

National Agriculture and Water Research Center,
Ministry of Agriculture and Water, Saudi Arabia.

THE ROLE OF SMALL RUMINANTS IN THE EPIZOOTIOLOGY OF FOOT AND MOUTH DISEASE IN SAUDI ARABIA WITH REFERENCE TO THE ECONOMIC IMPACT OF THE DISEASE ON SHEEP AND GOATS

(With 4 Tables and 5 Figures)

By

**M. A. FARAG; A. AL-SUKAYRAN*, K.S. MAZLOUM
and A.M.AL-BOKMY**

*: Department of Foot and Mouth Disease, Veterinary Serum and Vaccine
Research Institute, Abbassia, Cairo - Egypt.

(Received at 16/9/1998)

دور المجترات الصغيرة فى وبائية مرض الحمى القلاعية فى المملكة العربية
السعودية بالاشارة الى التأثير الاقتصادى لهذا المرض على الاغنام والماعز

مختار عامر فرج ، عبدالله محمد الصقيران ، كمال صابر مظلوم
أحمد منصور البقمى

تشكل المجترات الصغيرة العدد الاكبر من الحيوانات الزراعية بالمملكة العربية السعودية .
وقد اوضح المسح السيرولوجى الذى اجرى فى المناطق الرئيسية الخمس بالمملكة (مثلته فى
١٥ محافظة) انتشار العدوى بمرض الحمى القلاعية بين الاغنام والماعز فى جميع انحاء
المملكة . كان التبليغ عن حدوث اصابات لذلك المرض يتم باستمرار فى بعض محافظات
المملكة ، فيما كانت الصورة الاكثر انتشارا للاصابات بفيروس مرض الحمى القلاعية بين
المجترات الصغيرة تكون بدون اعراض مرضية واضحة . اوضحت النتائج السيرولوجية
بطريقه غير مباشرة ان الاصابه الغير ظاهرة (Subclinical) بفيروس مرض الحمى
القلاعية هى الاكثر شيوعاً . تم عزل مامجموعة ٩٩ (٩٢ Type O ، ٦ Type A و ١
Type Asia I) عترة فيروسية من اغنام وماعز مصابة ظاهريا (clinical) فى قطعان
موبوءة بمرض الحمى القلاعية . بالاضافه الى ٢١ عترة فيروسية للنوع السيرولوجى (O)
لفيروس مرض الحمى القلاعية تم عزلها من حلق اغنام وماعز من قطعان ترعى بجوار
ثلاث مزارع ابقار مختلفة . ووجد ان هذه الفيروسات (Type O carrier strains)

تشابهه انتجينا مع فيروسات (Type O) التي عزلت من اوبئة الحمى القلاعية فى مزارع الالبان الثلاثة المجاورة لهذه القطعان، وبناء على ذلك فقد تم مناقشة النواحي الوبائية لهذه النتائج وربطها بدور المجترات الصغيرة فى نقل فيروس الحمى القلاعية الى مناطق المملكة المختلفة وكذلك فى مزارع انتاج الالبان، بالاضافة الى مناقشة بعض البيانات الاولية عن الخسائر الاقتصادية التى احدثها مرض الحمى القلاعية فى المجترات الصغيرة، وقد تم تقديم اقتراح بانشاء برنامج وطنى لمقاومة مرض الحمى القلاعية فى المجترات الصغيرة فى المملكة العربية السعودية.

SUMMARY

Small ruminants represent the main population of domestic animals in Saudi Arabia. Serological surveys carried out in the main 5 Regions of the Kingdom (represent 15 Saudi provinces) revealed that infection with Foot and Mouth Disease (FMD) virus is nation-wide among sheep and goats. Clinical FMD in small ruminants is not common and the disease was currently reported in some provinces of the Kingdom. However, serological findings indirectly indicate that subclinical infection with FMD virus is more common. A total of 99 FMD viruses (92 type O, 6 type A and one type Asia 1) were isolated from clinically affected sheep and goats in herds exposed to FMD outbreaks. 21 serotype O FMD virus carrier strains were isolated from sheep and goats raised in close contact to 3 different dairy farms. The carrier strains revealed close antigenic relationship to the type O viruses that caused outbreaks in the neighbouring dairy farms. The epizootiological aspects of the obtained results in correlation to the possibilities of small ruminants in transmitting FMD virus to the different Regions of the Kingdom as well as to the dairy farms are interpreted. In addition, some preliminary data on the economic losses caused by FMD among small ruminants is also discussed. A proposal for initiating small ruminants control programme for FMD in Saudi Arabia is suggested.

Key Words: Foot and mouth disease -Epizootiology -Virus isolation -Typing - Serological survey-Economic losses-sheep and goats-Saudi Arabia.

INTRODUCTION

The enzootic status of foot and mouth disease (FMD) in Saudi Arabia is known since long time (Salah, 1961., Yasin,1963., Al-Mezini,1971). However, awareness of its economic importance had

increased only recently after the occurrence of the disease in modern dairy farms applying relevant preventive measures (Hafez, 1987). On the other hand, epizootiological information on the disease among indigenous animals and animals imported for slaughter, which are mostly small ruminants, was vague. The numbers of native sheep and goats in Saudi Arabia reportally are 7,321,172 and 4,308,509, respectively (Anon 1996). Most of these animals are nomadic and moving from region to region as well as the free range animals from the neighbouring countries. Moreover, about 6 to 7 million small ruminats are annually imported for slaughter. Approximately, half of the imported sheep and most of the imported goats are originating from countries where FMD is enzootic (Hafez *et al.*, 1994).

FMD control programmes in Saudi Arabia are mainly applied in dairy farms while most of the indigenous small ruminants are not vaccinated (Hafez *et al.*, 1993 a and b). On the other hand, clinical FMD was observed among sheep and/or goats in some Provinces. Eight large breeding farms, 23 nomadic flocks and 15 small breeding herds located in the Northern, Eastern and Central Regions of the Kingdom were affected (Unpublished data). Before this study, samples collected from small ruminants were submitted to the FMD-World Reference Laboratory (FMD-WRL), Pirbright, U.K., for diagnosis.

Thereafter, local studies on FMD were initiated and it became possible to carry out long term investigations on the epizootiological aspects of the disease under the Saudi field conditions. Data obtained from the field Veterinarians of 23 Provinces revealed the suspicion of clinical FMD among sheep and goats in 8 (35%) and 2 (9%) provinces, respectively (Hafez *et al.*, 1993 b). However, out of a total of 2,897 sheep and goats imported for slaughter from Sudan, Somalia, Egypt, Turkey, Syria, Jordan, Yemen and Pakistan, 117 (4%) were positive for the detection of VIA antibodies (Hafez *et al.*, 1994).

In the present studies, virological, serological and epizootiological data on the clinical and subclinical infection of sheep and goats in Saudi Arabia with FMD virus are interpreted. This data highlights the possible role of these animals on the transmission and persistence of the disease in the Kingdom. In addition, some preliminary data on the economic losses caused by FMD among small ruminants is also discussed. A proposal for inittating a control programme for FMD among small ruminants in Saudi Arabia is suggested.

MATERIAL and METHODS

Field samples

A total of 150 samples (epithelial tissues, heart, lymph nodes, whole dead lambs or kids) were collected from the following groups of sheep and/or goats for virus isolation:

- 1- Clinically affected nomadic sheep and/or goats.
- 2- Suddenly dead lambs and/or kids in nomadic flocks.
- 3- Large and small sheep breeding farms with suspected outbreaks of FMD.

Probang samples

Probang samples were collected from 14, 8 and 10 sheep, and 19, 10 and 10 goats, raised in 3 herds located in Al-Kharj, Tebrak and Mezahmiyah Provinces respectively. Sample collection was carried out using probang cups as described by Hedger and Stubbing (1971), the samples were treated with equal amount of trichlorotrifluoro-ethane as described by Suttmoller & Cottral (1967).

Virus isolation and typing

Primary isolation of FMD virus (from field & probang samples) was made in primary tissue-culture monolayers of bovine kidney cells as described by Hafez *et al.*, (1993 a). An Elisa FMD-typing kit provided by the FMD World Reference Laboratory (WRL) was used. Indirect sandwich Elisa described by Roeder & Blanc Smith (1987) with slight modification (Anon, 1989), was applied for serotyping of the isolates strains of FMD virus.

Serum samples

Blood samples were collected from 6159 non-vaccinated indigenous sheep and 1384 goats by Province Veterinarians of the main 5 Regions (represent 15 Saudi Provinces) for the detection of VIA antibodies using immunodiffusion test. These provinces are located in the Central, Eastern, Northern, Southern and Western Regions of the Kingdom.

Immunodiffusion test

The immunodiffusion test was carried out in 100 mm Petri dishes using FMD virus infection associated (VIA) antigen and reference positive serum as described by Hafez *et al.*, (1994).

Virus neutralization test

The microneutralization test was applied using BHK-21 monolayers, as described elsewhere (Golding *et al.*, 1976). One hundred

and fifty serum samples (103 sheep and 47 goats) which showed precipitating activity against VIA antigen, and 120 sera (80 sheep and 40 goats) without precipitating antibodies against VIA antigen were tested. These sera originated from different provinces covering the main 5 Regions of the Kingdom. Each serum sample was tested against four serotypes of FMD virus, using the virus strains O1 Manisa 68, A22 Iraq, C3 Phillipines and Asia1 India 79, respectively.

RESULTS

Epizootiological data

In collaboration with the concerned farm Veterinarian(s), the following data were collected after the occurrence of FMD outbreaks in each herd. Outbreaks of FMD usually occurred in sheep and goats in a mild form. Some outbreaks are severe. During these outbreaks, the reported data revealed that all age-groups of the animals were affected with morbidity rates ranging from 10 to 40%. Fever and anorexia are observed among some animals. Vesicle formation is not prominent. Lameness is often the only overt sign of the disease in the affected flocks. High mortalities among newborn lambs/kids (which may reach to 90 to 100% of animals younger than one month of age. (Unpublish data) are known. Also lambs/kids more than 4-6 months were lost during these outbreaks.

Virus isolation and typing

Examination of samples collected from 150 suspected FMD outbreaks/foci among sheep and goats in different Regions of the Kingdom revealed positive diagnosis in 99 (66%). Serotype O of FMD virus was confirmed in 92 cases including 6 outbreaks in large breeding farms. Six serotype A were isolated from outbreaks in 2 large breeding farms and 4 foci in small breeding herds. One serotype, Asia 1 FMD virus, was also isolated from a nomadic flock. The location from which the samples were collected and then positive diagnosis was confirmed are shown in Figure 2.

Virus isolation and typing from carrier animals

Out of a total of 71 probang samples examined in cell cultures, 21 virus strains were isolated (Table 1). The samples were from otherwise apparently healthy sheep and goats of one large breeding farm and 2 small breeding herds located in Al -Kharj, Tebrak and Mezahmyiah Provinces

respectively. All the isolated carrier strains were found to be serotype O of FMD virus.

Serological results

Detection of precipitating antibodies against VIA antigen

The results of immunodiffusion tests are shown in Figure 1 & Table 2. Of 6159 sheep sera and 1384 goats sera, 1263 (21%) and 232 (17%) were positive for the presence of precipitating antibodies against VIA antigen. The goats sera from Arar, Medina and Gizan were all negative when tested for antibodies against VIA. However, a proportion of sheep sera from animals raised in the same provinces were positive (Figures 1&3).

Detection of neutralizing antibodies against FMD virus

Examination of 150 serum samples (103 sheep and 47 goats) with precipitating antibodies against VIA antigen by virus neutralization test confirmed the presence of antibodies against one or more serotype of O, A and Asia1 of FMD virus in all tested samples (Table 3 & Figure 4). The positive percentage of the tested sera against serotype O, A, Asia1, O&A and O&Asia1 in the main 5 Regions of the Kingdom are shown in Table 3 & Figure 4. Antibodies against serotype O, A were detected in all 5 Regions, but antibodies against type Asia1 and O&Asia1 were detected in the Central Region only. Antibodies against serotypes O&A were detected in the Northern, Central and Southern Regions (Table 3 & Figure 4). In addition, out of 120 sera (80 sheep and 40 goats) without precipitating antibodies against VIA antigen re-tested by virus neutralization, various titers (ranging from 1:10 to 1:160) of neutralizing antibody against one or more serotype of FMD virus were detected. The percentages of positive results of the tested sera against serotypes O, A, Asia1 and O & A in the 5 main Regions are shown in Table 4 & Figure 5. However, no antibody against serotype C and O & Asia1 were detected in any sera tested.

DISCUSSION

Interpretation of virological, serological and epizootiological data

The main population of domestic animals in Saudi Arabia is small ruminant. The uncontrolled movements of these animals within the country or over the international borders between the Kingdom and neighbouring countries gives sheep and goats an important role in the epizootiology of FMD in Saudi Arabia. Our epizootiological data and

seroepizootiological results revealed that the occurrence of FMD among sheep and goats was mostly subclinical (Burrows, 1968., McVICAR and Suttmoller, 1972., Anderson *et al.*, 1976). Lameness, pyrexia and/ or anorexia was the most common clinical signs observed among some animals in the affected flocks. Sheep and goats are considered as maintaining host for infection with FMD virus (Brookby, 1981). The isolation of 99 FMD virus strains (92 type O, 6 type A and 1 type Asia1) from sheep and goats raised in 8 provinces located in the Northern, Eastern and Central Regions of the Kingdom indicates a nation-wide prevalence of FMD virus(es). Therefore, the movements of infected small ruminants with the prevalent field FMD viruses from one area to another area plays an important role in the transmission and persistence of FMD in Saudi fields. The excreted virus from clinical FMD cases (sheep and goats) can affect susceptible or immune animals. The infection of such animals will lead to further cycles of virus excretion and amplification of the infection among animals of the flock (McVICAR & Suttmoller, 1976., Donaldson & Kitching, 1989). On the other hand, the excreted virus will be transmitted to susceptible cattle and the clinical disease may occur (Brooksby, 1981). Comparative molecular studies carried out in FMD-WRL (Pribright, London, U.K.) revealed closer antigenic relationship of the serotype O carrier strains (selected from 21 serotype O carrier strains isolated from sheep and goats) to the type O viruses that caused outbreaks in the neighbouring dairy herds (FMD-WRL, Kitching, P., personal communication). These results reinforce the evidence that the infected sheep and goats will be transmitting the virus to the neighbouring dairy farms. High mortality (reaching up to 90%) among lambs or kids was observed in susceptible sheep and goats flocks affected with FMD virus (Hafez *et al.*, 1995 b).

The detection of precipitating antibodies against VIA antigen has been considered as a significant tool for epizootiological survey of FMD in Saudi Arabia (Dawe & Durojaive, 1986., Farag, 1983., Fernandez *et al.*, 1975., Hafez *et al.*, 1993 b., McVICAR & Suttmoller, 1970.). The detection of VIA antibodies in 17%, 26%, 5%, 5%, 9% of sheep and in 9%, 7%, 23%, 14% , 4% of goats raised in the Central, Northern, Southern, Eastern and Western Regions respectively of the Kingdom indicates a nation-wide prevalence of FMD virus(es).

The serotyping of the currently isolated FMD viruses from field cases (99 isolates) and carrier animals (21 isolates) revealed that serotype O is the predominant serotype in Saudi Arabia (92/99 of field viruses, 21

carrier strains). 6%(6/99) type A and 1%(1/99) type Asia1 were also detected from the typed viruses. These findings are in accordance with our seroepizootiological results which indicated the detection of naturally occurring neutralizing antibodies against serotyping O, A and Asia1 of FMD in the sera collected from non-vaccinated sheep and goats raised in the main 5 Regions of the Kingdom (Hafez *et al.*, 1993 a, Woodbury *et al.*, 1994). Despite the small number of sera examined by neutralisation tests, the results obtained confirm the present nationwide circulation of serotypes O, A and Asia1. Quadrivalent vaccine containing strains of O, A, C and Asia 1 is used in Saudi Arabia. The failure to detect type C antibodies and the detection of such antibodies in vaccinated animals (unpublished data) is an indirect indication that the examined animals had not been vaccinated.

The high percentage of positive serological test results in sheep and goats in many Regions of Saudi Arabia, in the absence of clinical FMD among these animals, indicates the importance of these range animals in transmitting FMD virus between Regions within the country.

A high percentage of sheep and goats that have recovered from FMD can become carriers for up to 2 years (Burrows, 1968., McVICAR and Suttmoller, 1969, Cottral, 1969). Despite the continuing failure to demonstrate transmission of FMD virus from carrier to susceptible animals, there are strong indications that some outbreaks of FMD which occurred in Zimbabwe and an outbreak which occurred in a Saudi dairy farm were associated with the movement of suspected carrier animals (Salt, 1992).

Economical assessments

FMD causes very high mortality among the lambs and kids crop of many small owners (reaching in some cases up to 90%, Unpublished data). The main income of most of these owners is dependent on selling the fattened yearling male animals. The deaths of the newborn animals simply deprives the owner from the next season new generation of females for replacing old ones or young males for selling. Such losses have direct influence on the socioeconomic conditions of many nomadic families, and on the national plans for development of animals resources. The estimated population of indigenous sheep and goats in Saudi Arabia are about 7,321,172 and 4,308,509 respectively (Anon, 1996). Usually, due to selling off of males for slaughter, it is considered that the half of this population are females and each will give an average birth of only one offspring per year. Therefore, about 5,815,000 lambs/kida may be born

annually in Saudi Arabia. If the mortality rate of the newly born animals reached 15% (in the absence of any vaccination history), about 872,250 lambs/kids may annually die due to infection with FMD virus. The estimated price of the newborn lambs/kids and the additional losses related to its death would be about 150 Saudi Riyal (SR) per (dead) lamb/kid (A.AL-Mukayel and A.M.AL-Bokmy, personal communication). Therefore, the total annual losses due to mortality of lambs/kids in the Kingdom can be possibly estimated to be around 130,837,500 SR. If all flocks of sheep and goats in the Kingdom were vaccinated against FMD using an average of two doses every year, about 23260,000 sheep doses will be annually required. The estimated price of sheep dose of FMD vaccine is 3 SR. Therefore, the annual total price of the required FMD vaccine to vaccinate all the indigenous sheep and goats in the Kingdom may be about 69,780,000 SR with cost benific ratio of 1: 1.875.

Proposals for control.

- 1- Control mreasure based on vaccination and including:
Obligatory standard FMD vaccination regimen applied as below
 - A) Lambs/kids primary vaccination at the age of 3 months, followed by a booster at four months of age and herd vaccination at 6 months intervals.
 - B) Pregnant ewes, only one vaccine dose at 2 months before lambing. A locall manufaturied vaccine of good quality should facilitate implementing of a nationwide vaccination campaign. In addition, the application of routine FMD vaccination for indigenous sheep and goats will improve the national control of the disease and will make the presently applied control in dairy farms more efficient.
- 2-Continued monitoring of the relationship between the vaccine and the field viruses will maintain the suitability of the vaccine strains to provide desired protection against the existing field viruses (Kitching *et al.*, 1988., Saumel *et al.*, 1990 a &b.).
- 3- Declaring the borders of the country as FMD control areas.
- 4- Institution of a movement permit system to control all movement of range animals, out of or into the control areas.
- 5- Prohibition of animal movement to and from the affected Region.
- 6- Agreements with neighbouring countries in order to ensure that the same standerds of disease control are applied.
- 7- Emphasis to be placed on the necessity of confirming the efficacy of current animals health measures.

REFERENCES

- AL- Mezaini, S. (1971):* " The situation of animal diseases in Saudi Arabia". Bull. Off. int. Epiz. 76, 443-445.
- Anderson, E.C., Doughy, W. J. & Anderson, J. (1976):* " The role of sheep and goats on the epizootiology of foot and mouth in Kenya". J. Hyg. Camb. 76, 395-402.
- Anon, (1989):* Foot and mouth Disease virus antigen detection: ELISA manual. Foot and Mouth Disease-World Reference Laboratory working protocol. 12 pp.
- Anon, (1996):* Agriculture statistical year book, Ministry of Agriculture and Water, Riyadh, Saudi Arabia, 9, 67-70.
- Brooksby, J. B. (1981):* " Foot- and- mouth disease". In: M.Ristic and I. Mc Intyre " Disease of cattle in the Tropics: Economic and Zoonotic Relevance", Current Topice in Veterinary Medicine and Animal Science, Martinus Nijhoff Publishers, The Hague, 6,pp.123-132.
- Burrows, R. (1968):* " The persistance of foot and mouth disease virus in sheep". J. Hyg. Camb. 66,633-640.
- Cottral, G.E.(1969):* " Persistance of foot and mouth disease virus in animals, their products and the environement ". Bull. Off. int. Epiz. 71, 549-563.
- Dawe, P.S & Durojaive, O, A. (1986):* A preliminary survey of antibody to VIA antigen of foot and mouth disease virus in Nigerian livestock. Rev. sci. tech. Off. int. Epiz., 5(3), 711-714.
- Donaldson, A. I. & Kitching, R. P. (1989):* " Transmission of foot and mouth disease by vaccinated cattle following natural challenge". Res. Vet. Sci. 46, 9-14.
- Farag, M. A., (1993):* Significance of virus infection associated (VIA) antigen as a tool for epizootiological survey to Foot and Mouth Disease in Egypt. Thesis, Cairo University, 71 pp.
- Fernandez, A. A., DE Mello, P.A., Gomer, I. & Rosenbero, F.J. (1975):* The used of virus infection associated antigen (VIA) in the detection of cattle exposed to FMDV. Bol. Centr. Panam. Fiebre Aftosa, 17/18, 19-22.
- Golding, S.M., Hedger, R.S. & Talbot, P. (1976):* Radial immunodiffusion and serum neutralization techniques for the assay of antibodies to swine vesicular disease . Res. Vet. Sci. 20, pp.142- 147

- Hafez, S.M. (1987): "The epizootiology of foot and mouth disease in dairy farms in Saudi Arabia". Proceeding of the workshop on Dairy production and Processing in Saudi Arabia. Riyadh, April 1987, 185-198.
- Hafez, S.M., Farag, M. A. & AL-Sukayran, A. (1994): "The impact of live animal importation on the epizootiology of foot and mouth disease in Saudi Arabia". Dtsch. tierarztl. Wschr. 101, 397-402.
- Hafez, S.M., Farag, M. A., Mazloun, K.S. & AL-Bokmy, A.M. (1993 a): Application of double sandwich enzyme linked immunosorbent assay for the diagnosis of Foot and Mouth disease in Saudi Arabia. Dtsch, Tierarztl. wschr, 100, 103 - 106
- Hafez, S.M., Farag, M.A. & AL-Sukayran, A. (1995): "An outbreak of foot and mouth disease in a sheep production farm in Saudi Arabia". Program and Abstracts: 16th Annual Meeting of the Saudi Biological Society, Riyadh, March 1995. 140.
- Hafez, S.M., Farag, M.A. & AL-Sukayran, A.M. (1993 b): "Epizootiology of foot and mouth disease in Saudi Arabia: II. Current status on dairy farms and control measures in operation". Rev. Sci. Off. Int. Epiz. 12, 817-830.
- Hedger, R.S. & Stubbing, a.G.J. (1971): "The carrier state in foot and mouth disease and the probang test". State Vet. J. 26, 45-50.
- Kitching, R.P., Rendle, R. & Ferris, N.P. (1988): "Rapid correlation between field isolates and vaccine strains of foot and mouth disease virus". Vaccine 6, 403-408.
- Mcvicar, J. W. & Suttmoller, P. (1969): "The epizootiological importance of foot and mouth disease carriers. I I. The carrier status of cattle exposed to foot and mouth disease following vaccination with an oil adjuvant inactivated virus vaccine". Arch. ges. Virusforsch. 26, 217-224.
- Mcvicar, J. W. & Suttmoller, P. (1972): Experimental foot and mouth disease in sheep and goats: An epizootiological model ". Arch. ges. Virusforsch. 38, 85-96.
- Mcvicar, J.W. & Suttmoller, P. (1970): Foot and mouth disease: the agar gel diffusion precipitin test for antibody to virus-infection-associated (VIA) antigen as a tool for epizootiological surveys. Am. J. Epidemiol., 92, 273-278.
- Mcvicar, J.W. & Suttmoller, P. (1976): "Growth of foot -and- mouth disease virus in the upper respiratory tract of non-immunised,

- vaccinated and reconverted cattle after intranasal inoculation". J.Hyg. Cambr. 76, 467-481.
- Roeder, P. L. & LE Blanc Smith, P.M. (1987):* Detection and typing of Foot and Mouth Disease virus by enzyme linked immun - osorbent assay: a sensitive, rapid and reliable technique for primay diagnosis. Res. Vet. Sci. 43,225-232
- Salah, M.N. (1961):* " Report to the Government of Saudi Arabia on the control of animal diseases". Food and Agriculture Organisation, Expanded Technical Assistance Programme, Project SAU / ANH, Report No. 1311, 20 pp.
- Salt, J. (1992):* " The possible epizootiological role of FMD- carrier animals on Saudi Arabia dairy farms". National Workshop on Foot and Mouth Disease in Saudi Arabia, November 1992, Riyadh. 5 pp.
- Samuel, A.R., Knowdes, N.J. & Kitching, R.P. (1990 b):* " preliminary antigenic and molecular analysis of strains of foot and mouth disease virus serotype O isolated from Saudi Arabia in 1988 and 1989 ". Report of the Session of the Reaserch Group of the standing Technical committee of the European commission for the control of Foot and Mouth Disease, Lindholm, Denmark. 139-145.
- Samuel, A.R., Ouldridge, E.J., Arrowsmith, A.E.M., Kitching, R.P & Knoweles, N.J. (1990 a):* Antigenic analysis of serotype O foot and mouth disease virus isolates from the Middle East, 1981 to 1988. Vaccine, 8, 390-396.
- Sutmoller, P. & C.A. Gaggero. (1965):* Foot and Mouth Disease carrier. Vet. Res., 77: 968 - 969
- Sutmol, P. & Cottral, G.E. (1967):* Improved techniques for the detection of FMDV in carrier cattle. Arch. ges. Virusforsch. 21, 170 - 177
- Woodbury, E.L., Samuel, A.R., Knowles, N.J., Hafez, S.M. & Kitching, R.P.(1994):* Analysis of mixed foot and mouth disease virus infections in Saudi Arabia : Prolonged circulation of an exotic serotype. Epidemiol. Infect., 112,201-211.
- Yasin, S.A. (1963):* " Report to the Governmant of Saudi Arabia on the Control of animal diseases". Food and Agriculture Organisation, Expanded Technical Assistance Programme, Project SAU / ANH, Report No. 1669, 26 pp.

Table 1. Isolation and typing of carrier strains of FMD from probang samples collected from sheep and goats

Province	sheep		Goats		Grand total	
	Tested*	positive**	Tested*	positive**	Tested*	positive**
Al-Kharj	14	7	19	4	33	11
Tebrak	8	4	10	2	18	6
Mezahmiyah	10	3	10	1	20	4
Total	32	14	39	7	71	21

* : Number of animals tested.

** : Serotype (O) of FMD virus was detected.

Table 2. Detection of antibodies to VIA antigen in sheep and goats sera collected from the main 5 regions of Saudi Arabia

Regions	Sheep			Goats		
	Tested*	positive	percentage	Tested*	positive	percentage
Northern	3156	834	26%	295	22	7%
Southern	177	8	5%	109	25	23%
Central	2099	362	17%	686	163	9%
Eastern	141	7	5%	98	14	14%
Western	586	52	9%	196	8	4%
Total	6159	1263	21%	1384	232	17%

* : Number of animals tested.

Table 3 . Neutralization of FMD virus serotypes using 150 sheep and goats sera reacted positive against VIA antigen.

Positive serum* for the presence of neutralizing antibodies against FMD virus serotype										
	Type O		Type A		Type Asia1		Type O&A		Type O& Asia1	
	sheep	goats	sheep	goats	sheep	goats	sheep	goats	sheep	goats
Northern Region Total number of sheep and goats tested (30)										
Total positive	12	8	3	3	0	0	4	0	0	0
Positive %	40%	27%	10%	10%	0%	0%	13%	0%	0%	0%
Central Region Total number of sheep and goats tested (80)										
Total positive	37	11	5	2	2	4	9	2	2	8
Positive %	46%	14%	6%	3%	3%	15%	11%	3%	3%	8%
Southern Region Total number of sheep and goats tested (20)										
Total positive	9	1	4	2	0	0	2	2	0	0
Positive %	45%	5%	20%	10%	0%	0%	10%	10%	0%	0%
Eastern Region Total number of sheep and goats tested (10)										
Total positive	5	3	1	0	0	1	0	0	0	0
Positive %	50%	30%	10%	0%	0%	10%	0%	0%	0%	0%
Western Region Total number of sheep and goats tested (10)										
Total positive	6	2	2	0	0	0	0	0	0	0
Positive %	60%	20%	20%	0%	0%	0%	0%	0%	0%	0%

* various titers ranging from 1:10 to 1:160 against serotype O, A, Asia1, O & A and O& Asia1 were detected in the sera of the positive animals.

Table 4 . Neutralization of FMD virus serotypes using 120 sheep and goats sera reacted negative against VIA antigen.

Positive serum* for the presence of neutralizing antibodies against FMD virus serotype										
	Type O		Type A		Type Asia1		Type O&A		Type O& Asia1	
	sheep	goats	sheep	goats	sheep	goats	sheep	goats	sheep	goats
Northern Region Total number of sheep and goats tested (20)										
Total positive	5	1	4	1	1	0	0	0	0	0
Positive %	25%	5%	20%	5%	5%	0%	0%	0%	0%	0%
Central Region Total number of sheep and goats tested (60)										
Total positive	14	8	6	2	1	2	7	0	0	0
Positive %	23%	13%	10%	3%	2%	3%	12%	0%	0%	0%
Southern Region Total number of sheep and goats tested (20)										
Total positive	7	1	3	0	1	1	1	0	0	0
Positive %	35%	5%	15%	0%	5%	5%	5%	0%	0%	0%
Eastern Region Total number of sheep and goats tested (10)										
Total positive	2	0	3	0	1	0	0	0	0	0
Positive %	20%	0%	30%	0%	10%	0%	0%	0%	0%	0%
Western Region Total number of sheep and goats tested (10)										
Total positive	2	1	2	0	0	0	1	0	0	0
Positive %	20%	10%	20%	0%	0%	0%	10%	0%	0%	0%

* various titers ranging from 1:10 to 1:160 against serotype O, A, Asia1 and O & A were detected in the sera of the positive animals.

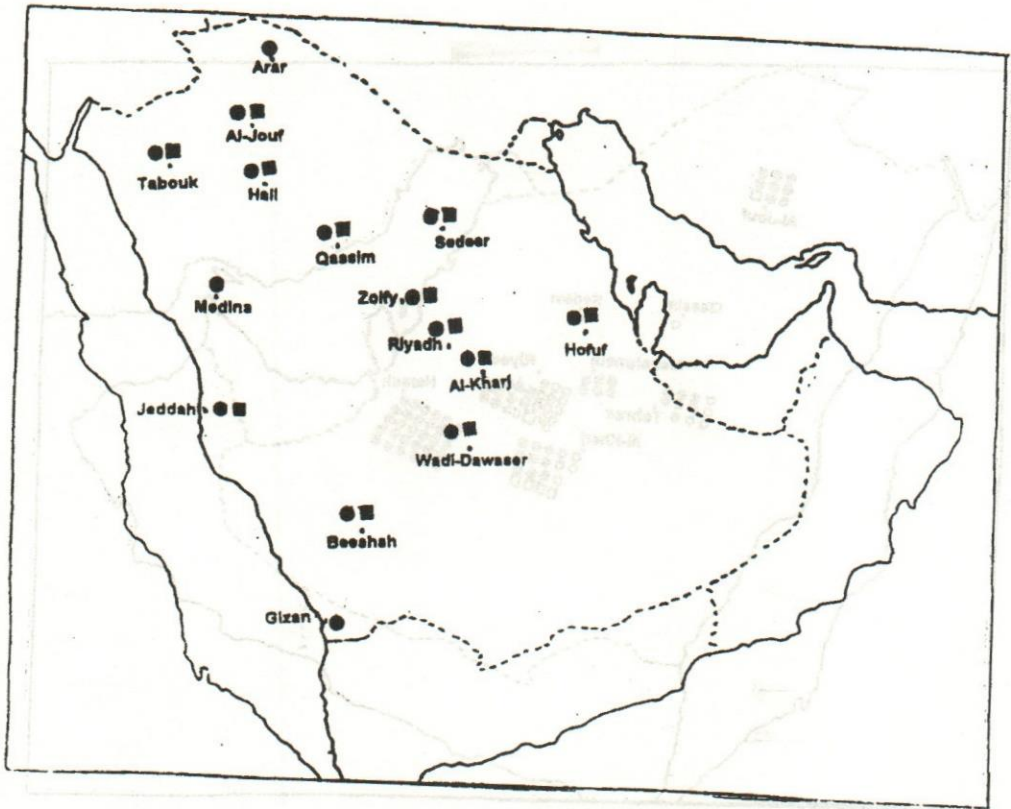


Figure 1.
Map of Saudi Arabia indicating the location of fifteen provinces and the sheep and goats in which precipitating antibodies against virus infection associated antigen were detected

Sheep ● Goats ■

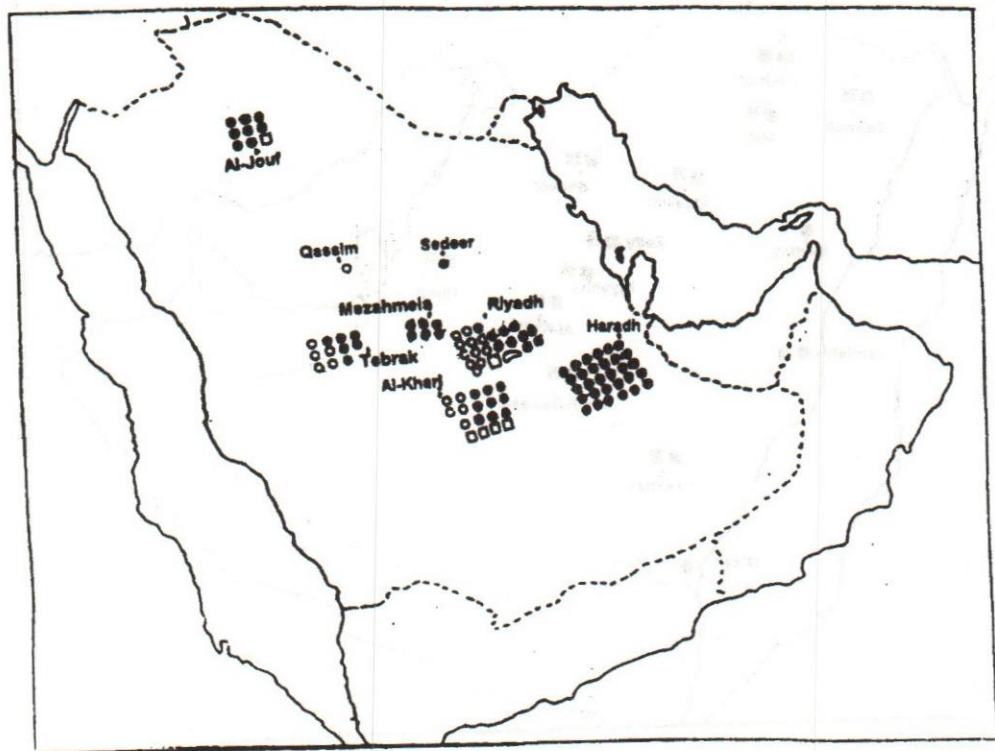


Figure 2.
Map of Saudi Arabia showing the geographical distribution of foot and mouth disease virus serotype O, A and Asia1 isolated from sheep and goats

	Type O	Type A	Type Asia1
Sheep	●	□	
Goats	○		◌

Figure 3. Detection of precipitating antibodies against VIA antigen in sera of non-vaccinated sheep and goats raised in 5 main regions of Saudi Arabia

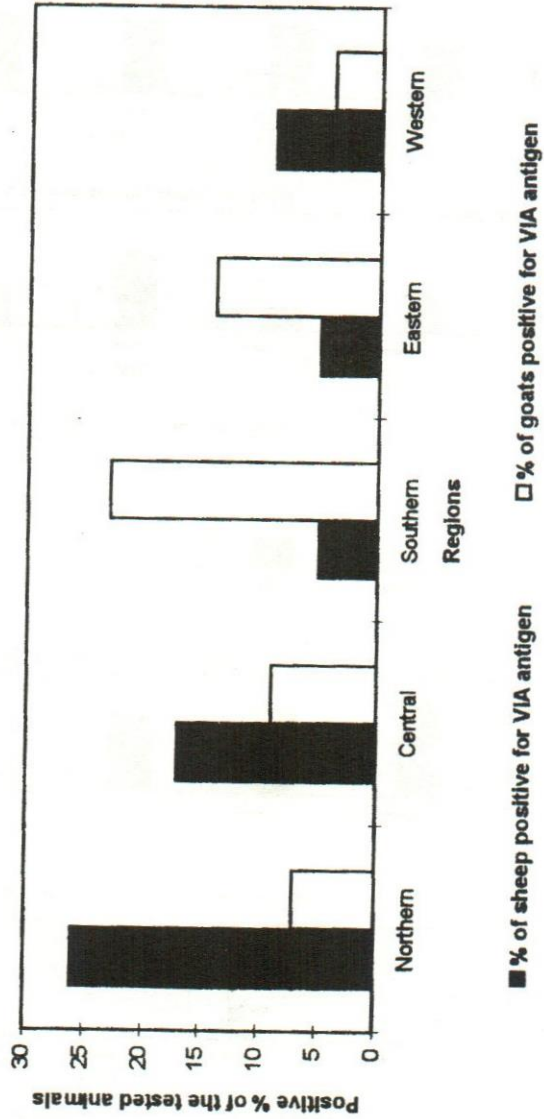


Figure 4. Antibodies against serotypes O, A and Asia1 of FMD virus detected in sheep and goats sera reacted positive against VIA antigen collected from different regions of Saudi Arabia.

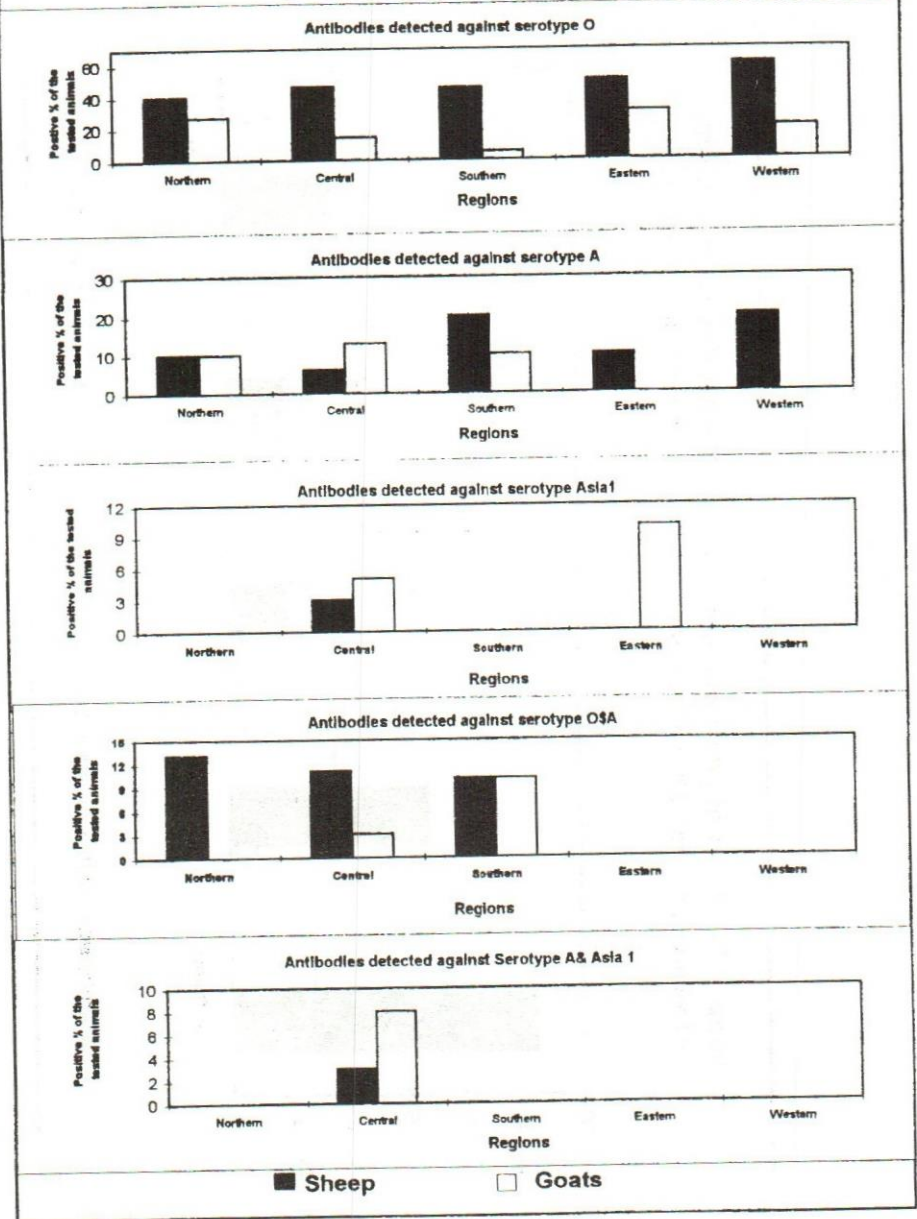


Figure 5. Antibodies against serotypes O,A and Asia 1 detected in sheep and goats sera reacted negative against VIA antigen collected from different regions of Saudi Arabia

