the infection of FMD in the farms is constant. 109 animals were found infected and there was no infection found in 23 animals. The rate of infection of FMDV serotype (O) was 82.57% (109/132). (Table 3.1.2).

3.3.9. Previous history of other diseases in the farm:

The previous history of infections of other diseases in the farms effects in the animals health. Previous history of the infections of other diseases in the farms in this study was analyzed. The result showed the history of the infections of other diseases in farms distribution of all tested animals in this study, 97 of the cattle were found in farms with history of infections of other diseases. Among farms with history of the infections of other diseases, 81animals were found infected. Rate of infection within these farms was 83.51% (81/97), while the total number of cattle in farms with no history of infections of other diseases was 35 cattle. Among these farms, 28 animals were found infected. Rate of infection within farms with no history of infections of other diseases was 80% (28/35). (Table 3.1.3).

The Chi- square test showed there is no significant association between the infection of FMDV serotype (O) and previous history of infections of other diseases in the farms (p-value = 0.639). (Table 3.1.4).

3.3.10. Hygienic Practices:

The result of present of antibodies of FMDV serotype (O) in this study, showed the distribution of 132 cattle tested for FMDV serotype (O) according to the Practices application of hygienic in farms. Just one cattle in this study was found in farm with good Practices application of hygienic, while One hundred thirty one cattle were found in farm with bad Practices application of hygienic. Among farm with good Practices application of hygienic, no animals were found infected. Rate of infection within this farm was 0% (0/1), while among farm with bad Practices application of hygienic, 109 animals were found infected. The rate of infection within farms with bad Practices application of hygienic was 83.21% (109/131). (Table 3.1.3).

The Chi-square test showed there is significant association between FMDV serotype (O) infection and hygienic Practices. (P-value = 0.029). (Table 3.1.4).

3.3.11. Manure Disposal:

One hundred thirty two cattle of various farms of Khartoum state were tested in this study. The result showed how many times the manure disposal from the farm by week's distribution, 11 of the cattle were found in farms disposed manure every week, 43 of cattle were found in farms disposed manure every two weeks and 78 of cattle were found in farms disposed manure every three weeks, (Table 3.1.2). Among farms disposed manure every week, 8 animals were found infected. Rate of infection within these farms was 72.73% (8/11). Among farms disposed manure every two weeks, 35 animals were found infected. Rate of infection within these farms was81.40% (35/43). Among farms disposed manure every three weeks, 66 animals were found infected. Rate of infection within farms disposed manure every three weeks was 84.62% (66/78). (Table 3.1.3).

The Chi- square test showed there is no significant association between the infection of FMDV serotype (O) and manure disposal of farms (p-value = 0.604). (Table 3.1.4).

3.3.12. Distance from other farms:

Because of FMD is the known as the air borne disease**,** the distance between farms were analyzed in this study. In all tested animals, just one cattle found in farm located far from other farms in one location. Rate of infection according to distance was 0% (0/1), while among animals found in farms with near distance, 109 animals were found infected. The rate of infection within farms with near distance was 83.21% (109/131). (Table 3.1.3).

The Chi-square test showed there is significant association between FMDV serotype (O) infection and distance between farms. (P-value = 0.029). (Table 3.1.4).

3.3.13. Green fodder:

One hundred thirty two cattle were tested in this study according to the green fodder, if it cut it from part of farm, or buy from markets or other farms. The result showed the green fodder distribution of all tested animals, in all tested animals, just one cattle found to be used green fodder by cut it from part of farm. Rate of infection in this farm was 0% (0/1), while 131 cattle found in farms used green fodder by buy it from markets or other farms, 109 animals were found infected. The rate of infection within these farms was 83.21% (109/131). (Table 3.1.3).

The Chi-square test showed there is significant association between FMDV serotype (O) infection and green fodder. (P-value = 0.029). (Table 3.1.4).

3.3.14. Concentrate feeding:

All tested animals in this study were found in farms that workers were prepared concentrate feeding of animals inside the farm. In this study the presence of FMDV serotype (O) and concentrate feeding of animals were analyzed, but there is no statistics are computed because the concentrate feeding of animals is constant. However 109 animals were found infected and on the other hand there was no infection found in 23 animals. Rate of infection of FMDV serotype (O) were showed about 82.57% (109/132). (Table 3.1.2).

3.3.15. Water source:

In this study the presence of FMDV serotype (O) and source of water in farms were analyzed, but there is no statistics are computed because the source of water is constant. 109 animals were found infected and no infection found in 23 animals. Rate of infection of FMDV serotype (O) were found to be about 82.57% (109/132). (Table 3.1.2).

3.3.16. Milking techniques:

About the system of milking techniques used in farms, there are two systems. First one by machine and the second one by hands. In this study the presence of FMDV serotype (O) and milking techniques in farms were analyzed, but there is no statistics are computed because the source of water is constant. 109 animals were

found infected and no infection found in 23 animals. Rate of infection of FMDV serotype (O) were showed about 82.57% (109/132). (Table 3.1.2).

3.3.17. Separation:

Application of separation system in farms adopted according to production (milk/meat) or according to age. In this study the presence of FMDV serotype (O) and separation in farms were analyzed. All tested animals in this study were found in farms adopted separation system according to age. The result showed that there is no statistics are computed because the separation system is constant. 109 animals were found infected and no infection found in 23 animals. Rate of infection of FMDV serotype (O) were showed about 82.57% (109/132). (Table 3.1.2).

3.3.18. Housing:

All farms in Khartoum state were designed to be as close farms. In this study the presence of FMDV serotype (O) and housing system were analyzed, all tested animals in this study were found to be in close farms. The result showed that there is no statistics are computed because the housing system is constant. 109 animals were found infected and no infection found in 23 animals. Rate of infection of FMDV serotype (O) were showed about 82.57% (109/132). (Table 3.1.2).

3.3.19. Feeding and drinking equipment:

In this study the presence of FMDV serotype (O) and feeding and drinking equipments in farms were analyzed. In all selected farms in Khartoum state, feeding and drinking equipment are share between all animals. The result showed that there is no statistics are computed because the used of feeding and drinking equipments in all selected farms is constant. 109 animals were found infected and no infection found in 23 animals. Rate of infection of FMDV serotype (O) were showed about 82.57% (109/132). (Table 3.1.2).

Table 3.1.2: Summary of frequency tables for potential risk factors of FMDV in 132 cattle tested at Khartoum state:

Risk Factors	Frequency	Relative Frequency %	Cumulative Frequency %
Age			
Young	7	5.3%	5.3%
Medium	64	48.5%	53.8%
Old	61	46.2%	**100** %
Sex			
Male	7	5.3%	5.3%
Female	125	94.7%	**100** %

Breed			
Local	24	18.2%	18.2%
Cross	108	81.8%	**100** %
Body condition			
Good	108	81.8%	81.8%
Bad	24	18.2%	**100%**
Herd size			
Small	9	6.8%	6.8%
Medium	77	58.3%	65.1%
Large	46	34.8%	**100%**
Previous history of other diseases in farm			
Yes	97	73.5%	73.5%
No	35	26.5%	**100%**

Table 3.1.2: Summary of frequency tables for potential risk factors of FMDV in 132 cattle tested at Khartoum state: continued

Risk Factors	**Frequency**	**Relative Frequency %**	**Cumulative Frequency %**
Locality			
Khartoum	14	10.6%	10.6%
Omdurman	73	55.3%	65.9%
Bahrry	45	34.1%	**100** %
Hygienic practices			
Good	1	.8%	.8%
Bad	131	99.2%	**100** %
Manure disposal			

One week	11	8.3%	8.3%
Two weeks	43	32.6%	40.9%
Three weeks	78	59.1%	**100** %
Green folder			
Cut it from farm	1	.8%	.8%
Buy it from markets	131	99.2%	**100%**
Feeding and drinking equipment			
Separated	0	0%	0%
Common	132	100%	**100%**
Distance from other farms			
Far	1	.8%	.8%
Near	131	99.2%	**100%**

Table 3.1.2: Summary of frequency tables for potential risk factors of FMDV in 132 cattle tested at Khartoum state: continued

Risk Factors	**Frequency**	**Relative Frequency %**	**Cumulative Frequency %**
Housing			
Open	0	0%	0%
Close	132	100%	**100%**
Separation			
According to production	0		
According to age	132	0%	0%
		100%	**100%**
Milking			
By machine	0	0%	0%
By hands	132	100%	**100%**

Grazing				
Open		0	0%	0%
Close	132		100%	**100%**
Concentrate feeding				
Buy from markets		0	0%	0%
Prepared in farm	132		100%	**100%**
Water source				
Dounky		0	0%	0%
Tape water	132		100%	**100%**
Previous history of FMD in farm				
No		0	0%	0%
Yes	132		100%	**100%**

Table 3.1.3: Summary of cross tabulation for potential risk factors of FMDV serotype (O) in 132 cattle tested at Khartoum state:

Risk factors	No. tested	No. infected (%)
Age		
Young	7	4 (57.14)
Medium	64	48 (75)
Old	61	57 (93.44)
Sex		
Male	7	4 (57.14)
Female	125	105 (84)
Breed		
Local	24	20 (83.33)
Cross	108	89 (82.41)
Body condition		
Good	108	89 (82.41)
Bad	24	20 (83.33)

Herd size		
Small	9	7 (77.78)
Medium	77	66 (85.71)
Large	46	36 (78.26)
Previous history of other diseases in farm		
Yes	97	81 (83.51)
No	35	28 (80)

Table 3.1.3: Summary of cross tabulation for potential risk factors of FMDV serotype (O) in 132 cattle tested at Khartoum state: continued

Risk factors	No. tested	No. infected (%)
Locality		
Khartoum	14	11 (78.57)
Omdurman	73	63 (86.30)
Bahry	45	35 (77.78)
Hygienic practices		
Good	1	0 (0)
Bad	131	109 (83.21)
Manure disposal		
One week	11	8 (72.73)
Two weeks	43	35 (81.40)
Three weeks	78	66 (84.62)
Green folder		
Cut it from farm	1	0 (0)
Buy it from markets	131	109 (83.21)

Feeding and drinking equipment		
Separated	0	0 (0)
Common	132	109 (82.57)
Distance from other farms		
Far	1	0 (0)
Near	131	109 (83.21)

Table 3.1.3: Summary of cross tabulation for potential risk factors of FMDV serotype (O) in 132 cattle tested at Khartoum state: continued

Risk factors	No. tested	No. infected (%)
Housing		
Open	0	0 (0)
Close	132	109 (82.57)
Separation		
According to production	0	0 (0)
According to age	132	109 (82.57)
Milking techniques		
By machine	0	0 (0)
By hands	132	109 (82.57)
Grazing		
Open	0	0 (0)
Close	132	109 (82.57)
Concentrate feeding		
Buy from markets	0	0 (0)
Prepared in farm	132	109 (82.57)

Water source		
Dounkys	0	0 (0)
Tape water	132	109 (82.57)
Previous history of FMD in farm		
No	0	0 (0)
Yes	132	109 (82.57)

Table 3.1.4: Summary of univariate analysis for potential risk factors of FMDV serotype (O) in 132 cattle tested at Khartoum state: The Chi- square test:

Risk factors	No. tested	No. infected (%)	d.f	Chi-square value	p-value
Age			**2**	**10.706**	**0.005**
Young	7	4 (57.14)			
Medium	64	48 (75)			
Old	61	57 (93.44)			
Sex			**1**	**3.323**	**0.068**
Male	7	4 (57.14)			
Female	125	105 (84)			
Breed			**1**	**0.012**	**0.914**
Local	24	20 (83.33)			
Cross	108	89 (82.41)			
Body condition			**1**	**0.012**	**0.914**
Good	108	89 (82.41)			
Bad	24	20 (83.33)			
Herd size			**2**	**1.266**	**0.531**
Small	9	7 (77.78)			
Medium	77	66 (85.71)			
Large	46	36 (78.26)			

Previous history of other diseases in farm			**1**	**0.220**	**0.639**
Yes	97	81 (83.51)			
No	35	28 (80)			

Table 3.1.4: Summary of univariate analysis for potential risk factors of FMDV serotype (O) in 132 cattle tested at Khartoum state: The Chi- square test: continued

Risk factors	No. tested	No. infected (%)	d.f	Chi-square value	p-value
Locality			**2**	**1.580**	**0.454**
Khartoum	14	11 (78.57)			
Omdurman	73	63 (86.30)			
Bahry	45	35 (77.78)			
Hygienic practices			**1**	**4.775**	**0.029**
Good	1	0 (0)			
Bad	131	109 (83.21)			
Manure disposal			**2**	**1.009**	**0.604**
One week	11	8 (72.73)			
Two weeks	43	35 (81.40)			
Three weeks	78	66 (84.62)			
Green folder			**1**	**4.775**	**0.029**
Cut it from farm	1	0 (0)			
Buy it from markets	131	109 (83.21)			
Feeding and drinking equipment			**1**	**Constant**	
Common	132	109 (82.57)			
Separated	0	0 (0)			
Distance from other farms			**1**	**4.775**	**0.029**

Far	1	0 (0)
Near	131	109 (83.21)

Table 3.1.4: Summary of univariate analysis for potential risk factors of FMDV serotype (O) in 132 cattle tested at Khartoum state: The Chi- square test: continued

Risk factors	No. tested	No. infected (%)	d.f	Chi-square value	p-value
Housing			**1**		
Close	132	109 (82.57)		**Constant**	
Open	0	0 (0)			
Separation			**1**		
According to age	132	109 (82.57)		**Constant**	
According to production	0	0 (0)			
Milking techniques			**1**		
By hands	132	109 (82.57)			
By machine	0	0 (0)		**Constant**	
Grazing			**1**		
Close	132	109 (82.57)		**Constant**	
Open	0	0 (0)			
Concentrate feeding			**1**		
Prepared in farm	132	109 (82.57)		**Constant**	
Buy from markets	0	0 (0)			
Water source			**1**		
Tape water	132	109 (82.57)		**Constant**	
Dounkys	0	0 (0)			
Previous history of FMD in farm			**1**		
Yes	132	109 (82.57)		**Constant**	
No	0	0 (0)			

Table 3.1.5: Multivariate analysis of FMDV serotype (O) and potential risk factors in 132 cattle tested at Khartoum state:

Risk factors	No. tested	No. infected (%)	d.f	Exp(B)	p-value	CI
Age			**2**		**0.001**	**1.385 –**
Young	7	4 (57.14)		Ref		**14.317**
Medium	64	48 (75)		-		
Old	61	57 (93.44)		4.453		
Sex			**1**		**0.068**	**0.063 –**
Male	135	2 (1.48)		Ref		**4.617**
Female	65	0 (0)		O.539		
Hygienic practices			**1**		**0.029**	**0.000 -**
Good	15	0 (0)		Ref		
Bad	185	2 (1.08)		8.004		
Green folder			**1**		**0.029**	**0.000 -**
Cut it from farm	1	0 (0)		Ref		
Buy it from markets	131	109 (83.21)		**5.170**		
Distance from other farms			**1**		**0.029**	**0.000 -**
Far	1	0 (0)		Ref		
Near	131	109 (83.21)		8.004		

3.4. Serum Neutralization Results:

FMDV Serotype (SAT 2):

From all tested sera (132) collected from cattle in Khartoum state, the result showed that low prevalence (24.2%) of FMD antibodies for serotype (SAT 2).The result shown in table (3.2.1).

Table 3.2.1: Frequency table for distribution of FMDV serotype (SAT 2) among 132 cattle tested in Khartoum state:

FMDV	Frequency	Percent (%)	Relative Percent (%)	Cumulative Percent (%)
- ve	100	75.76(%)	75.76(%)	75.76(%)
+ ve	32	24.24(%)	24.24(%)	**100(%)**
Total	**132**	**100(%)**	**100(%)**	

Frequency of FMDV serotype (SAT 2) in result is shown in table (3.2.1) distribution of FMDV serotype (SAT 2) antibodies in Khartoum state.**100** of cattle were negative **(75.8%)** and **32** of cattle were positive **(24.2%)**.

3.5. Analysis of risk factor for FMDV serotype (SAT 2)

3. 5.1. Localities:

Result of frequency of FMDV serotype (SAT 2) in Localities is shown in table (3.1.3). 14 cattle from Khartoum, 45 from Bahry and 73 from Omdurman. Infection was found to be 23.29 %(17/73) in Omdurman, in Khartoum rate of infection about 28.57 %(4/14), and Bahry 24.44% (11/45).

The results of association between localities and infection of FMDV serotype (SAT 2) (chi- square test), showed no significant association (p-value = 0.914). (Table 3.2.3).

3. 5.2. Age of animals:

One hundred thirty two cattle of various ages were tested in this study. The result showed the age distribution of cattle, 7 of the cattle were less than or equal to one year (young) , 64 of cattle were more than or equal to 5 years (medium) and 61 of cattle were more than 5 years (old) ,(Table 3.1.2). Among young animals 2 animals were found infected. Rate of infection within young animals was 28.57% (2/7). Among medium animals 13 animals were found infected. Rate of infection within medium animals was 20.31% (13/64). Among old animals 17animals were found infected. Rate of infection within old animals was 27.87% (17/61).
(Table 3.2.2).

The Chi- square test showed there is no significant association between the infection of FMDV serotype (SAT 2) and age of animals (p-value = 0.593).
(Table 3.2.3).

3. 5.3. Sex of animals:

The result of present of antibodies of FMDV serotype (SAT 2) in this study showed the distribution of 132 cattle tested for FMDV serotype (O) according to sex. Total number of male examined was 7 animals, while the total number of female examined was125 (table 3.1.2). Among males, 2 animals were found infected. Rate of infection within males was 28. 57% (2/7), while among females, 30 animals were found infected. The rate of infection within females was 24% (30/125). (Table 3.2.2).

The Chi-square test showed there is no significant association between FMDV serotype (SAT 2) infection and sex of animals (p-value = 0.784). (Table 3.2.3).

3. 5.4. Breed of animals:

According to breed, the result of study showed distribution of FMDV serotype (SAT 2) infection in Khartoum state. Total number of local breed was 24 animal. Among these 24 animals, 8were found infected. The rate of infection was 33.33%

(8/24). Total number of cross breed examined was 108. Among these, 24 were found infected. The rate of infection was 22.22% (24/108). (Table 3.2.2).

The chi- square test showed there is significant association between the infection of FMDV serotype (SAT 2) and type of breed (p-value = 0.251). (Table 3.2.3).

3. 5.5. Body condition:

The body condition of animals and the presence of antibodies were analyzed. One hundred and eighty of cattle were found to be in good condition, while 24 of cattle were found to be in bad condition (table 3.1.2). Among good animals, 24were found infected. The rate of infection within good condition animals was 22.22% (24/108). However 8 animals were found infected among bad animals. The rate of infection within bad animals was 33.33 % (8/24). (Table 3.2.2).

The chi- square test showed there is significant association between the infection of FMDV serotype (SAT 2) and body condition (p-value = 0.251). (Table 3.2.3).

3. 5.6. Grazing type:

As known in Khartoum state The grazing type of animals is close system. All tested animals in this study were found to be in close grazing type. In this study the grazing type of animals and the presence of FMDV serotype (SAT 2) were analyzed, but there is no statistics are computed because the grazing type of animals is constant. However 32 animals were found infected and on the other hand there was no infection found in 100animals. The rate of infection of FMDV serotype (SAT 2) were showed about 24.24% (32/132). (Table 3.1.2).

3. 5.7. Herd Size:

In this study herd size was analyzed. The result showed the herd size distribution of cattle, 9 of the cattle were found in small farms (less than or equal to fifty cattle), 77 of cattle were found in medium farms (more than fifty or equal to 100 cattle) and 46 of cattle were found in large farms (more than 100 cattle), (table 3.1.2). Among small farms 4 animals were found infected. Rate of infection within small farms was 44.44% (4/9). Among medium farms 24 animals were found infected. Rate of

infection within medium farms was 31.17% (24/77). Among large farms 4animals were found infected. Rate of infection within large farms was 8.70% (4/46). (Table 3.2.2).

The Chi- square test showed there is high significant association between the infection of FMDV serotype (SAT 2) and herd size (p-value = 0.007). (Table 3.2.3).

3. 5.8. Previous history of FMD in the farm:

The previous history of the infection of FMD in the farm and the presence of antibodies of FMDV serotype (SAT 2) in all tested animals were analyzed. There is no statistics are computed because all tested animals in this study were found to be in farms with previous history of the infection of FMD. That mean the previous history of the infection of FMD in the farms is constant. However 32 animals were found infected and on the other hand there was no infection found in 100animals. The rate of infection of FMDV serotype (SAT 2) were showed about 24.24% (32/132). (Table 3.1.2).

3. 5.9. Previous history of other diseases in the farm:

In this study previous history of the infection of other diseases in the farms was analyzed. The result showed the history of the infections of other diseases in farms distribution of all tested animals in this study, 97 of the cattle were found in farms with history of infection of other diseases. Among farms with history of the infection of other diseases, 30 animals were found infected. Rate of infection within these farms was 30.93% (30/97), while the total number of cattle in farms with no history of infection of other diseases was 35 cattle. Among farms with no history of infections of other diseases, 2 animals were found infected. Rate of infection within these farms was 5.71% (2/35). (Table 3.2.2).

The Chi- square test showed there is high significant association between the infection of FMDV serotype (SAT 2) and previous history of infections of other diseases in the farms (p-value = 0.003). (Table 3.2.3).

3. 5.10. Hygienic Practices:

The result of present of antibodies of FMDV serotype (SAT 2) in this study, showed the distribution of 132 cattle tested for FMDV serotype (SAT 2) according to the Practices application of hygienic in farms. From 132 cattle just one cattle in this study was found in farm with good Practices application of hygienic, while One hundred thirty one cattle were found in farm with bad Practices application of hygienic. Among farm with good Practices application of hygienic, no animals were found infected. Rate of infection within this farm with good Practices application of hygienic was 0% (0/1), while among farms with bad Practices application of hygienic 32 animals was found infected. The rate of infection within farms with bad Practices application of hygienic was 24.43% (32/131). (Table 3.2.2).

The Chi-square test showed there is no significant association between FMDV serotype (SAT 2) infection and hygienic Practices. (P-value = 0.570). (Table 3.2.3).

3. 5.11. Manure Disposal:

According to how many times the manure was disposal from the farm by weeks; one hundred thirty two cattle of various farms of Khartoum state were tested in this study. The result showed the distribution, 11 of the cattle were found in farms disposed manure every week, 43 of cattle were found in farms disposed manure every two weeks and 78 of cattle were found in farms disposed manure every three weeks, (Table 3.1.2). Among farms disposed manure every week, 2 animals were found infected. Rate of infection within these farms was 18.18% (2/11). Among farms disposed manure every two weeks, 13 animals were found infected. Rate of infection within these farms was 30.23% (13/43). Among farms disposed manure every three weeks, 17 animals were found infected. Rate of infection within farms disposed manure every three weeks was 21.79% (17/78). (Table 3.2.2).

The Chi- square test showed there is no significant association between the infection of FMDV serotype (SAT 2) and manure disposal of farms

(P-value = 0. 518). (Table 3.1.4).

3. 5.12. Distance from other farms:

Distance between farms located in one location was analyzed in this study. In all tested animals, just one cattle found in farm located far from other farms in one location. Rate of infection according to distance was 0% (0/1), while among animals found in farms with near distance, 32 animals were found infected. The rate of infection within farms with near distance was 24.43% (32/131). (Table 3.2.2).

The Chi-square test showed there is no significant association between FMDV serotype (SAT 2) infection and distance between farms.
(P-value = 0.570). (Table 3.2.3).

3. 5.13. Green fodder:

According to the green fodder, one hundred thirty two cattle were tested in this study if the green fodder cut it from part of farm, or buy from markets or other farms. The result showed the green fodder distribution of all tested animals, in all tested animals, just one cattle found to be used green fodder by cut it from part of farm. Rate of infection in this farm was 0% (0/1). While 131 cattle found in farms used green fodder by buy it from markets or other farms, 109 32 animals were found infected. The rate of infection within these farms was 24.43% (32/131). (Table 3.2.2).

The Chi-square test showed there is no significant association between FMDV serotype (SAT 2) infection and green fodder. (P-value = 0.570).
(Table 3.2.3).

3. 5.14. Concentrate feeding:

All tested animals in this study were found in farms that workers were prepared concentrate feeding of animals inside the farm. In this study the presence of FMDV serotype (SAT 2) and concentrate feeding of animals were analyzed, but there is no statistics are computed because the concentrate feeding of animals is constant. 32 animals were found infected and on the other hand there was no infection found in 100 animals. Rate of infection about 24.24% (32/132). (Table 3.2.2).

3. 5.15. Water source:

In this study the presence of FMDV serotype (SAT 2) and source of water in farms were analyzed, but there is no statistics are computed because the source of water is constant. However 32 animals were found infected and on the other hand there was no infection found in 100 animals. Rate of infection about 24.24% (32/132). (Table 3.2.2).

3. 5.16. Milking techniques:

About the system of milking techniques used in farms, there are two systems. First one by machine and the second one by hands. In this study the presence of FMDV serotype (SAT 2) and milking techniques in farms were analyzed.Because the source of water is constant, there is no statistics are computed. However 32 animals were found infected and no infection found in 100 animals. Rate of infection about 24.24% (32/132). (Table 3.2.2).

3. 5.17. Separation:

In this study the presence of FMDV serotype (SAT 2) and separation in farms were analyzed, all tested animals in this study were found in farms adopted separation system according to age. The result showed that there is no statistics are computed because the separation system is constant. 32 animals were found infected and no infection found in 100 animals. Rate of infection about 24.24% (32/132). (Table 3.2.2).

3. 5.18. Housing:

All farms in Khartoum state were designed to be as close farms. In this study the presences of FMDV serotype (SAT 2) and housing system was analyzed, all tested animals in this study were found to be in close farms. The result showed that there is no statistics are computed because the housing system is constant. However 32 animals were found infected and on the other hand there was no infection found in 100 animals. Rate of infection about 24.24% (32/132). (Table 3.2.2).

3. 5.19. Feeding and drinking equipment:

In all selected farms in Khartoum state, feeding and drinking equipment are share between all animals. In this study the presences of FMDV serotype (SAT 2) and feeding and drinking equipments in farms were analyzed. The result showed that there is no statistics are computed because the used of feeding and drinking equipments in farms is constant. 32 animals were found infected and no infection found in 100 animals. Rate of infection about 24.24% (32/132). (Table 3.2.2).

Table 3.2.2: Summary of cross tabulation for potential risk factors of FMDV serotype (SAT 2) in 132 cattle tested at Khartoum state:

Risk factors	No. tested	No. infected (%)

Age		
Young	7	2 (28.57)
Medium	64	13 (20.31)
Old	61	17 (27.87)
Sex		
Male	7	2 (28.57)
Female	125	30 (24)
Breed		
Local	24	8 (33.33)
Cross	108	24 (22.22)
Body condition		
Good	108	24 (22.22)
Bad	24	8 (33.33)
Herd size		
Small	9	4 (44.44)
Medium	77	24 (31.17)
Large	46	4 (8.70)
Previous history of other diseases in farm		
Yes	97	30 (30.93)
No	35	2 (5.71)

Table 3.2.2: Summary of cross tabulation for potential risk factors of FMDV serotype (SAT 2) in 132 cattle tested at Khartoum state: continued

Risk factors	No. tested	No. infected (%)

Locality			
Khartoum	14		4 (28.57)
Omdurman	73		17 (23.29)
Bahry	45		11 (24.44)
Hygienic practices			
Good		1	0 (0)
Bad		131	32 (24.43)
Manure disposal			
One week		11	2 (18.18)
Two weeks		43	13 (30.23)
Three weeks		78	17 (21.79)
Green folder			
Cut it from farm		1	0 (0)
Buy it from markets		131	32 (24.43)
Feeding and drinking equipment			
Common	132		32 (24.24)
Separated	0		0 (0)
Distance from other farms			
Far		1	0 (0)
Near		131	32 (24.43)

Table 3.2.2: Summary of cross tabulation for potential risk factors of FMDV serotype (SAT 2) in 132 cattle tested at Khartoum state: continued

Risk factors	No. tested	No. infected (%)

Housing		
Close	132	32 (24.24)
Open	0	0 (0)
Separation		
According to age	132	32 (24.24)
According to production	0	0 (0)
Milking techniques		
By hands	132	32 (24.24)
By machine	0	0 (0)
Grazing		
Close	132	32 (24.24)
Open	0	0 (0)
Concentrate feeding		
Prepared in farm	132	32 (24.24)
Buy from markets	0	0 (0)
Water source		
Tape water	132	32 (24.24)
Dounkys	0	0 (0)
Previous history of FMD in farm		
Yes	132	32 (24.24)
No	0	0 (0)

Table 3.2.3: Summary of univariate analysis for potential risk factors of FMDV serotype (SAT 2) in 132 cattle tested at Khartoum state: The Chi- square test:

Risk factors	No. tested	No. infected (%)	d. f	Chi-square value	p-value

Age			**2**	**1.046**	**0.593**
Young	7	2 (28.57)			
Medium	64	13 (20.31)			
Old	61	17 (27.87)			
Sex			**1**	**0.075**	**0.784**
Male	7	2 (28.57)			
Female	125	30 (24)			
Breed			**1**	**1.320**	**0.251**
Local	24	8 (33.33)			
Cross	108	24 (22.22)			
Body condition			**1**	**1.320**	**0.251**
Good	108	24 (22.22)			
Bad	24	8 (33.33)			
Herd size			**2**	**10.065**	**0.007**
Small	9	4 (44.44)			
Medium	77	24 (31.17)			
Large	46	4 (8.70)			
Previous history of other diseases in farm			**1**	**8.903**	**0.003**
Yes	97	30 (30.93)			
No	35	2 (5.71)			

Table 3.2.3: Summary of univariate analysis for potential risk factors of FMDV serotype (SAT 2) in 132 cattle tested at Khartoum state: The Chi- square test:

Continued

Risk factors	No. tested	No. infected (%)	d.f	Chi-square value	p-value
Locality			**2**	**0.180**	**0.914**
Khartoum	14	4			

Omdurman	73	(28.57)			
Bahry	45	17 (23.29)			
		11 (24.44)			
Hygienic practices			**1**	**0.322**	**0.570**
Good	1	0 (0)			
Bad	131	32 (24.43)			
Manure disposal			**2**	**1.315**	**0.518**
One week	11	2 (18.18)			
Two weeks	43	13 (30.23)			
Three weeks	78	17 (21.79)			
Green folder			**1**	**0.322**	**0.570**
Cut it from farm	1	0 (0)			
Buy it from markets	131	32 (24.43)			
Feeding and drinking equipment			**1**	**Constant**	
Common	132	32 (24.24)			
Separated	0	0 (0)			
Distance from other farms			**1**	**0.322**	**0.570**
Far	1	0 (0)			
Near	131	32 (24.43)			

Table 3.2.3: Summary of univariate analysis for potential risk factors of FMDV serotype (SAT 2) in 132 cattle tested at Khartoum state: The Chi- square test:

Continued

Risk factors	No. tested	No. infected (%)	d.f	Chi-square value	p-value
Housing			1		
Close	132	32 (24.24)		Constant	
Open	0	0 (0)			
Separation			1		
According to age	132	32 (24.24)		Constant	
According to production	0	0 (0)			
Milking techniques			1		
By hands	132	32 (24.24)		Constant	
By machine	0	0 (0)			
Grazing			1		
Close	132	32 (24.24)		Constant	
Open	0	0 (0)			
Concentrate feeding			1		
Prepared in farm	132	32 (24.24)		Constant	
Buy from markets	0	0 (0)			
Water source			1		
Tape water	132	32 (24.24)		Constant	
Dounkys	0	0 (0)			
Previous history of FMD in farm			1		
Yes	132	32 (24.24)		Constant	
No	0	0 (0)			

Table 3.1.8: Multivariate analyses of FMDV serotype (SAT 2) and potential risk factors in 132 cattle tested at Khartoum state:

Risk factors	No. tested	No. infected (%)	d.f	Exp(B)	p-value	CI
Breed			**1**		**0.251**	**.177 –**
Local	24	8 (33.33)		Ref		**1.701**
Cross	108	24		0.548		
		(22.22)				
Body condition			**1**		**0.251**	**0.669 –**
Good	108	24		Ref		**4.581**
Bad	24	(22.22)		1.750		
		8 (33.33)				
Herd size			**2**		**0.007**	**0.137**
Small	9	4 (44.44)		Ref		**-1.220**
Medium	77	24		.409		
Large	46	(31.17)		**-**		
		4 (8.70)				
Previous history of other diseases in farm			**1**		**0.003**	**0.364 -18.471**
Yes	97	30		2.593		
No	35	(30.93)		Ref		
		2 (5.71)				

CHAPTER FOUR

DISCUSSION

FMD is an important cattle disease in the world. It is a transboundary animal disease and is economically very important to countries which export and import animals or animal products. In Sudan FMD is the one of the most important disease. It happens when there is interaction of many risk factors associated with host, virus serotype (s), and environment. The aims of the present study were to estimate the FMD prevalence, and to determine the risk factors which could be associated with Foot and Mouth Disease of cattle in Khartoum State - Sudan.

The finding of the present study showed that the prevalence of FMD serotype (O) in Khartoum State was higher than that of FMD serotype (SAT 2). The prevalence of FMD serotype (O) and FMD serotype (SAT 2) was 82.6% and 24.24%, respectively, with an overall prevalence of 53.4%. The overall prevalence in the present study is semi close to a previous study conducted by Kibore, et al., (2013) in Kenya; which was 52.5%. The overall prevalence in the present study is higher than a previous study conducted by Abdulahi , et al., (2011) in Ethiopia; Chepkwony , et al., (2012) in the Somali-ecosystem; Sarker, et al., (2011) in Rajshahi; Fufa , et al., (2013) in Ethiopia; Esayas , et al., (2009) in southwestern Ethiopia; Habtamu , et al., (2011) in southern Ethiopia; Shiferaw, et al., (2011) in northeastern Ethiopia; Kinzang, et al., (2011) in Bhutan; Megersa, et al., (2009) in Southern Ethiopia; Yahya, et al., (2013) in East and West Hararghe zones, Ethiopia which was 14.05%, 45.3%, 25.07%, 8.01 %, 12.08% , 24.6 %, 5.6% , 17.6% , 9.5% and 11.6% respectively.

Nineteen risk factors were entered into SPSS using cross-tabulation and Chi-square to estimate significant statistical association between risk factors and FMD

with a significance level ≤ 0.25. No statistics are computed for eight risk factors such as feeding and drinking equipment, housing, separation, milking techniques, grazing type, concentrate feeding, water source and previous history of FMD in farm because zero is a number of one category of factors .

The following risk factors showed a significant association with FMD Serotype (O) in the univariate analysis, age (p-value = .005), sex (p-value = .068), Hygienic practices (p-value = .029), green fodder (p-value = .029), Distance from other farms (p-value = .029). In this study, herd size (p-value = .531), body condition (p-value = .914), breed (p-value = .914), Manure disposal (p-value = .604), locality (p-value = .454) and Previous history of other diseases in farm (p-value = .639) showed no significant statistical association with FMD serotype (O).

In the multivariate analysis, age (p-value = .005), hygienic practices (p-value = . 029), green fodder (p-value = .029) and distance from other farms (p-value = .029), showed a significant association with these serotype.

For FMD serotype (SAT2), just two risk factors showed significant statistical association in the univariate analysis such as herd size (p-value = .007) and previous history of other diseases in farm (p-value = .003). Other risk factors like age (p-value = .593), sex (p-value = .784), hygienic practices (p-value = .570), green fodder (p-value = .570), distance from other farms (p-value = .570), body condition (p-value = .251), breed (p-value = .251), manure disposal (p-value = .518) and locality (p-value = .914), showed no significant statistical association with FMD Serotype(SAT2).

In the multivariate analysis, herd size (p-value = .007) and Previous history of other diseases in farm (p-value = .003) showed significant statistical association with FMD serotype (SAT2).

All risk factors which had a significant effect in the univariate analysis were fitted in a multivariate logistic regression model at a significance level ≤ 0.05, so as to control for confounding and to measure the strength of association. In the

multivariate analysis risk factor such as age, hygienic practices, green fodder, distance from other farms, herd size, previous history of other diseases in farm were found significantly associated with the occurrence of FMD.

Furthermore, in this study sex was investigated. The majority of the cases of FMD serotype (O) were higher in females than males, which were 84% and 57.14% respectively; this is in disagreement with studies reported in Ethiopia; by Abdulahi et al., (2011) , Chepkwony, et al., (2012) , Fufa , et al., (2013), in Southwestern Ethiopia by Esayas , et al., (2009) and in Kenya by Kibore, et al., (2013). A finding of the present study is in agreement with a study reported in Rajshahi by Sarker, et al., (2011).

For FMD serotype (SAT2), the rate of infection within females was 24% and within males were 28. 57%, which is in agreement with previous findings from Esayas , et al., (2009) in Southwestern Ethiopia ; Chepkwony , et al., (2012) in Ethiopia ; Kibore, et al., (2013) in Kenya ; Fufa , et al., (2013) in Ethiopia and Abdulahi et al., (2011) in Ethiopia. A finding of the present study is in disagreement with a study reported in Rajshahi by Sarker, et al., (2011).

In this study locality also was investigated. Locality showed no significant statistical association with two FMD serotypes, (O) (p-value = 0.454) and (SAT2), (p-value = 0.914). These findings of no significant statistical association of FMD with locality is in disagreement with previous studies conducted in Ethiopia by Yahya, et al., (2013), in Kenya by Chepkwony, et al., (2012), in Southern Ethiopia by Megersa, et al., (2009), in southern Ethiopia by Habtamu , et al., (2011) and Esayas , et al., (2009) in Southwestern Ethiopia .

Three previous studies conducted in Nigeria by Misgana, et al., (2013) , Lazarus, et al., (2012) and Abdulahi et al., (2011) in Ethiopia supported this present study findings.

Additionally, age group was investigated for two serotypes. For serotype (O), age showed a higher rate in old group (93.44%), then medium group (75%) and at last

young group (57.14%) with significant statistical association of FMD (p-value = . 005). This outcome of the present study is in agreement with nine previous studies conducted in Ethiopia by Yahya, et al., (2013), in Kenya by Chepkwony , et al., (2012), Kibore, et al., (2013), in Rajshahi by Sarker, et al., (2011), in southern Ethiopia by Habtamu , et al., (2011), in Ethiopia by Shiferaw, et al., (2011), in Southern Ethiopia by Megersa, et al., (2009) and also in Ethiopia by Abdulah et al., (2011) , Fufa , et al., (2013) . Previous study disagreement with the present study findings which was reported, by Misgana, et al., (2013) in Ethiopia and by Esayas , et al., (2009) in Southwestern Ethiopia .

For the association between FMD serotype (SAT2) and age, higher rate of age showed in young group (28.57%), old group (27.87%), and medium group (20.31%). This study findings is supported by a previous studies conducted in Ethiopia, by Misgana, et al., (2013) and in Southwestern Ethiopia by Esayas , et al., (2009). Previous studies disagreement with the present study findings, reported, by Kibore, et al., (2013) in Kenya, Yahya, et al., (2013) in Ethiopia, Shiferaw, et al., (2011) in Ethiopia, Fufa, et al., (2013) in Ethiopia, Habtamu , et al., (2011) in southern Ethiopia, Megersa, et al., (2009) in Southern Ethiopia and by Sarker, et al., (2011) in Rajshahi .

Breed also was investigated in this study. For serotype (O) and serotype (SAT2), this risk factor showed no significant statistical association with FMD serotype (O) (p-value = 0.914) and FMD serotype(SAT2) (p-value = 0.251) respectively; this is in agreement with a study reported in Ethiopia, by Misgana, et al., (2013). Previous studies disagreement with the present study findings, reported, by Sarker, et al.,

(2011) in Rajshahi, Raouf, et al., (2012) in Sudan and Fufa, et al.,(2013) in Ethiopia.

Herd size in this study was investigated as risk factors. For serotype (O), herd size showed no significant statistical association (p-value = 0.531). This is in disagreement with studies reported in Ethiopia, by Misgana, et al., (2013), in Southern Ethiopia by Megersa, et al., (2009) and Shiferaw, et al., (2011).

For serotype (SAT2), herd size was high significantly associated with FMD prevalence (p-value = 0.007). Present study confirmed increase in FMD with an increase in herd size. This is in accord with findings of studies in Southwestern Ethiopia by Esayas , et al., (2009), in Southern Ethiopia by Megersa, et al., (2009) and in Ethiopia by Shiferaw, et al., (2011).

Previous history of FMD in farm also was investigated. It showed in the result as constant. Previous works conducted in Bhutan by Kinzang, D. et al., (2011) showed that previous history of FMD in farm as a risk factor for occurrence of FMD.

Previous history of other diseases in farm taken in this study as risk factors to show the associated with it and occurrence of FMD two serotypes. For serotype (O), result showed there is no significant association between the infection of FMDV serotype (O) and previous history of infections of other diseases in the farms (p-value = 0.639). For serotype (SAT2), result showed there is high significant association between the infection of FMDV serotype (SAT 2) and previous history

of infections of other diseases in the farms (p-value = 0.003). There is no information about the rate of this risk factor in previous studies.

All results of our present study with aims to show the association between risk factors and FMD serotype (O); FMD serotype (SAT2) was comparative with the prevalence of FMD as general in previous studies.

Previous studies did not show information about the association of many risk factors, with occurrence of FMD, such as green fodder, distance from other farms, manure disposal, hygienic practices, feeding and drinking equipment, housing, previous history of other diseases in farm, separation, milking techniques, grazing type, concentrate feeding and water source.

Conclusion

- In view of study findings, FMD is prevalent in Khartoum farms and FMD serotype (O) is the most prevalent, this may be due to that no application of specific multiple

vaccine contained serotypes known that its circulating in Khartoum State, or may be due to no veterinary extension about the nature of disease in the owner's community.
- Potential risk factors such as age, hygienic practices, green fodder, distance from other farms, herd size and previous history of other diseases in farm influenced the prevalence of FMD.

Recommendations

According to the results of the present study, the following points could be recommended:

1. There is need for rapid diagnosis of the disease based on molecular detection and molecular characterization of FMD circulating in the field.
2. Control strategy against this economically important emerging pathogen should be based on the application of FMD vaccination programme in Sudan.
3. Routine sero monitoring of disease and extension services direct to farmers.
4. Improvement of management systems and tight hygienic practices will reduce the prevalence of FMD.
5. More studies to verify the reported high activity of the three virus serotypes of FMD reported in Sudan.
6. More studies on potential risk factors that enhance the spread and transmission of FMD in the Sudan.

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Appendix I

Frequency tables for distribution of infection of FMD among 132 cattle tested at Khartoum state according to potential risk factors:

Appendix 1.1: Sex of animals

Valid	Frequency	Percent	Valid Percent	Cumulative Percent
Female	125	94.7%	94.7%	94.7%
Male	7	5.3%	5.3%	**100%**
Total	132	100%	100%	

Appendix 1.2: Breed of animals

Cumulative Percent	Valid Percent	Percent	Frequency	Valid
18.2%	18.2%	18.2%	24	Local
100%	81.8%	81.8%	108	Cross
	100%	100%	132	Total

Appendix 1.3: Age of animals

Cumulative Percent	Valid Percent	Percent	Frequency	Valid
5.3%	5.3%	5.3%	7	young
53.8%	48.5%	48.5%	64	Medium
100%	46.2%	46.2%	61	old
	100%	100%	132	Total

Frequency tables for distribution of infection of FMD among 132 cattle tested at Khartoum state according to potential risk factors: continued

Appendix 1.4: Body condition

Cumulative Percent	Valid Percent	Percent	Frequency	Valid
81.8%	81.8%	81.8%	108	Good
100%	18.2%	18.2%	24	Bad
	100%	100%	132	Total

Appendix 1.5: Locality

Cumulative Percent	Valid Percent	Percent	Frequency	Valid
10.6%	10.6%	10.6%	14	Khartoum
65.9%	55.3%	55.3%	73	Omdurman
100%	34.1%	34.1%	45	Bahrry
	100%	100%	132	Total

Appendix 1.6: Feeding and drinking equipments

Cumulative Percent	Valid Percent	Percent	Frequency	Valid
0%	0%	0%	0	Separated
100%	100%	100%	132	Common
	100%	100%	132	Total

Appendix 1.7: Hygienic practices

Cumulative Percent	Valid Percent	Percent	Frequency	Valid
.8%	.8%	.8%	1	Good
100%	99.2%	99.2%	131	Bad
	100%	100%	132	Total

Frequency tables for distribution of infection of FMD among 132 cattle tested at Khartoum state according to potential risk factors: continued

Appendix 1.8: Previous history of other disease in the farm

Cumulative Percent	Valid Percent	Percent	Frequency	Valid
73.5%	73.5%	73.5%	97	Yes
100%	26.5%	26.5%	35	No
	100%	100%	132	Total

Appendix 1.9: Previous history of FMD in the farm

Cumulative Percent	Valid Percent	Percent	Frequency	Valid
0%	0%	0%	0	No
100%	100%	100%	132	Yes
	100%	100%	132	Total

Appendix 1.10: Herd size

Cumulative Percent	Valid Percent	Percent	Frequency	Valid
6.8%	6.8%	6.8%	9	Small
65.1%	58.3%	58.3%	77	Medium
100%	34.8%	34.8%	46	Large
	100%	100%	132	Total

Appendix 1.11: Distance from other farms

Cumulative Percent	Valid Percent	Percent	Frequency	Valid
.8%	.8%	.8%	1	Far
100%	99.2%	99.2%	131	Near
	100%	100%	132	Total

Frequency tables for distribution of infection of FMD among 132 cattle tested at Khartoum state according to potential risk factors: continued

Appendix 1.12: Manure disposal

Cumulative Percent	Valid Percent	Percent	Frequency	Valid
8.3%	8.3%	8.3%	11	One week
40.9%	32.6%	32.6%	43	Two weeks
100%	59.1%	59.1%	78	Three weeks
	100%	100%	132	Total

Appendix 1.13: Green fodders

Cumulative Percent	Valid Percent	Percent	Frequency	Valid
.8%	.8%	.8%	1	Cut it from farm
100%	99.2%	99.2%	131	Buy it from markets
	100%	100%	132	Total

Appendix 1.14: Housing

Cumulative Percent	Valid Percent	Percent	Frequency	Valid
0%	0%	0%	0	Open
100%	100%	100%	132	Close
	100%	100%	132	Total

Appendix 1.15: Milking techniques

Cumulative Percent	Valid Percent	Percent	Frequency	Valid
0%	0%	0%	0	By machine
100%	100%	100%	132	By hands
	100%	100%	132	Total

Frequency tables for distribution of infection of FMD among 132 cattle tested at Khartoum state according to potential risk factors: continued

Appendix 1.16: Separation

Cumulative Percent	Valid Percent	Percent	Frequency	Valid
0%	0%	0%	0	According to production
100%	100%	100%	132	According to age
	100%	100%	132	Total

Appendix 1.17: Grazing

Cumulative Percent	Valid Percent	Percent	Frequency	Valid
0%	0%	0%	0	Open
100%	100%	100%	132	Close
	100%	100%	132	Total

Appendix 1.18: Water source

Cumulative Percent	Valid Percent	Percent	Frequency	Valid
0%	0%	0%	0	Dounkey
100%	100%	100%	132	Tape water
	100%	100%	132	Total

Appendix 1.19: Concentrate feeding

Cumulative Percent	Valid Percent	Percent	Frequency	Valid
0%	0%	0%	0	Buy from markets
100%	100%	100%	132	Prepared in farm
	100%	100%	132	Total

Appendix II

FMD serotype (O)

Distribution and prevalence of infection of FMD serotype (O) among 132 cattle tested at Khartoum state according to potential risk factors:

Appendix 2.1: Sex of animals

Results	Sex of animal		Total
	Female	Male	
- ve	20	3	23
	16%	42.86%	17.4%
+ ve	105	4	109
	84%	57.14%	82.6 %
Total	**125**	**7**	**132**

Appendix 2.2: Breed of animals

Results	Breed of animals	Total

- ve	4 16.67%	19 17.59%	23 17.4%
+ ve	20 83.33%	89 82.41%	109 82.6 %
Total	**24**	**108**	**132**

Distribution and prevalence of infection of FMD serotype (O) among 132 cattle tested at Khartoum state according to potential risk factors: continued

Appendix 2.3: Age of animals

Results	**Age of animals**			**Total**
	Young	**Medium**	**Old**	
- ve	3	16	4	23
	42.86%	25%	6.56%	17.4%
+ ve	4	48	57	109
	57.14%	75%	93.44%	82.6 %
Total	**7**	**64**	**61**	**132**

Appendix 2.4: Body condition

Results	**Body condition**		**Total**
	Good	**Bad**	
-ve	19	4	23
	17.59.%	16.67%	17.4%
+ve	89	20	109
	82.41%	83.33%	82.6 %
Total	**108**	**24**	**132**

Appendix 2.5: Locality

Results	**Locality**			**Total**
	Khartoum	**Omdurman**	**Bahrry**	

-ve	3	10	10	23
	21.43%	13.70%	22.22%	17.4%
+ve	11	63	35	109
	78.57%	86.30%	77.78%	82.6 %
Total	**14**	**73**	**45**	**132**

Distribution and prevalence of infection of FMD serotype (O) among 132 cattle tested at Khartoum state according to potential risk factors: continued

Appendix 2.6: Feeding and drinking equipments

Results	**Feeding and drinking equipments**		**Total**
	Separated	**common**	
-ve	0	23	23
	0%	17.4%	17.4%
+ve	0	109	109
	0%	82.6%	82.6%
Total	**0**	**132**	**132**

Appendix 2.7: Hygienic practices

Results	**Hygienic practices**		**Total**
	Good	**Bad**	
-ve	1	22	23
	100%	16.79%	17.4%
+ve	0	109	109
	0%	83.21%	82.6%
Total	**1**	**131**	**132**

Appendix 2.8: Previous history of other disease in the farm

Results	**Previous history of other disease in the farm**		**Total**
	No	**Yes**	
-ve	7	16	23

	20%	16.49%	17.4%
+ve	28	81	109
	80%	83.51%	82.6%
Total	**35**	**97**	**132**

Distribution and prevalence of infection of FMD serotype (O) among 132 cattle tested at Khartoum state according to potential risk factors: continued

Appendix 2.9: Previous history of FMD in the farm

Results	**Previous history of FMD in the farm**		**Total**
	No	**Yes**	
-ve	0	23	23
	0%	17.4%	17.4%
+ve	0	109	109
	0%	82.6%	82.6%
Total	**0**	**132**	**132**

Appendix 2.10: Herd size

Results	**Herd size**			**Total**
	Small	**Medium**	**Large**	
-ve	2	10	10	23
	22.22%	14.29%	21.74%	17.4%
+ve	7	66	36	109
	77.78%	85.71%	78.26%	82.6%
Total	**9**	**77**	**46**	**132**

Appendix 2.11: Distance from other farms

Results	**Distance from other farms**		**Total**
	Far	**Near**	
-ve	1	22	23
	100%	16.79%	17.4%
+ve	0	109	109

	0%	83.21%	82.6%
Total	**1**	**131**	**132**

Distribution and prevalence of infection of FMD serotype (O) among 132 cattle tested at Khartoum state according to potential risk factors: continued

Appendix 2.12: Manure disposal

Results	**Manure disposal**			**Total**
	One week	**Two weeks**	**Three weeks**	
-ve	3	8	8	23
	27.27%	18.60%	15.38%	17.4%
+ve	8	35	66	109
	72.73%	81.40%	84.62%	82.6%
Total	**11**	**43**	**78**	**132**

Appendix 2.13: Green fodders

Results	**Green fodders**		**Total**
	Cut it from farm	**Buy it from markets**	
-ve	1	22	23
	100%	16.79%	17.4%
+ve	0	109	109
	0%	83.21%	82.6%
Total	**1**	**131**	**132**

Appendix 2.14: Housing

Results	**Housing**		**Total**
	Open	**Close**	
-ve	0	23	23
	0%	17.4%	17.4%
+ve	0	109	109
	0%	82.6%	82.6%
Total	**0**	**132**	**132**

Distribution and prevalence of infection of FMD serotype (O) among 132 cattle tested at Khartoum state according to potential risk factors: continued

Appendix 2.15: Milking techniques

Results	Milking techniques		Total
	By machine	By hands	
-ve	0	23	23
	0%	17.4%	17.4%
+ve	0	109	109
	0%	82.6%	82.6%
Total	**0**	**132**	**132**

Appendix 2.16: Separation

Results	Separation		Total
	According to production	According to age	
-ve	0	23	23
	0%	17.4%	17.4%
+ve	0	109	109
	0%	82.6%	82.6%
Total	**0**	**132**	**132**

Appendix 2.17: Grazing

Results	Grazing		Total
	Open	Close	
-ve	0	23	23
	0%	17.4%	17.4%
+ve	0	109	109
	0%	82.6%	82.6%
Total	**0**	**132**	**132**

Distribution and prevalence of infection of FMD serotype (O) among 132 cattle tested at Khartoum state according to potential risk factors: continued

Appendix 2.18: Water source

Results	**Water source**		**Total**
	Tape water	**Dounkey**	
-ve	23 17.4%	0 0%	23 17.4%
+ve	109 82.6%	0 0%	109 82.6%
Total	**132**	**0**	**132**

Appendix 2.19: Concentrate feeding

Results	**Concentrate feeding**		**Total**
	Buy from markets	**Prepared in farm**	
-ve	0 0%	23 17.4%	23 17.4%
+ve	0 0%	109 82.6%	109 82.6%
Total	**0**	**132**	**132**

Appendix III

FMD serotype (O)

Association between infections of FMD serotype (O) among 132 cattle tested at Khartoum state and potential risk factors using the Chi- square test:

Appendix 3.1: Sex of animals

	Value	d.f	Asymp.sig (2-sided)
Pearson chi- square	**3.323**	**1**	**0.068**
Likelihood Ratio	**2.635**	**1**	**0.105**
Linear by Linear Association	**3.298**	**1**	**0.069**
N of Valid Cases		**132**	

Appendix 3.2: Breed of animals

	Value	d.f	Asymp.sig (2-sided)
Pearson chi- square	**0.012**	**1**	**0.914**
Likelihood Ratio	**0.012**	**1**	**0.913**
Linear by Linear Association	**0.012**	**1**	**0.914**
N of Valid Cases		**132**	

Appendix 3.3: Age of animals

	Value	d.f	Asymp.sig (2-sided)
Pearson chi- square	**10.706**	**2**	**0.005**
Likelihood Ratio	**11.045**	**2**	**0.004**
Linear by Linear Association	**10.624**	**1**	**0.001**
N of Valid Cases		**132**	

Association between infections of FMD serotype (O) among 132 cattle tested at Khartoum state and potential risk factors using the Chi- square test:

continued

Appendix 3.4: Body condition

	Value	d.f	Asymp.sig (2-sided)
Pearson chi- square	**0.012**	**1**	**0.914**
Likelihood Ratio	**0.012**	**1**	**0.913**
Linear by Linear Association	**0.012**	**1**	**0.914**
N of Valid Cases		**132**	

Appendix 3.5: Locality

	Value	d.f	Asymp.sig (2-sided)

Pearson chi- square	**1.580**	**2**	**0.454**
Likelihood Ratio	**1.571**	**2**	**0.456**
Linear by Linear Association	**1.224**	**1**	**0.269**
N of Valid Cases		**132**	

Appendix 3.6: Feeding and drinking equipments

	Value	**d.f**	**Asymp.sig** (2-sided)
Pearson chi- square	**No statistics are computed because**		
Likelihood Ratio			
Linear by Linear Association	**factor is constant**		
N of Valid Cases		**132**	

Association between infections of FMD serotype (O) among 132 cattle tested at Khartoum state and potential risk factors using the Chi- square test:

continued

Appendix 3.7: Hygienic practices

	Value	**d.f**	**Asymp.sig** (2-sided)
Pearson chi- square	**4.775**	**1**	**0.029**
Likelihood Ratio	**3.531**	**1**	**0.060**
Linear by Linear Association	**4.739**	**1**	**0.029**
N of Valid Cases		**132**	

Appendix 3.8: Previous history of other disease in the farm

	Value	**d.f**	**Asymp.sig** (2-sided)
Pearson chi- square	**.220**	**1**	**0.639**
Likelihood Ratio	**.215**	**1**	**0.643**
Linear by Linear Association	**.218**	**1**	**0.641**
N of Valid Cases		**132**	

Appendix 3.9: Previous history of FMD in the farm

	Value	**d.f**	**Asymp.sig** (2-sided)

Pearson chi- square	**No statistics are computed**
Likelihood Ratio	
Linear by Linear Association	**because factor is constant**
N of Valid Cases	**132**

Association between infections of FMD serotype (O) among 132 cattle tested at Khartoum state and potential risk factors using the Chi- square test:

continued

Appendix 3.10: Herd size

	Value	**d.f**	**Asymp.sig** (2-sided)
Pearson chi- square	**1.266**	**2**	**0.531**
Likelihood Ratio	**1.251**	**2**	**0.535**
Linear by Linear Association	**.373**	**1**	**0.542**
N of Valid Cases		**132**	

Appendix 3.11: Distance from other farms

	Value	**d.f**	**Asymp.sig** (2-sided)
Pearson chi- square	**4.775**	**1**	**0.029**
Likelihood Ratio	**3.531**	**1**	**0.060**
Linear by Linear Association	**4.739**	**1**	**0.029**
N of Valid Cases		**132**	

Appendix 3.12: Manure disposal

	Value	**d.f**	**Asymp.sig** (2-sided)
Pearson chi- square	**1.009**	**2**	**0.604**
Likelihood Ratio	**.930**	**2**	**0.628**
Linear by Linear Association	**. 897**	**1**	**0.344**
N of Valid Cases		**132**	

Association between infections of FMD serotype (O) among 132 cattle tested at Khartoum state and potential risk factors using the Chi- square test:

continued

Appendix 3.13: Green fodders

	Value	d.f	Asymp.sig (2-sided)
Pearson chi- square	**4.775**	**1**	**0.029**
Likelihood Ratio	**3.531**	**1**	**0.060**
Linear by Linear Association	**4.739**	**1**	**0.029**
N of Valid Cases		**132**	

Appendix 3.14: Housing

	Value	d.f	Asymp.sig (2-sided)
Pearson chi- square	**No statistics are computed**		
Likelihood Ratio			
Linear by Linear Association	**because factor is constant**		
N of Valid Cases	**132**		

Appendix 3.15: Milking techniques

	Value	d.f	Asymp.sig (2-sided)
Pearson chi- square	**No statistics are computed**		
Likelihood Ratio			
Linear by Linear Association	**because factor is constant**		
N of Valid Cases	**132**		

Association between infections of FMD serotype (O) among 132 cattle tested at Khartoum state and potential risk factors using the Chi- square test:

continued

Appendix 3.16: Separation

	Value	d.f	Asymp.sig (2-sided)
Pearson chi- square	**No statistics are computed**		
Likelihood Ratio			

Linear by Linear Association	**because factor is constant**
N of Valid Cases	**132**

Appendix 3.17: Grazing

	Value	d.f	Asymp.sig (2-sided)
Pearson chi- square	**No statistics are computed**		
Likelihood Ratio			
Linear by Linear Association	**because factor is constant**		
N of Valid Cases	**132**		

Appendix 3.18: Water source

	Value	d.f	Asymp.sig (2-sided)
Pearson chi- square	**No statistics are computed**		
Likelihood Ratio			
Linear by Linear Association	**because factor is constant**		
N of Valid Cases	**132**		

Appendix 3.19: Concentrate feeding

	Value	d.f	Asymp.sig (2-sided)
Pearson chi- square	**No statistics are computed**		
Likelihood Ratio			
Linear by Linear Association	**because factor is constant**		
N of Valid Cases	**132**		

Appendix IV

FMD serotype (SAT2)

Distribution and prevalence of infection of FMD serotype (SAT2) among 132 cattle tested at Khartoum state according to potential risk factors:

Appendix 4.1: Sex of animals

Results	Sex of animal		Total
	Female	Male	
- ve	95 76%	5 71.23%	100 75.76%
+ ve	30 24%	2 28.57%	32 24.24 %

Total	**125**	**7**	**132**

Appendix 4.2: Breed of animals

Results	**Breed of animals**		**Total**
	Local	**Cross**	
- ve	16 66.67%	84 77.77%	100 75.76%
+ ve	8 33.33%	24 22.22%	32 24.24 %
Total	**24**	**108**	**132**

Distribution and prevalence of infection of FMD serotype (SAT2) among 132 cattle tested at Khartoum state according to potential risk factors: continued

Appendix 4.3: Age of animals

Results	**Age of animals**			**Total**
	Young	**Medium**	**Old**	
- ve	5 71.43%	51 79.69%	44 72.13%	100 75.76%
+ ve	2 28.57%	13 20.31%	17 27.87%	32 24.24 %
Total	**7**	**64**	**61**	**132**

Appendix 4.4: Body condition

Results	**Body condition**		**Total**
	Good	**Bad**	
-ve	84 77.78.%	16 66.67%	100 75.76%
+ve	24	8	32

	22.22%	33.33%	24.24 %
Total	**108**	**24**	**132**

Appendix 4.5: Locality

Results	**Locality**			**Total**
	Khartoum	**Omdurman**	**Bahrry**	
-ve	10	56	34	100
	71.43%	76.71%	75.56%	75.76%
+ve	4	17	11	32
	28.57%	23.29%	24.44%	24.24 %
Total	**14**	**73**	**45**	**132**

Distribution and prevalence of infection of FMD serotype (SAT2) among 132 cattle tested at Khartoum state according to potential risk factors: continued

Appendix 4.6: Feeding and drinking equipments

Results	**Feeding and drinking equipments**		**Total**
	Separated	**common**	
-ve	0	100	100
	0%	75.76%	75.76%
+ve	0	32	32
	0%	24.24 %	24.24 %
Total	**0**	**132**	**132**

Appendix 4.7: Hygienic practices

Results	**Hygienic practices**		**Total**
	Good	**Bad**	
-ve	1	99	100
	100%	75.57%	75.76%
+ve	0	32	32

	0%	24.43%	24.24 %
Total	**1**	**131**	**132**

Appendix 4.8: Previous history of other disease in the farm

Results	**Previous history of other disease in the farm**		**Total**
	No	**Yes**	
-ve	33	67	100
	94.29%	69.07%	75.76%
+ve	2	30	32
	5.71%	30.93%	24.24 %
Total	**35**	**97**	**132**

Distribution and prevalence of infection of FMD serotype (SAT2) among 132 cattle tested at Khartoum state according to potential risk factors: continued

Appendix 4.9: Previous history of FMD in the farm

Results	**Previous history of FMD in the farm**		**Total**
	No	**Yes**	
-ve	0	100	100
	0%		
		75.76%	75.76%
+ve	0	32	32
	0%	24.24%	24.24 %
Total	**0**	**132**	**132**

Appendix 4.10: Herd size

Results	**Herd size**			**Total**
	Small	**Medium**	**Large**	
-ve	5	53	42	100
	55.56%	68.83%	91.30%	75.76%
+ve	4	24	4	32
	44.44%	31.17%	8.70%	24.24 %
Total	**9**	**77**	**46**	**132**

Appendix 4.11: Distance from other farms

Results	Distance from other farms		Total
	Far	**Near**	
-ve	1	99	100
	100%	75.57%	75.76%
+ve	0	32	32
	0%	24.43%	24.24 %
Total	**1**	**131**	**132**

Distribution and prevalence of infection of FMD serotype (SAT2) among 132 cattle tested at Khartoum state according to potential risk factors: continued

Appendix 4.12: Manure disposal

Results	Manure disposal			Total
	One week	**Two weeks**	**Three weeks**	
-ve	9	30	61	100
	81.82%	69.77%	78.21%	75.76%
+ve	2	13	17	32
	18.18%	30.23%	21.79%	24.24 %
Total	**11**	**43**	**78**	**132**

Appendix 4.13: Green fodders

Results	Green fodders		Total
	Cut it from farm	**Buy it from markets**	
-ve	1	99	100
	100%	75.57%	75.76%
+ve	0	32	32
	0%	24.43%	24.24 %
Total	**1**	**131**	**132**

Appendix 4.14: Housing

Results	Housing		Total
	Open	Close	
-ve	0	100	100
	0%	75.76%	75.76%
+ve	0	32	32
	0%	24.24 %	24.24 %
Total	**0**	**132**	**132**

Distribution and prevalence of infection of FMD serotype (SAT2) among 132 cattle tested at Khartoum state according to potential risk factors: continued

Appendix 4.15: Milking techniques

Results	Milking techniques		Total
	By machine	By hands	
-ve	0	100	100
	0%	75.76%	75.76%
+ve	0	32	32
	0%	24.24 %	24.24 %
Total	**0**	**132**	**132**

Appendix 4.16: Separation

Results	Separation		Total
	According to production	According to age	
-ve	0	100	100
	0%	75.76%	75.76%
+ve	0	32	32
	0%	24.24 %	24.24 %
Total	**0**	**132**	**132**

Appendix 4.17: Grazing

Results	Grazing	Total

	Open	Close	
-ve	0 0%	100 75.76%	100 75.76%
+ve	0	32	32
	0%	24.24 %	24.24 %
Total	**0**	**132**	**132**

Distribution and prevalence of infection of FMD serotype (SAT2) among 132 cattle tested at Khartoum state according to potential risk factors: continued

Appendix 4.18: Water source

Results	**Water source**		**Total**
	Tape water	**Dounkey**	
-ve	100 75.76%	0 0%	100 75.76%
+ve	32	0	32
	24.24 %	0%	24.24 %
Total	**132**	**0**	**132**

Appendix 4.19: Concentrate feeding

Results	**Concentrate feeding**		**Total**
	Buy from markets	**Prepared in farm**	
-ve	0 0%	100 75.76%	100 75.76%
+ve	0	32	32
	0%	24.24 %	24.24 %
Total	**0**	**132**	**132**

Appendix V

FMD serotype (SAT2)

Association between infections of FMD serotype (SAT2) among 132 cattle tested at Khartoum state and potential risk factors using the Chi- square test:

Appendix 5.1: Sex of animals

	Value	d.f	Asymp.sig (2-sided)
Pearson chi- square	**.075**	**1**	**0.784**
Likelihood Ratio	**.073**	**1**	**0.787**
Linear by Linear Association	**.075**	**1**	**0.784**
N of Valid Cases		**132**	

Appendix 5.2: Breed of animals

	Value	d.f	Asymp.sig (2-sided)
Pearson chi- square	**1.320**	**1**	**0.251**
Likelihood Ratio	**1.249**	**1**	**0.264**
Linear by Linear Association	**1.310**	**1**	**0.252**
N of Valid Cases		**132**	

Appendix 5.3: Age of animals

	Value	d.f	Asymp.sig (2-sided)
Pearson chi- square	**1.046**	**2**	**0.593**
Likelihood Ratio	**1.052**	**2**	**0.591**
Linear by Linear Association	**.429**	**1**	**0.512**
N of Valid Cases		**132**	

Association between infections of FMD serotype (SAT2) among 132 cattle tested at Khartoum state and potential risk factors using the Chi- square test: continued

Appendix 5.4: Body condition

	Value	d.f	Asymp.sig (2-sided)
Pearson chi- square	**1.320**	**1**	**0.251**

Likelihood Ratio	**1.249**	**1**	**0.264**
Linear by Linear Association	**1.310**	**1**	**0.252**
N of Valid Cases		**132**	

Appendix 5.5: Locality

	Value	**d.f**	**Asymp.sig** (2-sided)
Pearson chi- square	**1.580**	**2**	**0.454**
Likelihood Ratio	**1.571**	**2**	**0.456**
Linear by Linear Association	**1.224**	**1**	**0.269**
N of Valid Cases		**132**	

Appendix 5.6: Feeding and drinking equipments

	Value	**d.f**	**Asymp.sig** (2-sided)
Pearson chi- square	**No statistics are computed because**		
Likelihood Ratio			
Linear by Linear Association	**factor is constant**		
N of Valid Cases		**132**	

Association between infections of FMD serotype (SAT2) among 132 cattle tested at Khartoum state and potential risk factors using the Chi- square test: continued

Appendix 5.7: Hygienic practices

	Value	**d.f**	**Asymp.sig** (2-sided)
Pearson chi- square	**.322**	**1**	**.570**
Likelihood Ratio	**.558**	**1**	**.455**
Linear by Linear Association	**.320**	**1**	**.572**
N of Valid Cases		**132**	

Appendix 5.8: Previous history of other disease in the farm

Value	**d.f**	**Asymp.sig**

			(2-sided)
Pearson chi- square	**8.903**	**1**	**0.003**
Likelihood Ratio	**10.893**	**1**	**0.001**
Linear by Linear Association	**8.835**	**1**	**0.003**
N of Valid Cases		**132**	

Appendix 5.9: Previous history of FMD in the farm

	Value	**d.f**	**Asymp.sig** (2-sided)
Pearson chi- square	**No statistics are computed because**		
Likelihood Ratio			
Linear by Linear Association	**factor is constant**		
N of Valid Cases		**132**	

Association between infections of FMD serotype (SAT2) among 132 cattle tested at Khartoum state and potential risk factors using the Chi- square test: continued

Appendix 5.10: Herd size

	Value	**d.f**	**Asymp.sig** (2-sided)
Pearson chi- square	**10.065**	**2**	**0.007**
Likelihood Ratio	**11.124**	**2**	**0.004**
Linear by Linear Association	**9.742**	**1**	**0.003**
N of Valid Cases		**132**	

Appendix 5.11: Distance from other farms

	Value	**d.f**	**Asymp.sig** (2-sided)
Pearson chi- square	**.322**	**1**	**0.570**
Likelihood Ratio	**.558**	**1**	**0.455**
Linear by Linear Association	**.320**	**1**	**0.572**
N of Valid Cases		**132**	

Appendix 5.12: Manure disposal

	Value	**d.f**	**Asymp.sig** (2-sided)
Pearson chi- square	**1.315**	**2**	**0.518**

Likelihood Ratio	**1.294**	**2**	**0.524**
Linear by Linear Association	**. 152**	**1**	**0.697**
N of Valid Cases		**132**	

Association between infections of FMD serotype (SAT2) among 132 cattle tested at Khartoum state and potential risk factors using the Chi- square test: continued

Appendix 5.13: Green fodders

	Value	**d.f**	**Asymp.sig** (2-sided)
Pearson chi- square	**.322**	**1**	**0.570**
Likelihood Ratio	**.558**	**1**	**0.455**
Linear by Linear Association	**.320**	**1**	**0.572**
N of Valid Cases		**132**	

Appendix 5.14: Housing

	Value	**d.f**	**Asymp.sig** (2-sided)
Pearson chi- square	**No statistics are computed because**		
Likelihood Ratio			
Linear by Linear Association	**factor is constant**		
N of Valid Cases		**132**	

Appendix 5.15: Milking techniques

	Value	**d.f**	**Asymp.sig** (2-sided)
Pearson chi- square	**No statistics are computed because**		
Likelihood Ratio			
Linear by Linear Association	**factor is constant**		
N of Valid Cases		**132**	

Association between infections of FMD serotype (SAT2) among 132 cattle tested at Khartoum state and potential risk factors using the Chi- square test: continued

Appendix 5.16: Separation

	Value	d.f	Asymp.sig (2-sided)
Pearson chi- square	**No statistics are computed because**		
Likelihood Ratio			
Linear by Linear Association	**factor is constant**		
N of Valid Cases	**132**		

Appendix 5.17: Grazing

	Value	d.f	Asymp.sig (2-sided)
Pearson chi- square	**No statistics are computed because**		
Likelihood Ratio			
Linear by Linear Association	**factor is constant**		
N of Valid Cases	**132**		

Appendix 5.18: Water source

	Value	d.f	Asymp.sig (2-sided)
Pearson chi- square	**No statistics are computed because**		
Likelihood Ratio			
Linear by Linear Association	**factor is constant**		
N of Valid Cases	**132**		

Appendix 5.19: Concentrate feeding

	Value	d.f	Asymp.sig (2-sided)
Pearson chi- square	**No statistics are computed because**		
Likelihood Ratio			
Linear by Linear Association	**factor is constant**		
N of Valid Cases	**132**		

Appendix VI

Questionnaire for data collection to investigate the risk factors which could be associated with Foot and Mouth Disease (FMD) in Khartoum State - Sudan

- Animal NO( )

1. Breed of animal

0- Local ( ) 1- Cross ( )

2. Age of animal

0- Less or equal one year (young) 1- More than one year and equal five years (medium) 2- More than five years (old)

3. Sex of animal

1- male ( ) 1- Female ( )

4. Body condition

1- Good ( ) 1- Poor ( )

5. Herd Size

1- Less or equal 50(Small) ( ) 1- More than 50 and equal100 (medium) ( ) 2- More than100(large)( )

6. Grazing Type

1. Open ( ) 1. Close ( )

7. Previous history of FMD in the farms

1. Yes ( ) 1. No ( )

8. Locality

1. Khartoum ( ) 1-Bahrry ( ) 2- Omdurman( )

9. Previous history of other diseases in the farms

1. No ( ) 1. Yes ( )

10. Hygienic Practices

1. Good ( ) 1. Bad( )

11. Manure Disposal

1- One week ( ) 1-Two weeks ( ) 2- Three weeks( )

12. Distance from other farms

1. Far ( ) 1. Near ( )

13. Green Fodder

1. Cut it from the farm ( ) 1. Buy it from the market ( )

14. Concentrate feeding

1. Buy it from the market ( ) 1. Prepared it in the farm( )

15. Water Source

1. Tape water ( ) 1. Dounkey ( )

16. Milking Techniques

1. Machine ( ) 1. Hands ( )

17. Housing

1. Open ( ) 1. Close( )

18. Separation

1. According to age ( ) 1. According to production ( )

19. Feeding and drinking equipments

1. Privet ( ) 1. Common ( )

20. Result of FMD serotype (O)

0. Negative ( ) 1. Positive ( )

21. Result of FMD serotype (SAT2)

0. Negative ( ) 1. Positive ( )