FOOT AND MOUTH DISEASE IN IRAQ: STRATEGY AND CONTROL

by

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Abstract

Foot-and-mouth disease (FMD) is a highly infectious viral disease of cattle, pigs, sheep, goats, buffalo, and artiodactyl wildlife species. Foot-and-mouth disease virus is endemic and periodic devastating epidemics have occurred and caused heavy economic losses in Iraq for a long time. The first official cases of FMD were recorded in 1937, while the first record of a specific FMD serotype in Iraq was serotype A in 1952. Other serotypes have been reported since then; serotypes O, SAT-1 and Asia1 were recorded in 1957, 1962, and 1975, respectively. Veterinary Services in Iraq has been severely weakened over the past two decades, and its infrastructure has been devastated as a consequence of previous political conflicts, wars and international sanctions. The breakdown of Veterinary Services led to the disruption of disease control strategies, collapse of disease surveillance and monitoring, and weakening of response systems. The destruction of the Al-Dora FMD laboratories for diagnosis and vaccine production by the United Nation in 1996, and the restrictions placed on the importation of vaccines have strongly affected the FMD control program. A severe epidemic of FMD occurred in Iraq in 1998, affecting 2.5 million ruminants and causing heavy losses in newly born animals. It is estimated to have killed about 550,000 animals. The outbreak was due to the serotype O1 Middle East strain which has affected large and small ruminants. In 2009, Iraq was severely affected by new serotype A (subtype A Iran 05).

The major efforts of Veterinary Services in Iraq have been directed towards control of FMD by vaccination strategies. Two types of vaccine have been used, trivalent vaccine (O, A 22, and Asia 1) for cattle and buffalo and monovalent vaccine (O Manisa) for sheep and goats. Vaccination has been implemented once yearly on a voluntary basis. Sometimes other limited control measures have accompanied vaccination, which include quarantine, movement

control, focused vaccination, disinfection, and public awareness programs. The FMD control program in Iraq has been confronted by many challenges: deficits in FMD surveillance and emergency preparedness, limited diagnostic capabilities, difficulties in restricting animal movement, and lack and irregular supply of appropriate vaccines.

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CHAPTER 1 - Foot and Mouth Disease General Review

1.1 Introduction

Foot-and-mouth disease (FMD) is an infectious viral disease of domestic and wild animals. It affects almost all cloven-footed animals including mainly ruminants such as cattle, buffalo, sheep, goats, and swine. The disease is present in most parts of the world. The disease is characterized by vesicular lesions and erosions of the epithelium of the mouth, nose, muzzle, feet, teats and udder. FMD-infected animals usually develop blister-like lesions in the mouth, tongue and lips, teats, or between the hooves, which causes them to salivate profusely or become lame. Morbidity and mortality are highest in the young; dairy breeds are particularly susceptible to FMD infection and, if they survive the acute disease, they might suffer serious, lengthy post-infection debility and loss of production. In a susceptible population, morbidity approaches 100%. The disease is rarely fatal, except in young animals (Geering and Lubroth, 2002).

1.2 History of FMD

Foot-and- mouth disease has been recognized as a significant epidemic disease threatening the cattle industry since the sixteenth century. The earliest description of probable FMD was given by Hieronymi Fracastorii in 1546. He described the disease, which occurred in northern Italy in 1514, as being unusual and affecting only cattle. In 1780 Le Vaillant (1795) from southern Africa, described a disease in cattle which "attacked the feet of oxen causing them to swell prodigiously and after producing suppuration, sometimes the hooves dropped off". Gordon Cumming (1850) and General S.J.P. Kruger (1858) also described a disease in southern Africa which was probably FMD; Hutcheon (1894) recorded an outbreak in South Africa, originating in Mashonaland and the Northern part of the Transvaal in 1893. In 1896, a panzootic outbreak of rinderpest swept through southern Africa and only isolated pockets of wildlife and cattle survived. It is estimated the total ruminant population was probably reduced by 95%. There are no additional reports of FMD in southern Africa until 1931 when the disease was observed in Rhodesia (modern Zimbabwe), except for outbreaks of disease in Cape Town in 1903 which originated from the importation of live, diseased animals from Argentina and were successfully controlled. In Germany, the existence of FMD was first reported by Adami in 1754, while in Great Britain it was first recorded in August 1839. FMD was endemic in continental Europe during this period and outbreaks were also recorded for the first time in Canada and the United States in the late 18th century (Knowles, 1990).

Loeffler and Frosch discovered that the FMD virus can be filterable and smaller than any known bacteria in 1898. Thus, FMD virus became the first virus of vertebrates to be discovered, soon after the discovery of tobacco mosaic virus of plants (Mahy, 2005). In 1922, Vallée and Carré first showed the existence of two immunological types of FMDV by cross-immunity tests in cattle. They were designated by their areas of origin, O (Oise, a department in northern France) and A (Allemagne - Germany). Soon after Waldmann and Trautwein reported the existence of three immunologically distinct types, A, B and C. Comparison of these viruses revealed that Waldmann and Trautwein's types A and B were the same as Vallée and Carré's types O and A, respectively; type C was distinct. Thus the three types became known, by international agreement, as Vallée O, Vallée A and Waldmann C and later simply as O, A and C. Many atypical virus strains were later described, mainly from Africa, until in 1948 a sample submitted to the World Reference Labratory from Bechuanaland (modern Botswana) yielded a virus (BEC/1/48) which in cross-protection tests in cattle and guinea pigs was found to be distinct from O, A and C. Subsequently, a virus isolate from northern Rhodesia (RHO/1/48) was identified as yet another distinct type. Retrospective testing of viruses isolated between 1931 and 1937 revealed isolates from southern Rhodesia in 1937 (RV/11/37) and 1931 (RV/1/31) which were similar to the 1948 isolates from Bechuanaland and Northern Rhodesia (modern Zambia), respectively. A further virus isolate from southern Rhodesia (modern Zimbabwe) in 1934 (RV/7/34) was found to be a third new type. These new types were designated SAT (southern African Territories) types 1, 2 and 3. The seventh serotype, designated Asia 1, was first recognized in the early 1950's as viruses were isolated from India in 1951 and 1952 and Pakistan in 1954, respectively (Knowles, 1990).

1.3 Etiology of the disease

In 1898 Loeffler and Frosch recognized the FMD causative agent as a viral pathogen and it is the sole member of the genus Aphthovirus belonging to the Picornaviridæ family. The FMD virion contains a single-strand RNA of positive polarity approximately 8500 nucleotides long (Domingo et al., 1992). The virus capsid is non-enveloped and has icosahedral symmetry with a diameter of approximately 300 Å, consisting of 60 copies of each of the structural proteins VP1, VP2, VP3 and VP4 (Fig. 0.20). While the first three structural proteins (MW≈24 kDa) have surface components, the fourth (MW≈8.5 kDa) is internal. The virion is also usually composed by one or two units of VP0, the precursor of VP2 and VP4 (Acharya et al., 1989).

The FMD virus has 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. Serotypes and strains of FMD virus vary within each geographic region, and Serotype O is the most common serotype worldwide. This serotype is responsible for a pan-Asian epidemic that began in 1990 and has affected many countries throughout the world, but other serotypes also cause serious outbreaks. Immunity to one serotype does not provide any cross-protection to other serotypes. Within a serotype there are different subtypes, especially within types A and O.   Cross-protection against other strains varies with their antigenic similarity (Murphy et al., 1999).

Methods have been used previously to differentiate FMD virus strains included the migration of viral structural proteins in SDS-polyacrylamide gel electrophoresis (Knowles and Sharma, 1990) and using electrofocusing (King et al., 1983).   However, now the main technique for characterization of genetic relationships between strains is the nucleotide sequence of viral RNA. The seven serotypes of FMDV were clustered into distinct genetic lineages with 30-50% difference in the VP1 gene (Knowles and Samuel, 2003). According to the VP1 sequence data type O, the most prevalent FMDV, could be further grouped into eight topotypes in which the differences in nucleotide sequence are up to 15%. The eight topotypes are Middle East-South Asia, South–East Asia, Indonesia-1, Cathay, East Africa, Europe-South America, West Africa and Indonesia-2 (Samuel and Knowles, 2001).

Field strains of FMDV attach to cells using integrin receptors $\alpha v\beta 6$, $\alpha v\beta 3$ and $\alpha v\beta 8$ (Jackson et al. 2003). The virus enters the cell via receptor-mediated endocytosis, and uncoating occurs due to acidification within the endosomal pathway (Jackson et al, 2000).

The virus is quickly inactivated outside the pH range of 6.0-9.0 and by desiccation and temperatures >56°C, although residual virus may survive a considerable time when associated with animal protein (for instance, a proportion of FMDV in infected milk will survive pasteurization at 72°C for 15 sec). The virus is very sensitive to desiccation. In aerosols, it survives best when the relative humidity exceeds 70%, and there is a critical humidity level of 55–60%, below which survival is poor (Sellers et al,1971). Sunlight and ultraviolet radiation have little effect on FMDV (Donaldson and Ferris, 1975). As long as the humidity remains above 55%, temperature is the major determinant of virus survival; the lower the temperature, the longer the survival.

Experiments have been conducted in Russia in the early 20th century apparently demonstrated the survival of virus in frozen or liquid manure for periods of more than 6 months in winter (Cottral, 1969), but it is not clear how long infectivity persists in dry fecal material under different environmental conditions.

The FMDV is resistant to lipid solvents such as ether and chloroform. Because of the sensitivity of the virus to acid and alkaline pH, sodium hydroxide, sodium carbonate, and citric or acetic acid are effective disinfectants (Randrup, 1954). Since feces are neutral in pH, the survival of virus in slurry depends largely on temperature and humidity (Parker, 1971).

1.3 Transmission

Transmission of FMDV occurs readily by direct contact between infected and susceptible animals. In addition, direct contact of susceptible animals with contaminated inanimate objects or fomites (hands, footwear, clothing, vehicles, etc.), consumption of contaminated meat products, ingestion of contaminated milk, artificial insemination with contaminated semen, and by inhalation of infectious aerosols. Aerosols transmission can occur in animals in close proximity to each other during the viremic stage of FMDV infection, or by wind-borne aerosols from far distances (up to 60 km overland and 300 km by sea). Animals infected with (FMDV) exhale virus in their breath as droplets and droplet nuclei vary depending on the virus strain, disease stage, and animal species. For instance, pigs infected with certain strains of virus can emit more than three orders of magnitude more airborne virus than cattle or sheep. However, for this to occur the proper environmental conditions of high humidity with decreased UV radiation (foggy conditions) and low temperatures must exist. These conditions have been observed in northern portions of Europe but not in the tropics due to low humidity, higher temperatures and abundant sunlight (USAHA, 2008). Several factors affect the spread of the FMD. The most important is the species infected, as well as the number of direct and indirect contacts among animals (mainly movements of animals and humans), animal density in the area, husbandry methods, environmental conditions, and delays in identifying the disease and applying control measures. Of all mechanisms of transmission of FMD, movements of infected animals are by far the most important, followed by movement of contaminated animal products (Donaldson, 1994). Once one or more animals in a herd have been infected, the quantity of virus in the environment will be greatly amplified, and transmission by different routes will be possible. The virus can be spread over long distances by incubating in asymptomatic carrier animals; by vehicles such as feed trucks; by birds, coyotes, domestic animals such as dogs and cats, rodents and arthropods; by mechanical vectors; and by fomites. Garbage containing uncooked meat scraps and bones from infected animals has been a source of infection in pigs. Humans may inhale and harbor the virus in the respiratory tract for as long as 24 hours, and may serve as a source of infection to animals (APHIS, 1991).

The FMDV is shed in large amounts from infected animals from as early as 1-2 days before the appearance of clinical signs, and for 7-10 days after the onset of clinical symptoms. Virus is excreted in all body fluids and excretions, as well as in exhaled air. Pigs are notorious for excreting large amounts of FMD virus (estimated at 10 million to 10 billion infective doses per day). Cattle are not that different in the amount of virus shed, primarily in the form of sloughed oral and pedal epithelium. There is also significant amount of FMDV shed in the milk of lactating cows reaching levels of five million infective doses per milliliter of milk (USDA, 1994).

1.4 Clinical course of disease

FMD has one of the shortest incubation periods of any major infectious disease known. In most situations, the incubation period for clinical signs to appear is usually 3-5 days. However, once an active outbreak of FMD occurs and there is a large amount of FMDV in the environment, incubation periods as short as 24-36 hours can be seen.

Foot-and-mouth disease is characterized by fever and blister-like lesions or vesicles occurring on the tongue, dental pad, gums, hard palate, lips, nostrils, muzzle, coronary bands, teats, udder, snout of pigs, and inter-digital spaces. Clinically, these lesions result in excessive salivation and lameness. In sheep and goats, the lesions are usually less pronounced. The disease is clinically indistinguishable from vesicular stomatitis, swine vesicular disease, and vesicular exanthema of pigs, which are notifiable diseases for this reason (Alexandersen et al., 2003). In cattle and pigs the clinical signs of FMD are prominent and severe, with the lesions easy to detect grossly. However, the clinical signs and or diagnosis of FMD in small ruminants may be difficult to detect due to the mild nature of the lesions (Kitching and Alexandersen, 2002; Kitching and Hughes, 2002). Some strains of FMDV may be of low or have no virulence for some species, however, can be extremely virulent for other species (Kitching, 2000).

Infection of susceptible animals with FMDV leads to lameness, listlessness, and inappetence. The characteristic lesions of vesicles can be found on the feet, in and around the mouth, and on the mammary glands and teats. In severe infections of the feet, hooves may be shed, which is more noticed in swine. 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. The severity of clinical signs varies with the strain of virus, the exposure dose, and the species, age, breed and degree of immunity of the animal. The signs can range from mild or inapparent. Death may result in some cases. Mortality from multifocal myocarditis is most commonly seen in young animals and myositis may also occur in other sites (Alexandersen and Mowat, 2005).

Morbidity is usually very high (close to 100%) in fully susceptible cloven-hoofed domestic animals. Morbidity in susceptible wildlife is quite variable from high to very low, depending on the FMDV subtype and the species involved. Generally, it is very low in adult animals (1-5%) but higher in young calves, lambs and piglets (20% or higher) (USAHA, 2008).

On post mortem, often lesions of FMD are visible as single or multiple vesicles or bullae varying from 2 mm to 10 cm in diameter. Early lesions range from a small pale area to a fluid-filled vesicle, sometimes coalescing with adjacent lesions to form bullae. The vesicles rupture, leaving red eroded areas, which may then be covered with a gray fibrinous coating. This coating becomes yellow, brown, or green and is replaced by new epithelium with a line of demarcation that gradually fades. Occasionally fluid may escape through the epidermis instead of forming vesicles. These "dry" lesions appear necrotic instead of vascular. Dry lesions are more common in the pig oral cavity. Lesions at coronary bands progress similarly: the skin and hoof separate and, as healing occurs, a line showing evidence of coronitis appears on the hoof. Pigs may actually slough their claws in severe cases (Spickler and Roth, 2008).

1.5 Economic Impact

Foot-and-mouth disease is one of the most important livestock diseases in the world, with the potential to cause a huge economic impact. Losses arise from the direct effects of the disease on production, costs of disease control, and restriction of trade. Direct effects are of greatest importance in dairy and pig production systems. Costs of disease control, whether by stamping-out or vaccination are high. Even countries that are free of the disease incur prevention and emergency preparedness costs. Many studies indicate that where FMD eradication is feasible, this is the least-cost policy option, even allowing for the costs of prevention, emergency preparedness and the risk of outbreaks. Where eradication is not feasible, it is economically beneficial to protect high producing livestock by vaccination. Vaccination of less efficient producing animals may also be justified, especially where these animals produce milk or traction power, or where this would serve to protect high-producing livestock from disease challenge (James and Rushton, 2002). It has been estimated that the cost of the FMD epidemic the United Kingdom experienced in 2001 was more than 15 billion USD, including compensation paid to farmers, cost for cleaning and disinfecting, support for businesses impacted by the outbreak, legal claims, decline in tourism, and mental health assistance (UK National Audit Office, 2002).

1.6 Diagnosis

Primary diagnosis of FMD commonly involves recognition of typical clinical signs in affected animals. Laboratory assessment should be used to differentiate FMD from other vesicular diseases. Immunological methods, isolation of virus and polymerase chain reaction (PCR) are used to identify viral antigen, virus or viral genome, respectively. Enzyme-linked immunosorbent assay (ELISA) detection of specific FMDV antigens in epithelial tissue samples and cell culture isolation are now used routinely in laboratories to diagnose FMDV (OIE, 2004).

The earlier use of the complement fixation test has largely been supplanted by ELISA due to greater sensitivity and specificity and ability to deal with large numbers of samples. Laboratory diagnosis is usually made by ELISA detection of specific FMDV antigens in epithelial tissue suspensions, often accompanied by concurrent cell culture isolation and the application of ELISA to any samples showing a cytopathogenic effect (Hamblin et al., 1984; Roeder and Le Blanc Smith, 1987). Antigen-capture ELISA uses specific high titred guinea pig and rabbit antiserum to detect specific FMD serotype antigens. Different rows in multiple well microtitre plates are coated with rabbit anti-sera against each of the seven serotypes of FMD virus. Test sample suspensions are added to each of the rows, and appropriate controls are also included. Then guinea-pig anti-sera against each of the respective serotypes of FMD virus are added followed by rabbit anti-guinea-pig serum conjugated to an enzyme. After adding enzyme substrate and chromogen, a color change indicates a positive reaction (Ferris and Dawson, 1988; Hamblin et al., 1984).

Virus isolation remains the ultimate proof of the presence of live FMDV. Primary cells like bovine thyroid cells or lamb kidney cells (House and House, 1989) are very sensitive but laborious to maintain. The quality can differ with each cell batch and requires therefore a well established quality assurance/quality control (QA/QC) system to guarantee a yearly availability of cells with the same sensitivity. Cell lines are easier to cultivate, and pig cell lines were commonly used, such as IB-RS-2, PK15 or SK6 for samples from different species. However, pig cell lines were not always suitable for isolation of FMDV coming from goats or sheep that sometimes excrete very low amounts of virus. The BHK-21T cell line seems to be less species dependent (Bouma et al., 2001).

Reverse transcription polymerase chain reaction (RT-PCR) can be applied to amplify genome fragments of FMDV in diagnostic materials including epithelium, milk, serum, vesicular fluid, and esophageal- pharyngeal samples. Reverse transcription combined with real-time PCR has a better sensitivity comparable to that of virus isolation and large numbers of small volume samples can be tested by automated procedures. Specific primers have been designed to distinguish between each of the seven serotypes (OIE, 2004).

1.7 FMD Vaccine

Foot-and-mouth disease virus was the first animal virus described as a causative agent by Loeffler and Frosch in 1897 and FMD vaccines were among the first animal vaccines to be developed, with efforts to immunize animals by exposure to infectious virus beginning at the end of the 19th century (Lombard et al., 2007). The first inactivated vaccine was developed by Waldmann et al. around 1937 using vesicular fluid obtained from tongues of deliberately infected cattle, and subsequently inactivated with formaldehyde (Waldmann and Zimmermann, 1955). But industrial production of inactivated vaccines did not begin until the 1950s after Frenkel described the culturing of tongue epithelium from healthy slaughtered animals (Lombard et al., 2007).

Protein vaccines were developed as alternatives to the inactivated vaccine by the mid 1970s. Researchers had developed information concerning the virus capsid structure and determined that one of the capsid proteins, VP1, had a prominent surface exposure (Rowlands et al., 1971). VP1 was isolated from purified virus and induced a neutralizing antibody response in swine and protected both swine and cattle against FMDV challenge (Bachrach et al., 1975). Attempts to develop live attenuated FMD vaccines have met limited success with vaccine viruses showing unstable phenotypes or differences in pathogenesis for individual species (e.g. attenuated in cattle but not in swine) or viruses too attenuated to consistently induce protective immune responses. The limitations of developing attenuated vaccines were due to problems of incomplete attenuation and protective immune responses were not as consistent with inactivated vaccines. Live FMD vaccines have not been present for many years due to concerns over reversion to virulence through mutation or recombination with field viruses. These live vaccines relied on the use of viruses selected in cell culture or in laboratory animals showing attenuated phenotypes (Rodriguez and Grubman, 2009).

1.8 FMD Control

Foot-and-mouth disease control has the ultimate aim of eradication of the virus from the population. Control of FMD depends on controlling its spread from an infected to a susceptible animal, either by preventing the movement of the virus in infected animals, animal products, fomites, aerosol or carriers or by reducing the number of susceptible animals by vaccination (Kitching, 2005). The FMD status of any particular country or region can be defined as endemic, epidemic (sporadic), or free. FMD-free regions can be defined by national borders (e.g., Australia, Indonesia), by supranational borders (e.g., Europe, North America) or by disease-free zones within non-free areas which are maintained by movement control (e.g., Zimbabwe, South Africa). Sporadic regions are characterized by repeated incursions of FMD viruses into regions where disease does not usually occur. The disease is either eliminated through a control program or disappears naturally without intervention until the next introduction months or years later. Early detection of disease, imposition of quarantine measures followed by stamp out of infected livestock and implementation of movement restriction to reduce the risk of mechanical spread has been the classical approach to FMD control (OIE, 2004).

Countries generally free of FMD usually attempt to control by strict import controls, as was seen in Europe in 2001, is not always successful. However, the benefit of maintaining the national flock and herd free of FMD without the use of vaccination, in terms of increased export markets and without the regular expense of vaccine, was considered to exceed the cost of eliminating the occasional outbreak of disease and encouraged the EU to stop prophylactic vaccination at the end of 1991 (Kitching, 2005) .

Control of FMD by stamping out depends on having effective veterinary services, funding for compensation, adequate resources to slaughter and dispose of carcasses and movement restriction enforcement. In some countries and situations it is not possible to control the disease using stamping out procedures (Yang et al., 1999). Vaccination is used as an option to control FMD when stamping out is not feasible. The aim is still to control and eradicate the infection but short-term vaccination is aimed at preventing clinical disease and reducing the level of virus shedding. When used in an emergency outbreak situation the effectiveness of FMDV control by vaccination will depend on the vaccine strains available. At this time a closely matched strain would be required immediately to formulate a vaccine (Kitching et al., 1989).

The OIE developed new trade guidelines for FMD in 1992, incorporating rules for zoning and the use of vaccination (OIE Terrestrial Code; see Appendix 3). The International Committee of OIE made an additional revision of vaccination at its 70th General Session in May 2002. This allows for countries that do not slaughter vaccinated animals to regain country freedom after 6 months instead of 12 months, provided ‘non-structural protein’ tests are used to verify lack of infection in vaccinated animals. Zoning and regionalization for FMD was also recognized by the Uruguay Round of the General Agreement on Tariffs and Trade (GATT) in 1993, in the Sanitary and Phytosanitary Agreement. Implementation of these new principles is now under the jurisdiction of the World Trade Organization (WTO), which was established in 1995.

The adoption of zoning and the use of FMD vaccine will therefore have important implications for the control of an FMD outbreak and the subsequent establishment of FMD-free status and international trade (AUSVET, 2006).

1.9 Geographical distribution of FMD virus serotypes

FMD virus is distributed globally with the exception of North America, Western Europe, and Australia. Serotypes are not uniformly distributed in regions of the world where the disease still occurs. Six of the seven FMDV serotypes of (O, A, C, SAT-1, SAT-2, SAT-3) have occurred in Africa, while Asia contends with four serotypes (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 et al., 2008). The virus has been widely distributed in Africa and Eurasia from ancient times, but the New World was probably free of infection until introduction with European livestock during the nineteenth century. The current global burden of FMD virus infection is maintained within three continental reservoirs of Asia, Africa and South America that can be further subdivided into seven major virus pools of infection (Paton et al., 2008). Each virus pool contains at least three serotypes of virus, and because virus circulation is mainly within these regional reservoirs, strains have evolved which are specific to the region and which often (in the case of type A and SAT viruses) require tailored vaccines. An eighth pool of infection, in Western Europe, was present until the 1980s, but has been eradicated through a combination of preventive vaccination and zoo-sanitary measures (Valarcher et al., 2008); Figure 1.1.

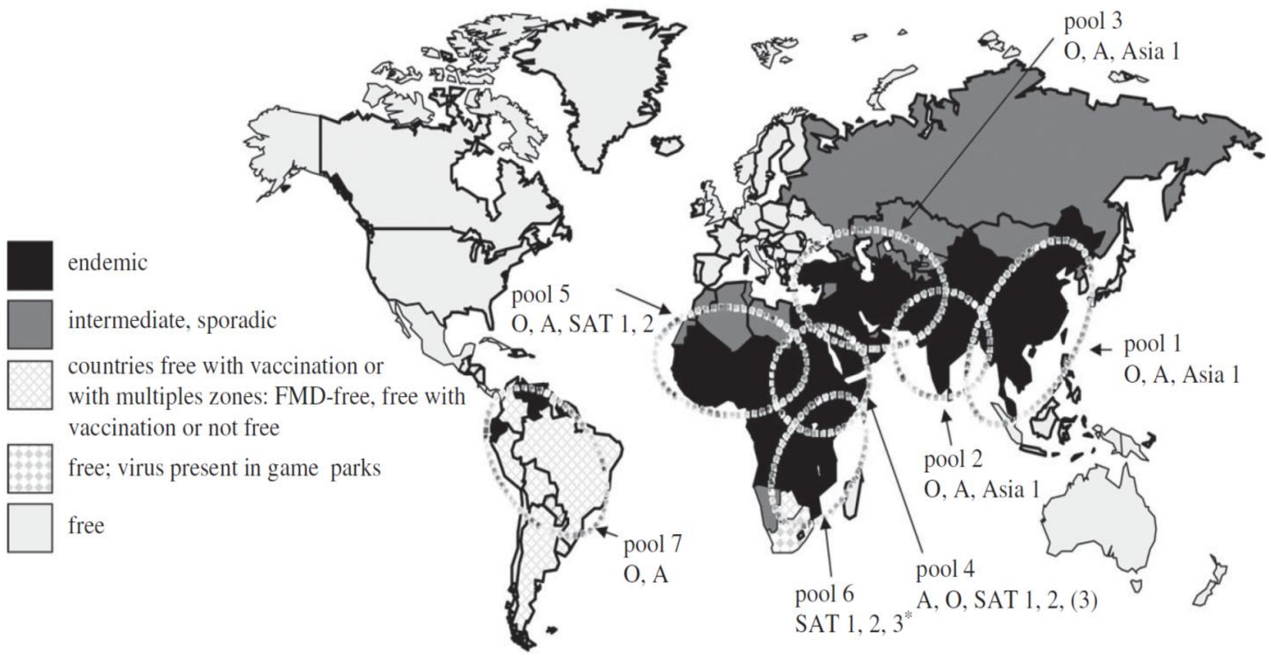


Figure 1.1 FMD status in 2008 overlaid with regional FMDV pools and predominant virus serotypes.

Adapted from FMD World Reference Laboratory (*http:// www.wrlfmd.org/).*

The relative distributions of the different serotypes and topotypes of FMD virus, and their restriction and persistence in certain geographical areas, does suggest that some strains adapt to certain hosts, and the existence of the carrier state could provide at least a partial explanation.

1.9.1 Serotype O

Foot-and-mouth disease serotype O viruses were classically divided into 10 or 11 antigenic subtypes (Davie, 1964), although it is now recognized that antigenic variation with this serotype is not as extensive as once thought and relatively few vaccine strains are able to protect against most field outbreaks. Disease caused by serotype O has always been the most dominant and most widely distributed. It has the reputation of being the most aggressive serotype and the most difficult to control by vaccination, although so far there is no genetic explanation as to why this serotype is so invasive. Some of the strains are clearly catholic in their host range, appearing equally virulent and transmissible in sheep, goats, pigs and cattle, whereas others, like those of the Cathay topotype, will only cause disease in pigs, even under experimental conditions (Dunn and Donaldson, 1997). The Cathay topotype is found in the densely pig-populated countries of southeast Asia and appears to be maintained by feeding susceptible pigs waste food contaminated with virus. Unlike the Cathay topotype, the PanAsia topotype is not restricted to infecting pigs. In the UK it caused clinical disease in cattle, pigs, sheep and goats, although its effect on sheep was less obvious (see above). In South Korea during the 2000 outbreak it affected only cattle, whereas in the 2002 outbreak it affected only pigs. However, when it was discovered in 1999 in Taiwan the same strain failed to produce clinical disease in Chinese Yellow cattle but caused outbreaks in other cattle and goats. In Mongolia, a PanAsia strain reportedly killed Asian camels during their 2000 outbreak (Kitching, 2005).

1.9.2 Serotype A

Foot-and-mouth disease serotype A viruses have always been considered to be antigenically the most diverse of the Eurasian serotypes and up to 32 subtypes had been defined by the early 1970s (Davie, 1964; Pereira, 1977). Some of these subtypes have been shown to be genetically distinct (e.g. A22 Iraq, A24 Cruzeiro), although many have not been examined.

Although this system of subtyping was discontinued, type A viruses are still considered to be extremely antigenically and genetically diverse (Knowles and Samuel, 2003).

There is greater antigenic diversity between serotype A strains than between strains within serotypes O, C or ASIA 1, and there has been a constant and frequent appearance of antigenically new strains, particularly in western Asia. The World Reference Laboratory for FMD maintains a database of more than 2,000 FMD virus partial 1D gene sequences, which can be rapidly compared with the sequence of a new outbreak strain to identify a possible origin. In 1996, outbreaks due to a strain of serotype A were causing major concern to the dairy industry in Iran, because of the lack of immunity provided by the current vaccine. When the IP4 gene was sequenced, it was 18% different from anything in the database, which was very unusual as previously even a 10% difference from existing strains, other than within the SAT serotypes, was rare (Kitching, 1998).

1.9.3 Serotype Asia 1

Serotype Asia 1 was first detected in 1951 through 1952 from samples collected in India and Pakistan in 1954 (Dhanda et al., 1959). The primary serotype-endemic region for Asia 1 seems to be the Indian subcontinent (Afghanistan, India, Pakistan, Bhutan, Nepal), where outbreaks occur regularly, and some have speculated that this distribution is related to that of the Asian water buffalo. The serotype has been more sporadically reported from countries to the west or east; it has spread periodically into the Middle East and occasionally to Europe (Schumann et al., 2008), but it has not been reported from Africa or the Americas. However, even in its endemic heartland, the Asia 1 serotype has normally been the cause of only a small proportion of cases compared with the proportion caused by serotypes O and A. Similarly, in

Southeast Asia, where serotypes O and A are prevalent every year, outbreaks due to Asia 1 have been reported only sporadically in the past 10 years; a recent gap in reporting occurred between 2002 and 2005 (Valarcher et al., 2009).

1.9.4 Serotype C

Serotype C has a very limited distribution compared with most of the other FMDV serotypes. During the last 20 years there have been no major outbreaks reported due to this strain. Sporadic outbreaks have occurred from which a strain of serotype C was isolated, particularly in Nepal, Bhutan and India. More recently, only Kenya has been reporting outbreaks due to serotype C, and these may be associated with the continuing use of a strain of serotype C in the locally produced vaccine (Kitching, 2005).

Historically, serotype C has been recorded in Europe, South America, EA, North Africa, Angola and southern Asia. However, it now appears to be limited to the Indian sub-continent and only appears intermittently. It is not clear why serotype C is apparently disappearing, although vaccination and control campaigns have been responsible for its eradication in Europe and South America, where the last outbreaks occurred in 1989 (Italy) and 1994 (Argentina), respectively. However, this is not the case in Asia (Knowles and Samuel, 2003).

1.9.5 Serotypes SAT

Serotypes SAT (Southern African Territories) include three types, SAT1, SAT2 and SAT3 of FMDV. These serotypes are geographically restricted to Africa. Where the natural host for the SAT viruses is the African buffalo (*Syncerus caffer*) in which overt disease is rarely observed (Hedger, 1976; Thomson, 1995). These animals are usually persistently infected in the oropharynx, sometimes with multiple serotypes and often for long periods of over five years. This is longer than that recorded for cattle, particularly with these serotypes, which adds support to the hypothesis of the importance of the carrier state for the survival of the FMDV (Condy et al., 1985). The SAT serotypes are normally confined to sub-Saharan Africa. However, a number of outbreaks of SAT 1 have been recorded in the Middle East (1962 - 1965 and 1969 - 1970) and, on one occasion (1962) in Greece. Recently type SAT 2 spread into Saudi Arabia and Kuwait, but has since been eradicated (Knowles and Samuel, 2003).

There is considerable sequence variation between strains within each of the SAT serotypes, suggesting that there could be considerable antigenic variation (Bastos et al. 2001; Vosloo et al., 1995). The more common serotype isolated from cattle in Africa is SAT 2. The African buffalo maintains SAT 1 and 3, occasionally causing outbreaks in cattle with which the buffalo have contact. (Bastos et al., 2000).

Serotype SAT 1 has been classified into three topotypes (Bastos et al., 2001; Reid et al., 2001). The first occurs in southeastern Zimbabwe and South Africa, the second occurs in western Zimbabwe, Botswana and Namibia and has been named topotype II or WZ; and the third which is found in northwestern Zimbabwe, Zambia and Malawi is called topotype III or NWZ. However, other topotypes exist in East and West Africa (Reid et al., 2001).

Serotype SAT 2 viruses have been isolated from cattle and buffalo in South Africa, Namibia and Zimbabwe. It has been found that SAT 2 viruses from southern Africa fall into two topotypes, one occurred in Zimbabwe between 1981 and 1991 and the other one throughout the southern African region and extending into East Africa and the Middle East. Additional topotypes are also present in East and WA. Therefore, unlike SAT 1 and SAT 3, southern

African SAT 2 viruses do not appear to fall into the same geographically based groupings (Vosloo et al., 1992).

Serotype SAT 3 has three topotypes, I-SEZ (southeastern Zimbabwe and South Africa), II-WZ (western Zimbabwe and Botswana) and III-NWZ (northwestern Zimbabwe and Malawi) (Reid et al., 2001). These appear to have the same geographical distribution as the southern African SAT 1 virus. A fourth topotype has been identified in Ugandan buffalo, although no outbreaks of SAT 3 have ever been recorded in cattle outside of the southern African region. It is possible that SAT 3 viruses exist in buffalo populations in other parts of Africa and it is predicted these would be highly divergent from those in southern Africa (Knowles and Samuel, 2003).

1.10 FMD in Middle East:

The Middle East is regarded as the region of the world most heavily affected by FMD. The situation in the Middle East constitutes a threat to other regions of the world, especially Europe. During the past few years, FMD spread several times from the eastern part of the Middle East to Europe, infecting Turkey (Thrace), Greece, Bulgaria and Italy (Aidaros, 2002).

The livestock population of the Middle East includes 30 million cattle and buffalo, and more than 120 million small ruminants (sheep and goats) (Anon, 2001). FMD has been mentioned in the Middle East since the latter years of the Ottoman rule, namely the late 19th and the early 20th Century, and serotype O has been recorded in all countries of the Middle East on numerous occasions between 1952 and 2009 (Table I) (FAO, 2010) Serotypes, O, A, Asia 1, SAT1, C and SAT 2, have been recorded in Middle East region, but serotype O of FMD virus is the most prevalent. Currently, only one country in the Middle East (Cyprus) is presently included OIE list of FMD free countries. Figure (1.2) shows serotypes in countries of Middle East which have caused FMD outbreaks between 2002 and 2010.

In the past, exotic strains of FMDV were involved in panzootics, covering large parts of the Middle East and even extending to the frontier of Europe. A remarkable example was the rapid dissemination of virus serotype SAT1 which entered Bahrain (through imported sheep from Africa) in December 1961. The virus spread northwest to reach Iraq, Jordan, Israel and Syria by April 1962, continuing into Iran and Turkey. In September 1962, it crossed the Bosporus to enter Europe for the first time and in November caused an outbreak near the border between Turkey and Greece (Anon, 2001).

The Middle East has been severely affected kklby two separate serotype A epidemics, one which emerged in Iran (A Iran 05) in 2005 - 2006, and an incursion of an African serotype A virus into Egypt, causing widespread outbreaks in 2006. The serotype A Iran 2005 was first observed in Iran and moved westward into Turkey (including the European part of Thrace). It continued to spread in 2006, circulating in Turkey and Iran, and was also detected in Pakistan, Saudi Arabia and Jordan. The virus was identified in 2009 in Iraq, Kuwait and Bahrain, and was recently identified in samples sent by Lebanon and Libya to the WRL. This strain matched with A Iraq 22. Since August 2007, a new sublineage of this strain (named A-Iran-05ARD-07) has been found in Turkey, for which A Iraq 22 is not protective. This new sublineage matches with A Turkey 2006 (OIE, 2009).

Type A FMDV was diagnosed in 2006 in 8-9 governorates in Egypt and genetically, this new serotype A differs considerably from the Middle Eastern viruses and was closely related to FMDV from East Africa (FAO/OIE 2006). The same strain was again identified in February 2009 in Egypt. The detection in outbreaks in 2009 suggests establishment of this East African strain in the Mediterranean region (OIE, 2009).

In 2007, a new FMD virus serotype O, the type O PanAsia 2, appeared in the Middle East. This new strain in the region probably originated from a strain circulating in India in 2001 and the pandemic dispersal of O PanAsia 2 lineage affected Pakistan, Iran, Jordan, Turkey, Israel, the Palestinian Autonomous Territories, UAE, Kuwait, Bahrain, KSA, probably Lebanon and also Egypt. This strain was responsible of high mortality on lambs and calves during the winter (OIE, 2009).

In the first months of 2009, outbreaks of FMD caused by serotype A were detected in several countries in the region. This serotype is considered endemic in Turkey and Iran but as a result of genetic and antigenic drift, sweeping regional epidemics occur at intervals. The last major serotype A change in the region was in 2005-2006, when an epidemic of the A Iran 05 strain spread through Iran, Turkey, Pakistan, reaching the Thrace region of Turkey and as far as

Jordan. In 2008, a new variant of the type A Iran 05 virus replaced the previous strain in Turkey, and this, and related type A viruses appear to be on the move in the region (FAO, 2009).

Lack of sufficient and efficient veterinary infrastructure, the unstable political situation prevailing in the Middle East, a deficient regional cooperation and interchange of epidemiological information and uncontrolled animal movement represent challenges for various Middle East countries to implement successful control programs for FMD. Ritual mass slaughter where large numbers of animals are moved over long distances to be crowded in poor conditions before and during their slaughter in sacred sites during the Muslim pilgrimage season in Mecca, Arabia Saudi contributes to the frequent occurrence of outbreaks and allows introduction of new serotypes to the region (Anon, 2001).

Vaccination is a common strategy adopted to control FMD in the Middle East, however, many countries of this region use vaccination as a tool for preventing economic losses caused by the disease rather than as a means of preventing the spread of infection. For instance, in Iran, dairy cattle are vaccinated preventively and sheep and goats are only vaccinated when outbreaks occur (Aidaros, 2002). Vaccination policy is different from country to country. It is prohibited in Cyprus, compulsory in Bahrain, Egypt, Jordan, Kuwait, Lebanon (cattle), Syria and Turkey, and implemented on voluntary basis in Iraq, Oman, PAT, Qatar, UAE and Yemen. Qatar will soon enforce compulsory vaccination. FMD vaccination is mainly focused on cattle and some countries (Kuwait, Lebanon, Sudan and Yemen) have no vaccination program on sheep and goats (FAO/OIE, 2009).

Table 1.1: FMD Serotype in Middle East

Country	FMD Reported	A	O	SAT1	Asia 1	C	SAT2
Iraq	first recorded	1952	1957	1962	1975	-	-
	Last recorded	2009	2001	-	1985	-	-
Iran	first recorded	1960	1956	1962	1957	-	-
	Last recorded	2010	2010	1964	2004	-	-
Turkey	first recorded	1958	1957	1962	1973	1959	-
	Last recorded	2010	2010	1965	2000	1959	-
Yemen	first recorded	1976	1974	1984	1974	-	1990
	Last recorded	1989	1990	-	1980	-	
Kuwait	first recorded	1964	1963	1969	1978	1982	2000
	Last recorded	2009	2008	1970	1981		2000
Bahrain	first recorded	1965	1966	1962	1985	-	-
	Last recorded	2009	2008	-	2009	-	-
Oman	first recorded	-	1976	-	1980	-	-
	Last recorded	-	2001	-	1989	-	-
EAU	first recorded	1977	1972	-	-	-	-
	Last recorded	1990	2010	-	-	-	-
Sudia Arabia	first recorded	1973	1971	1970	1980	1984	2000
	Last recorded	2005	2009	-	1994		-
Syria	first recorded	1953	1955	1962	1959	1969	-
	Last recorded	2002	2002		1988		-
Qatar	first recorded	-	1999	-	-	-	-
	Last recorded	-	2001	-	-	-	-
Palestinian Autonomous Territories	first recorded	?	2002	-	-	-	-
	Last recorded	2009	2007	-	-	-	-
Jordan	first recorded	1964	1962	1962	1961	1969	-
	Last recorded	2006	2006	-	-	-	-
Israel	first recorded	1965	1962	1962	1957	1970	-
	Last recorded	2009	2009	-	1989		-
Cyprus	first recorded	1957	1964	-	-	-	-
	Last recorded	1964	2007	-	-	-	-
Lebanon	first recorded	1955	1959	1962	1959	1969	-
	Last recorded	2009	2003	-	1984		-
Egypt	first recorded	1952	1951	-	-	1950	-
	Last recorded	2009	2009	-	-	-	-

http://www.wrlfmd.org/ The FAO reference Laboratory for foot and mouth disease (Pirbright Laboratory)

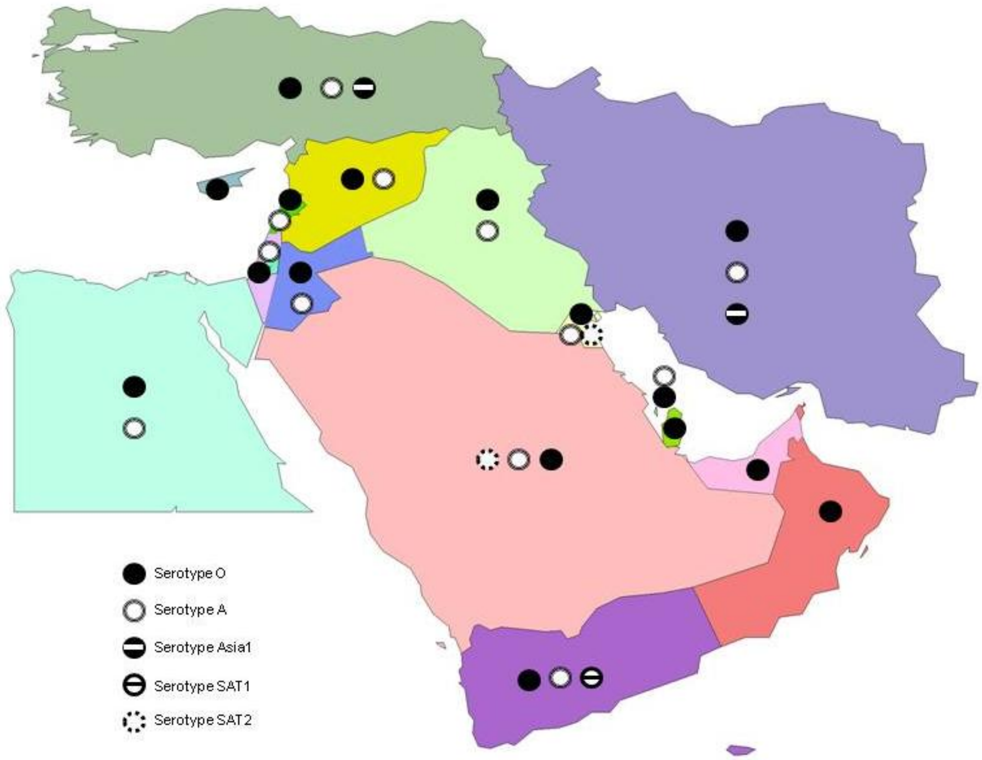


Figure 1.2: FMD Virus Serotypes in the Middle East, 2002 – 2010.

CHAPTER 2 - Foot-and Mouth-Disease in Iraq

2.1 Geography

Iraq, a country in Western Asia spanning most of the northwestern end of the Zagros mountain range, the eastern part of the Syrian Desert and the northern part of the Arabian Desert. It is bordered by Jordan to the west, Syria to the northwest, Turkey to the north, Iran to the east, and Kuwait and Saudi Arabia to the south. Iraq has a narrow section of coastline measuring 58 km (35 miles) on the northern Arabian Gulf. The capital city, Baghdad is in the center-east of the country. Iraq consists of 18 governorates and each governorate consists of many districts.

2.2 History

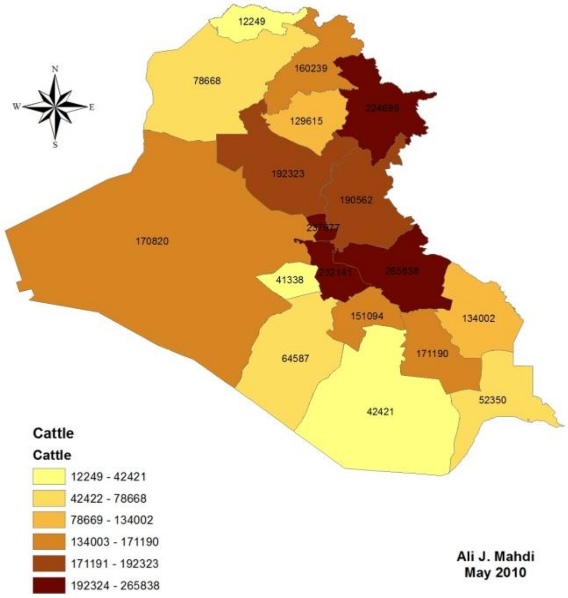
Small and large ruminants have been domesticated and bred for more than 6000 years in Mesopotamia (Iraq). Traditional husbandry methods have been developed in accordance with the prevailing arid and semi-arid climatic conditions, characterized by seasonal and long-term periods of draught. Biblical descriptions of flocks moving over thousands of miles such as the route of the Patriarch Abraham, who moved from 'Ur of the Chaldees' (southern Iraq), along the Euphrates river northwest to Haran (Turkish-Syrian border), then southwards to Canaan, and of herdsmen and shepherds struggling for wells and water sources have not lost their relativity to the present day (Anon, 2001). Iraq’s livestock production has been defined by different systems. For instance, sheep, goats, and buffalo production generally follows the traditional semi-nomadic system which is characterized by low inputs and it is based in villages and small towns. Cattle production was mostly used for “draft and manorial purposes” and follows the low input type. A smaller percentage of cattle have been used for dairy production, which relies on modern technologies located close to urban centers (Koucher, 1999).

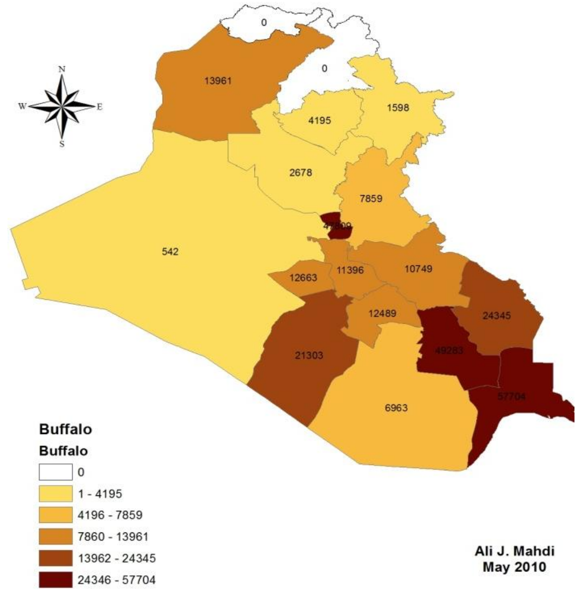
2.3 Livestock in Iraq

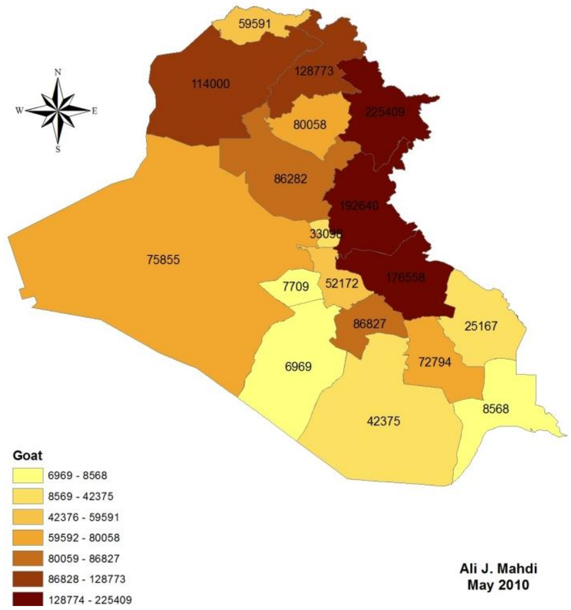
2.3.1 Livestock Population

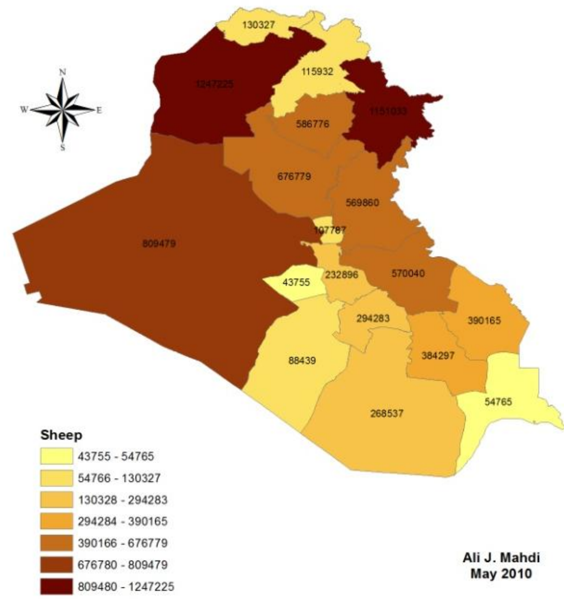
Livestock production in Iraq has traditionally been dominated by small ruminants (sheep and goats). Large ruminant production (cattle, buffaloes and camels) comprise a much smaller share of the livestock sector (Appendix A). Iraq's sheep and goat population peaked in 1970 at an estimated 15.4 million head, while the cattle population peaked in 1974 at over 3 million head (Schnepf, 2003).

The latest livestock census in 2008, which was carried out by the Ministry of Agriculture, estimated that the population of sheep, goat, cattle, buffalo and camels in Iraq are 7,722,375, 1,474,846, 2,552,113, 285,537 and 58,293, respectively (M.O.A., 2008). There is considerable disagreement between the Veterinary Services estimation of livestock population and the outcome of this 2008 census, due to Veterinary Services objection of the methodology used for sampling the animals rather than comprehensive counting. However, it is clear that all ruminants have been in decline as rapid human population growth and urbanization have increased pressure for higher valued food crops on suitable grazing land, increasing drought years in the last two decades and the flourishing of animal smuggling to neighboring countries during United Nation sanctions on Iraq between 1990 and 2003, while limited investment and increasing feed-import costs slowly squeezed profitability out of the sector. Figure (2.1) shows the distribution of livestock in governorates of Iraq from the census of 2008.









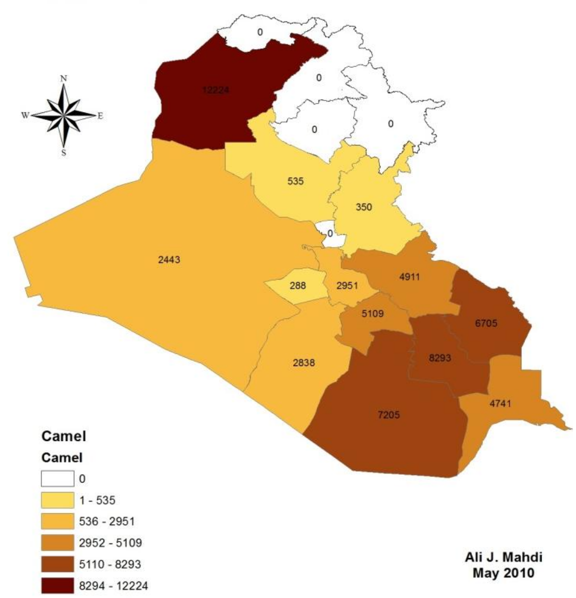


Figure 2.1: Distribution of Livestock in Governorates of Iraq, Livestock Census 2008.

2.3.2 Animal production and farming systems

Livestock in Iraq are raised under predominately traditional systems of production and three types of animal production occur under existing farming systems.

1- The dry-land mixed farming system is based on rain-fed wheat and barley alternated with fallow.

2- The rain-fed mixed farming system offers opportunities for more secure cropping than the dry-land mixed farming system, and it supports a wider range of crops. Within this system, small ruminants are important sources of animal protein, normally grazing natural pasture and waste areas on the farm during winter, and supported by crop residues during summer. The livestock are fed supplementary barley grain in late summer when the crop residues are exhausted.

3- The upland pastoral system involves nomadic and sedentary grazing of small ruminants on the rangeland forest and mountain areas. The livestock are fed supplementary barley grain in late summer when the crop residues are exhausted. Animal nutrition in this system is generally poor, the areas are often overgrazed and the performance parameters of these livestock may be low. There is considerable variation in the quality of native pastures as well as the extent of the land degradation (FAO, 2003).

Livestock husbandry in large ruminants (cattle and buffalo) differs from small ruminants. Generally, cattle and buffalo are kept as small contained herds living in the villages and towns or their environs mostly near the rivers. They have a restricted movement outside the village, and are fed on limited local grazing supplemented with seasonal crop residues. Commercial dairy stations are restricted which had been owned by the government and sold to the privet sector. They are less active due to the situation of Iraq after 2003. Sheep and goats have a wider distribution throughout the country and their husbandry system is characterized by an extensive and seasonal migration throughout Iraq and into neighboring countries. Animals provide by far the most important source of dietary protein for the Iraqi people through meat and milk products.

2.4 Veterinary Services in Iraq

2.4.1 Structure and mission

Veterinary Services in Iraq was established during British Mandate in 1924. The aim of its establishment was to protect and improve animal health quality, animal products, and public health. Veterinary Services have been traditionally supplied by the government. They consist of specialized central facilities and coordination functions located in Baghdad, veterinary hospitals at the governorate level, and veterinary dispensaries at the district level. There are 18 veterinary hospitals working at the governorate level; and at the district level, there are 228 veterinary dispensaries in the Center and South, and 45 equivalent veterinary centers under the Kurdistan Regional Government in the north part of Iraq.

The major functions of the animal health system in Iraq are:

- Provision of vaccines and drugs through a veterinary distribution chain down to the district,
- Animal and zoonotic disease control,
- Deliver of veterinary services,
- Animal disease surveillance and monitoring (general & targeted) strategies,
- Improvement of animal breeding and productivity,
- Quarantines, and imports and exports protocols,
- Emergency Response (emergency animal diseases preparedness programs)
- Diagnostic system,

- Quality control of veterinary pharmaceutical, vaccines and biologics, and
- Public health and food safety (slaughter houses and animal products hygiene).

As a consequence of previous political conflicts which led to three wars, United Nation sanctions between 1990 and 2003, and longtime neglect of public services, veterinary services and many public facilities and functions were weakened, with dramatic decline in performance. The deterioration of Veterinary Services activities led to the disruption of disease control strategies, collapse of disease surveillance and monitoring, and weakening in response systems. The breakdown of the animal health program has enhanced emergence of animal infectious disease outbreaks, which also affected public health and the national economy.

2.4.2 Veterinary diagnostic laboratories

The veterinary diagnostic laboratories in Iraq are an integral part of Veterinary Services to address the various needs of animal health protection and food safety. Surveillance and diagnosis of clinical cases of animal disease are necessary to determine the existence or introduction of a disease, and laboratory testing is a crucial part of these surveillance programs. Thus, veterinary diagnostic laboratories are the backbone of disease control programs administered by the Veterinary Services of a country (Schmitt, 2003).

National veterinary diagnostic laboratories in Iraq are administered by Veterinary Services. They consist of two types, general and specialized:

1- General veterinary laboratories are categorized according to their activities:
    a) Central Veterinary Laboratories: there are two central labs in Iraq (Baghdad and Erbil).
    b) Provincial Veterinary Laboratories: there are three provincial labs in Iraq, the

veterinary lab of Mosul, the veterinary lab of Samawa and the veterinary lab of Basra which are located in governorates of Ninava, Muthan and Basra, respectively.

c) Local Veterinary laboratories: there are 13 labs, which are located in governorates of Anbar, Dohuk, Sulymaniah, Wasit, Salah Addin, Qadisyah, Kirkuk, Babil, ThiQar, Missan, Najif and Karbala.

2- Specialized Veterinary laboratories: there are five specialized labs in Iraq, which are located in Baghdad:

a) Al Dora FMD Laboratories: for FMD diagnosis and FMD vaccine production (presently not functional).

b) National project of controlling Brucellosis Laboratory: for *Brucella* diagnosis and Brucella vaccine and diagnostic kit production.

c) Quality Control Veterinary Laboratory: for quality assurance and to register veterinary vaccine, pharmaceuticals and biologics.

d) Food Safety Laboratory: The lab investigates for chemical and microbial contamination of dairy products and meats in Iraqi markets.

e) Iraqi National Center for Transboundary Animal Disease (TADs center) Laboratory: is to control the main list A OIE diseases by monitoring and early warning.

Figure 2.2 shows the distribution of veterinary laboratories in Iraq.

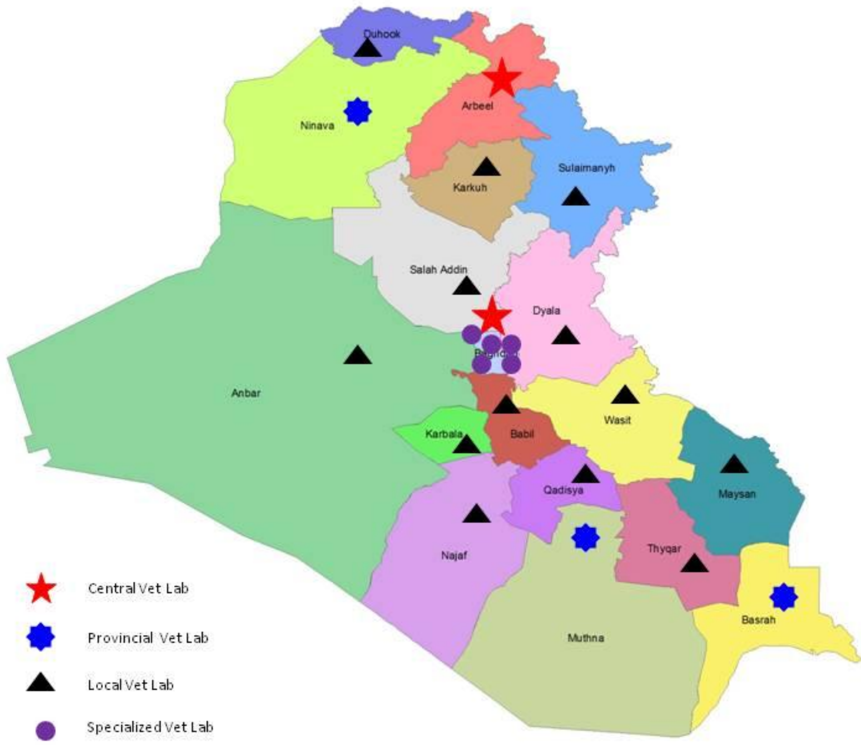


Figure 2.2: Distribution of veterinary laboratories in Iraq

2.4.3 Most devastating events

Veterinary Services, including veterinary hospitals, district clinics, diagnostic facilities, andcold-chain storage and distribution systems in Iraq, have been exposed to severe destruction directly from the wars and/or, more frequently, extensive looting and vandalism immediately after the wars.

Below are some of the devastating events which affected Veterinary Services between 1991 and 2008.

- Bombarding and destroying most parts of the Veterinary Vaccines Production Laboratories during 2nd Gulf war in 1991.
- Looting, destroying, and burning the central veterinary hospitals in 12 governorates with most their related clinics and facilities post-2nd Gulf war in 1991.
- Foot-and-mouth disease laboratories destroyed by the United Nation Special Commission (UNSCOM) in 1996. The laboratories were BL3 level and used for FMD diagnosis and vaccine production.
- Looting and destroying headquarters of the Iraqi Veterinary Services in Baghdad in 2003 post-3rd Gulf war.
- Looting, destroying, and burning most facilities of the Central Veterinary Diagnostic Laboratory and the Laboratory for Brucellosis and TB in Baghdad. The mobs released a lot of highly infectious agents, as well as looted the main veterinary warehouses, destroying the strategic cold storages, in 2003 post-3rd Gulf war.
- Bombarding and destroying the Brucella vaccine production facility in 2006.
- Destroying and looting the facilities of the Entomology research department of Old World Screw Worm flies (*Chysomya bezziana*) and released huge numbers of flies in 2003 post-3rd Gulf war.

- Assassination and kidnapping groups of veterinarians, technicians, and highly qualified experts (such as the General Director of the Iraqi Veterinary Services in 2007) between 2004 and 2008. Other groups fled the country to save their lives.

2.5 Foot-and-Mouth disease in Iraq

2.5.1 History

The FMD virus is endemic and periodic devastating epidemics usually occur in Iraq since the latter years of the Ottoman rule in the late 19th and the early 20th century. However, according to the annual technical report of 1937-1938 of Veterinary Services of Iraq, the first notifiable cases of FMD were recorded in 1937, among a herd of 202 cattle which entered the Iraqi border in the Sulimanyha governorate at the check point of Bashder from Iran. Eleven animals from this herd were euthanized soon after their arrival since they were in advanced clinical stages of disease. The rest of herd were kept under quarantine and monitored for asymptomatic and symptomatic treatment until they recovered from clinical disease. According to the annual technical report of Veterinary Services of Iraq, the first outbreak of FMD was noticed in 1938 among the three adjacent governorates (Basra, Missan, and Diala) to Iran. These outbreaks were mainly seen in cattle and buffalo. The number of infected animals in Basra, Diala, and Missan were 135, 1109 (809 cattle + 300 buffalo), and 324 (68 cattle + 256 buffalo), respectively. The report also mentioned the wild boars inhabiting border marshland in Basra and Missan governorates played a vital role in transmission of the virus and spread the disease from Iran to Iraq. The report also mentioned the earlier treatment of infection with caustic soda @ 4/1000 and 8/1000 to disinfect the cloves (hoof) of infected animals, and other inanimate objects in the locality, was the main procedure to contain the outbreak (VSI Reports).

In 1945, there was another major outbreak among sheep, cattle, goats, and buffalo all over the country in Iraq, where it infected 20,092 animals and 113 of them were reported dead. The report also mentioned that 53,094 animals were immunized during this period; however, the report lacked evidence of the proper immunization protocols followed, since vaccination strategies were uncommon to control the disease at that time (no clear evidence about this data). Whereas in 1957, the annual report showed there was a huge outbreak of FMD involving most of the Iraqi governorates among cattle, buffalo, sheep, and goats. The report also indicated 801,135 animals were infected with FMD, where mass treatment was done using caustic soda to curtail the symptoms and reduce the economic losses. At that time, Veterinary Services of Iraq had not adopted certain procedures and/or protocols for the control of disease (VSI Reports). Table 2.1 shows the number of infected animals with FMD outbreaks from 1938-1960.

Table 2.1: Number of infected animals with FMD outbreaks, 1938-1960.

Year	No. of infected Animals	Animal species
1938	1,568	Cattle, Buffalo
1945	20,298	Cattle, Buffalo, Sheep, Goats
1946	11,732	Cattle, Buffalo, Sheep, Goats
1947	1,096	Cattle, Buffalo, Sheep, Goats
1948	410	Cattle, Buffalo
1951	23,726	Cattle, Buffalo, Sheep, Goats
1952	1,482	Cattle
1953	219	Cattle
1954	165	Cattle
1955	615	Cattle, Buffalo
1956	2,072	Cattle, Buffalo
1957	801,135	Cattle, Buffalo, Sheep, Goats
1958	3,683	Cattle, Buffalo
1959	1,270	Cattle, Buffalo
1960	6,862	Cattle, Buffalo, Sheep, Goats

According to FAO Reference Laboratory for Foot-and-Mouth Disease (IAH, Pirbright Laboratory), the first official record of FMD strain in Iraq was serotype A in 1952. Other serotypes have been reported later. Serotypes O, SAT-1 and Asia1 were recorded in 1957, 1962, and 1975, respectively. Table 2.2 shows the involvement of serotypes and subtypes during the outbreaks between 1952 and 2010.

Table 2.2: Major serotypes and subtypes involved in FMD outbreaks, 1952-2010.

Year	Serotype
1952	A
1955	A
1957	O
1959	O
1962	Sat 1
1964	O, A_{22}
1966	O
1969	O
1970	O, A
1973	O
1975	Asia 1
1978	A
1983	Asia1
1984	Asia 1
1985	O1
1993	O1
1998	O *Manisa*
1999	O *Manisa*
2000	A IRN 96
2002	A IRN 96
2009	A Iran 05

2.5.2 FMD Current Situation

2.5.2.1 FMD outbreak (1998/99)

The report on the 1998/99 FMD outbreak in Iraq has some documentation. However, only selected reports were discussed, and these reports provided varying figures for outbreak estimations. According to one of the reports, the first severe FMD epidemic outbreak occurred in Iraq in 1998. A review reporting on FMD from Middle East indicated that 50,678 cattle and 982,309 small ruminants had been infected with the FMD virus (mainly with serotypes O and A) in 13 governorates with a mortality of 3,832 (7.5%) and 48,089 (4.9%), respectively (Aidaros, 2002). Ahmed El Idrissi, FAO personnel, pointed out in his report to the FAO that the FMD outbreak of 1998-99, affected 3 million ruminants (about 25 % of the population) and caused heavy losses in newborn animals. He estimated about 500,000 animals had been killed, and the epizootic was due to the subtype O1 Middle East strain. This strain was unanimously considered extremely severe, affecting not only cattle and buffalo but sheep and goats as well, which previously was not the case in Iraq (El Idrissi, 2003). The government of Iraq, through their permanent representative to the United Nations, sent a letter dated March 28, 2001 addressed to Secretary-General accusing the United Nations of causing the FMD epidemic of 1998 because of the sanctions imposed on Iraq where 575,421 lambs and calves were lost and more than 2.5 million animals were infected with FMDV (Iraqi Gov., 2001).

Based on the reports, we conclude the severity of the epidemic outbreak was significant and affected food-production farm animals in Iraq, contributing major economic loss to the country. Central and State Veterinary Services failed to confront the outbreak because of the absence of the FMD Contingency Plan, surveillance and reporting; and there was a lack of vaccines provision and effective communication with the neighboring countries for information exchange. In addition to poor veterinary infrastructure hampering effective implementation intervention strategies locally, there was high risk to other governorates and neighboring countries. Iraq contacted the FAO in December 1998 and reported FMD had occurred since the beginning of November 1998, and vaccination was urgently required to control the disease. Due to the political ban imposed by the United Nations, provision of FMD vaccine for Iraq was authorized only after acceptance by the Sanctions Committee that the measure was necessary (Aidaros, 2002).

Veterinary Services was trying to mitigate the impact of the disease by treatment of infected animals (treating the symptoms, using caustic soda for local treatment and antibiotic for general treatment) and implementation of some control measures such as the disinfection of contaminated inanimate objects or fomites and animal movement restriction. The available quantities of vaccines were used to contain the outbreak in some limited areas. After, the Sanctions Committee authorized consignments of FMD vaccines, a mass vaccination program was initiated to contain the disease. Cattle, buffalo, sheep and goats were vaccinated with two injections with regular vaccinations carried out once a year. Sheep and goats were vaccinated with the monovalent vaccine (O1 serotype) while cattle and buffalo received the trivalent vaccine (O1, A22, Asia1). From early of 1999 to 2002, (55,820,000) doses of monovalent and trivalent FMD vaccines were delivered to all governorates of Iraq through the different phases of the program's memorandum of understanding between Iraq and United Nations. The last vaccination campaigns were carried out in spring/autumn 2002. Seventy percent of the susceptible animals in the governorates of the center/southern Iraq were covered during vaccination campaigns of the year 2001 and 2001 Table 2.3. In the three northern governorates (Dohuk, Erbil and Sulymaniah), about the same rate was achieved in 2002; however, in 2001 the vaccination coverage was too low due to vaccine shortage and the focus on cattle vaccination was a priority. In 2002, 10 FMD-like incidents in cattle were reported in the three northern governorates. Samples collected and submitted to the FAO/OIE World Reference Laboratory (Pirbright Laboratory) showed the outbreak was due to serotype A FMDV (El Idrissi, 2003).

Late arrival of vaccines in small quantities over long periods of several months due to the nature of the procurement process under the Security Council Resolution 986-"Oil for Food" program, and the limited and irregular supply of vaccine, added an extra burden on the Veterinary Services to manage the outbreak and mitigate its effects.

Table 2.3: Number of infected and vaccinated animals, 1996-2009.

	Infected Animals		Vaccination status	
Year	**Cattle & Buffalo**	**Sheep & Goats**	**Cattle & Buffalo**	**Sheep & Goats**
2009	14,198	14,036	378,776	187,189
2008	892	1,755	204,921	3,304,825
2007	2,828	12,957	205,368	2,702,725
2006	3,917	3,218	415,320	7,200,198
2005	68	1,008	189,476	3,038,706
2004	967	2,315	160,038	3,943,321
2003	No Data because of 3rd Gulf war on Iraq			
2002	0	0	5,299,177	
2001	54	17	12,160,060	
2000	5,512	4,280	10,274,178	
1999	137,262	326,502	18,588,231	
1998	7,124	16,864	220,008	
1997	632	10,541	9,8181	
1996	1,233	12	22,300	

2.5.2.2 FMD in Iraq 2004-2009

Foot-and-mouth disease is endemic in all Middle East countries and periodic devastating epidemics occur that spread rapidly across national and regional borders. Iraq is located within the center of this region and because of the geographic location; it is immensely influenced by the slight to severe epidemiological changes of FMD among neighboring countries. The sequelae of the devastating effect of 1998-1999 epidemic outbreaks in Iraq continued until 2000 and 2001. However, the annual report of Veterinary Services of 2002 does not record any notifiable infections due to FMD. This drastic decrease in epidemics might be attributed to the vaccination campaigns implemented after 1999 where more than 27 million small and large ruminants were vaccinated, or it might be due to effective control measures targeting the virus. Whereas in 2003, the 3rd Gulf war and its consequences led to the breakdown in most public services and governmental activities, especially the veterinary services in the middle and southern parts of Iraq, leading to complete cessation of vaccination campaigns. In addition, the war led to no control of the borders with neighboring countries and caused the lack or complete loss of veterinary quarantine measures. This facilitated the movement of livestock across the borders of adjacent countries, particularly Iran (where FMD has wide distribution), and introduced animal products without permission or certified veterinary license. Consequently, the disease started re-emerging in 2004, where 967 cattle and buffalo and 2,315 sheep and goats were infected. However, it is expected that these figures do not reflect the real situation due to lack of epidemiological surveillance, reporting, and veterinary services. The point to be noted during this period is many of the Veterinary Service centers were under rehabilitation due to the 2003 damage. The Veterinary Services resumed the vaccination campaign the same year, and vaccinated 3,94,3321 goats and sheep and 160,038 cattle.

In 2005, a new FMD virus serotype “A” lineage spread through Iran and moved westward into Saudi Arabia and Turkey. It continued to circulate in Turkey and Iran during 2006. It is anticipated this virus began spreading to Iraq from one or more endemic countries such Turkey situated on the northern border, Iran on east sharing borders with Iraq up to 12,000 km, and Saudi Arabia on southwestern borders. The spread also may be due to unrestricted movement of animals and animal products between countries leading to incidents of infection in Iraq. The FMD rate of infection increased during 2006, in spite of ongoing vaccination campaigns.

In 2007, there was significant increase of FMD cases among sheep and goats, where 12,957 cases were recorded and 2,828 cases were reported in cattle (including most of the governorates). The severity in disease outbreak was due to lack of quarantine, security deterioration which disrupted most Veterinary Service activities, and a vast majority of public services were paralyzed during this period. During this outbreak, 1,280 serum samples were collected from 6 governorates from the southern part of the country and tested using ELISA at the Central Veterinary Laboratory to get the actual picture of the disease in the country. The detected prevalence in each governorate fluctuated from 7.9 to 22.6 %. Three samples were sent for virus isolation and none of the samples were sent to reference laboratories for serotyping (FAO/OIE, 2009).

In 2008 there was a drastic decrease in the number of infected cases of FMD in both small and large ruminants. During this period, the Iraqi government reported 148 outbreaks affecting 1,612 sheep and goats, 779 cattle, 19 buffalo, and 19 deaths to OIE (OIE, 2009). All 18 governorates of the country were represented in 4,550 samples collected during 2008. The prevalence was 4.7 to 95 %, and for the entire country the detected prevalence was 23 %. (FAO/OIE, 2009).

In January and February of 2009, more than 130 outbreaks of FMD were reported in central and southern Iraq, and samples sent to a FAO reference lab showed the outbreak was due to serotype A Iran-05 (Appendix B). The 2009 annual report recorded 14,036 cases of FMD in sheep and goats, 14,198 in cattle and buffalo in all governorates of Iraq; the rate of infection fluctuated among governorates, Figure 2.3. The highest prevalence of FMD infection in sheep and goats was recorded in Basra and Karbala governorates, and the highest prevalence in cattle was recorded in Basra, Karbala and Ninava governorates. The highest percentage of infection in buffalo was recorded in Basra, Karbala, and Missan governorates. Basra showed a high percentage of infection among animals, which is likely due to its geographic location where it shares borders with three neighboring countries (Iran, Kuwait and Saudi Arabia).An appeal through FAO/EuFMD Commission for assistance was answered by the European Union. A consignment of FMD vaccine (A22 Iraq, O and Asia 1) was sent to Iraq as a contribution towards the vaccination campaign against the disease in the eastern part of the country. The consignment consisted of 500,000 doses of FMD vaccine, formulated from the stocks stored in the premises of the European Community antigen bank by Merial S.A.S. at the request of the Commission. The vaccines were due to arrive in Iraq on 16 March 2009 (FAO, 2009) but bureaucracy and long routine processing by Veterinary Services for releasing this consignment delayed utilizing the vaccine for long time. The situation revealed chaotic administration and overall lack of coordination and organization.

Fig. 2.3: shows the infection rate of FMD from 2004-2009 among both large and small ruminants.

Fig. 2.4: shows the vaccination status and the number of animals vaccinated 2004-2009.

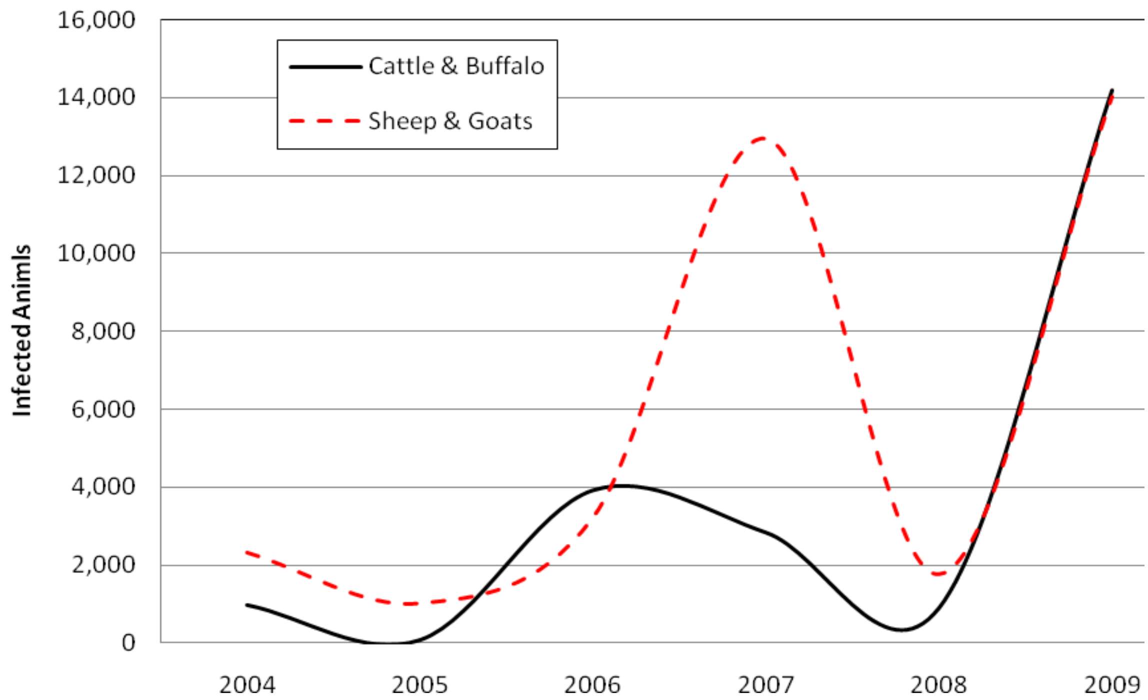


Figure 2.3: FMD reported cases in Iraq, 2004-2009.

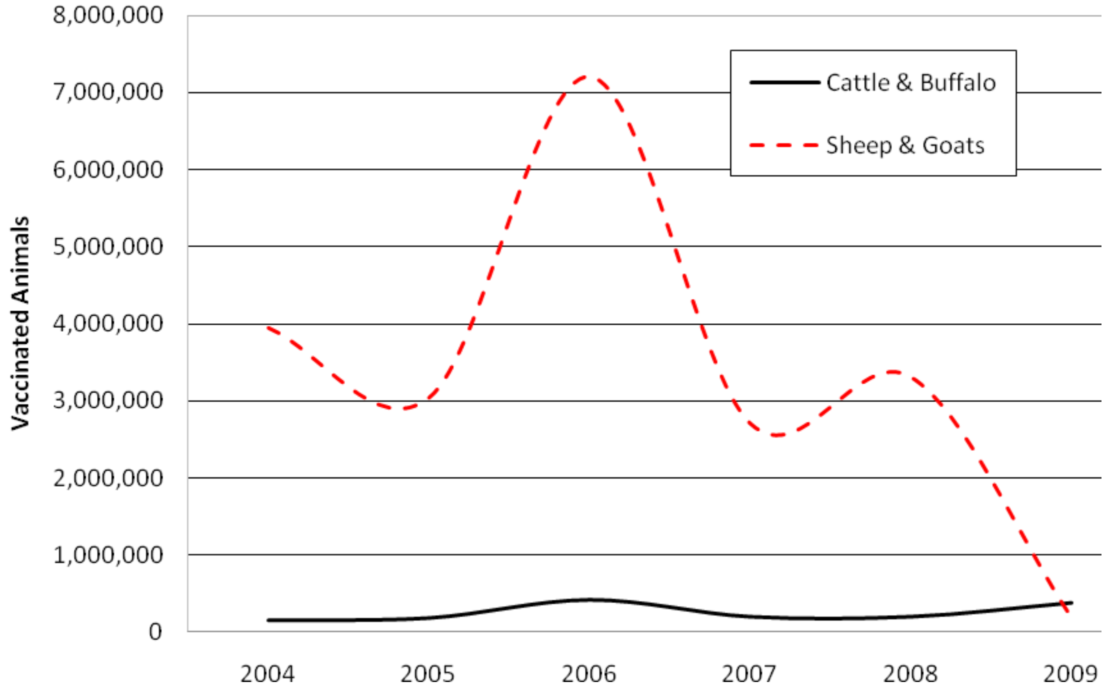


Figure 2.4: Number of FMD Vaccinated Animals in Iraq, 2004-2009.

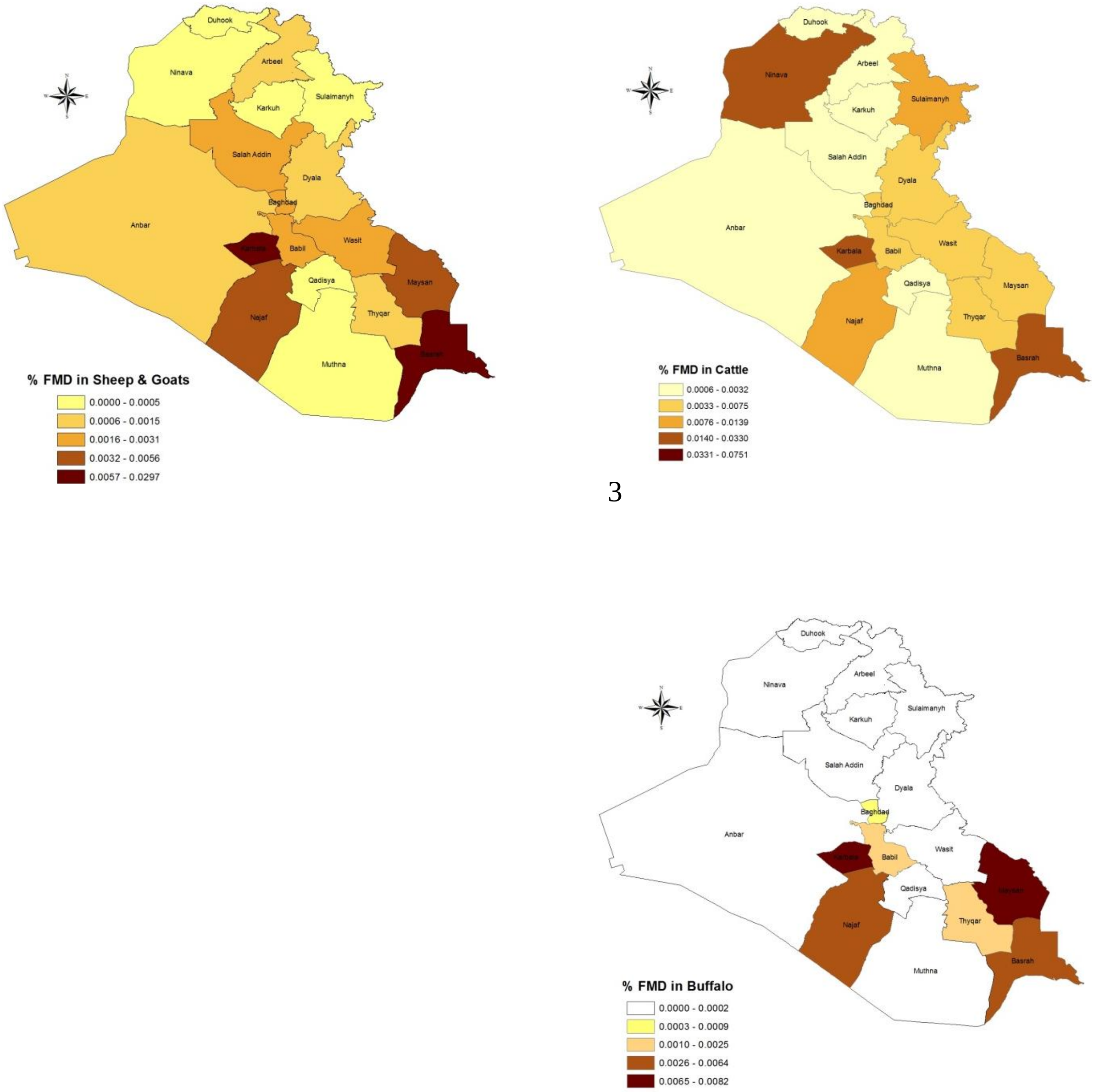


Figure 2.5: Percentages of FMD Infection Distribution in Governorates of Iraq, 2009.

2.5.3 FMD Diagnostic Laboratories in Iraq

The veterinary diagnostic laboratory system serves as the cornerstone for FMD surveillance by performing the diagnostic tests necessary to provide a definitive diagnosis to determine the predominant strains in the country and evaluate the disease status of targeted animal populations. Diagnosis of FMD virus was one of the main objectives of the Central Veterinary Laboratory. This diagnosis was done by classical laboratory tests and tissue culture methods for virus isolation and detection. In 1982 a specialized laboratory was established for the diagnosis of FMD and this center started diagnosis, isolation, detection of FMD virus until 1992; however, in early 1992 the United Nation placed the facility under continuous monitoring and many materials (biological), needed for FMD diagnosis and vaccine production were placed under scrutiny and/or ban. In 1996, the UNESCOM destroyed this unique facility and all the laboratories and vaccine production plant, leading to complete cessation of vaccine production and diagnosis. The result was complete lack of diagnosis or vaccine for FMD after 1996. Because of the lack of FMD investigation and vaccine production capacity the FMD epidemic outbreak in 1998 occurred, where 3 million ruminants were infected and about 500,000lambs and calves died due to FMD. After this outbreak, some animal health organizations realized the impact of the situation and its dissemination to other neighboring countries, which led to release of FMD vaccine and the ban on biological materials. The virology units of Central Veterinary Laboratory in Baghdad and Erbil started a re-investigation of FMD virus to find out the actual status of virus.

After 2003, financial and technical support was provided by different donor countries, including regional and international organizations to rehabilitate the veterinary infrastructure. Iraq also was included in the regional project for FMD control, which was sponsored by Arab

Organization for Agricultural Development (AOAD). FAO provided some equipment and materials needed for the diagnostic activities, some FMD vaccines and some staff were trained in diagnostic skills by the FAO. This support, however, is not sufficient enough to implement a good quality FMD investigation process and control program. In addition, the security collapse after 2005 seriously contributed to the lack of significant outcomes. So far, all contributions have not made an impact on disease prevalence in Iraq, which was the key goal.

2.5.3.1 Al Dora FMD Laboratories

In the early 1970s, Iraq made major investments in immunizing its livestock against FMD. The FMD vaccine plant in Al Dora, south of Baghdad, 20 km from city center was planned and built 1977-1982 as a turn-key facility by a foreign contractor (IFFA Merieux, France). The plant was designed to produce vaccine against three strains of FMD virus (O, A and Asia) in Iraq, using a production method based on cell culture in large fermenters, and for the identification of various strains of the virus that caused disease. The plant had a design capacity to produce 12 million doses of triple vaccine a year. They began producing vaccine in April of 1982 and output met all of Iraq's needs. Large quantities of vaccine were exported to Bahrain, Lebanon, Egypt, Laos, Qatar, Jordan, and France. The plant continued to produce and to export until early 1991, which contributed to controlling FMD in Iraq and other countries in the region during this time.

The Food and Agriculture Organization of the United Nations (FAO) regarded the plant facilities as a reference laboratory for the identification of FMDV types and strains. In 1991, work at the FMD Laboratories was briefly suspended by the United States and its coalition partners. It subsequently resumed, and production continued until 1992. Work then halted when the raw materials held in the plant stockrooms were exhausted and it was impossible to import more due to the blanket UN sanctions imposed on Iraq. In 1994, United Nation placed Al Dora facility under an intensive and ongoing monitoring regime. In December 1995, UNSCOM stopped all activities in FMD laboratories and closed them completely as a prelude to their destruction, which took place in May 1996, on the grounds that the facility and some items of equipment had been used in the Iraqi biological weapons program. The weapons inspection team of the United Nation (UNSCOM) destroyed laboratory equipment and concrete sealed the facilities including the air-handling equipment. The vaccine production system was entirely disabled and the plant was completely out of working order. In addition, FMD vaccine was placed on the list of items subject to export/import monitoring mechanisms for Iraq by the Security Council in Resolution 1051 (1996). In 1999, Iraq asked FAO to rehabilitate the site for reproducing vaccines. FAO representatives in Iraq visited the site but United State and British objections blocked rehabilitation despite obtaining approval in principle from the FAO.

2.5.3.2 National Center for Transboundary Animal Diseases

The National Center for Transboundary Animal Diseases (TADs Center) was established in 2008 by Iraqi Veterinary Services in collaboration with OIE and FAO. The principal goal of the Center is to control OIE List “A” diseases through sero-surveillance and epidemiological investigations of the diseases in Iraq affecting food-producing livestock and public health. Although TADs Center is not specialized to control only FMD, one of the main goals of the Center is FMD (an OIE list “A” disease). Currently the Center collects epidemiological data on samples for diagnostic purposes, and employs ELISA testing and tissue culture for investigation. The Center also coordinates with FMD reference laboratories by submitting samples for further confirmative diagnosis, such as virus typing and characterization. Although the Center does enormous work on effective controlling of diseases, it needs support in the form of equipment, scientific skills, and efficient personnel to carry out objectives that would effectively intervene during a disease outbreak. Because of the abovementioned insufficiencies, the Center cannot implement effective strategies to control FMD in Iraq or the region.

2.6 FMD Surveillance System in Iraq

The key to success in handling animal disease epidemics is early detection. If a disease is detected very early in epidemic development, the possibility exists that it can be arrested and eliminated before causing substantial damage. Early detection presupposes there is a surveillance system in place that will bring infection to light as soon as possible. Surveillance implies an active process in which data is collected, analyzed, evaluated, and reported to those involved, with a goal of providing better reaction to control or contain the disease or condition. A country's veterinary authorities are then placed in the position of being able to manage the problem before it becomes uncontrollable, thus protecting the local livestock industry and ensuring food security for those closely dependent upon livestock. The dynamic situation of FMD requires continuous monitoring to update epidemiological information and provide the proper responses. Generally, the main objectives of FMD surveillance program are (FAO, 1999):

- Early detection of FMD in susceptible animals.
- Enabling Veterinary Services early reaction to minimize the impact of FMD on animal health and the economy.
- Correct identification of resource needs in the field so existing resources may be correctly deployed in FMD management and control.
- Provision for strategic decision-making support.
- Measurements of FMD control system performance.

Governments must realize animal disease surveillance is a key function of their national veterinary services. This concept is still immature in some minds of Veterinary Services authorities of Iraq; or, they are at least unclear in its objective. Therefore, the development of diseases surveillance has been slow or non-existent for some time. Iraq has very limited capacities and capabilities for FMD surveillance and reporting in the field due to the present poor status of Veterinary Services in particular and public services in general. Currently, the FMD surveillance system in Iraq is confronted by many challenges, including the following:

- Lack of an active animal health information system.
- Lack of specialized FMD laboratories.
- Insufficient diagnostic equipment and materials.
- Insufficient veterinary diagnostic skills.
- Lack of national or provincial mapping of the FMD susceptible animal population.
- Insufficient collaboration between the private veterinary sector and governmental Veterinary Services.
- Lack of communication, information exchange and collaboration between neighboring countries, which results in deficient surveillance and monitoring of animal movement in common borders.
- Unstable political situation.

The current FMD surveillance system in Iraq should be re-assessed to address the gaps and to propose appropriate improvements to make it effective and successful. It should meet all the needs of disease control and prevention. To reach this goal many considerations should be taken into account, such as the following:

1- Reactivation of Al-Dora FMD laboratories and renovation of the facilities for FMD diagnosis and vaccine production.
2- Establishing an Animal Health Information System.

3- Continue submission of samples to FAO/OIE FMD reference laboratories to identify and study predominant strains and sub-strains in Iraq, and the potential introduction of others.

4- Link with the OIE/FAO laboratory networking system for updating disease information in the country.

5- Analysis of collected data at the national and provincial level, which assists in early warning and reaction to control and contain the disease.

6- Use of rapid and reliable field tests.

7- Encourage laboratory quality assurance program for regional proficiency testing.

8- Strengthen rapid testing and boundary quarantine.

9- Train staff for field reporting and sample collection.

10- Improvement of information gathering (active and passive).

11- Harmonize the surveillance strategies with the neighboring regional countries.

12- Strengthen the collaboration between Veterinary Services and Ministries of Environment, Health, Higher Education, and Interior to extend utilization of the governmental resources.

13- Strengthen the collaboration the veterinary laboratories and the local and international scientific institutions and universities for carrying out related studies and research.

14- Introduce newer diagnostic tests in laboratories like PCR, RT-PCR, virus isolation in tissue culture and other means of antigen detection.

15- Establish networks for exchanging information between veterinary laboratories and all veterinary centers.

16- Strengthen the diagnostic capabilities in border quarantines.

17- Develop a standard format for livestock population mapping that is applicable across the country and will assist in planning FMD monitoring and control.

2.7 FMD Control Program in Iraq

Foot-and-mouth disease is endemic in Iraq with a frequent occurrence of outbreaks all over the country. The major efforts of Veterinary Services in Iraq have been directed towards control of FMD by vaccination for decades. Mass vaccination can be an important tool for FMD control, and the coverage must be sufficient to stop spread. Two vaccination options to support control and eradication policy are available and include:

- Strategic vaccination around outbreaks (barrier vaccination, such as ring vaccination, or high-risk enterprise vaccination) to help contain the disease while stamping-out operations are carried out; and
- General vaccination over a wide area (blanket vaccination) where other disease control methods would be too demanding of veterinary resources or too costly in terms of compensation payments.

In addition, vaccination during FMD outbreaks can be employed in two main ways; (1) suppressive vaccination is applied to animals that are immediately at risk or are exposed in an infected area; and (2) preventive vaccination is applied to high-risk animals or to enterprises that are not in an infected area but are likely to be exposed to infection in the near future (AUSVET, 2006); however, vaccination alone cannot provide an effective control program. Other methods should be accompanied with vaccination, which include quarantine, rapid detection and reporting of outbreaks, movement control, disinfection, sero-monitoring, sero-surveillance and public awareness.

In areas where FMD is endemic like Iraq, many parameters must be taken into account before embarking on a coordinated vaccination campaign (Rweyemamu et al., 2008):

- identify prevalent serotypes and subtypes
- evaluate the socio-economic impact of FMD
- establish and maintain capacity for regular access to good laboratory diagnostic services
- designate presumed FMD areas
- define the distribution and epidemiology of FMD
- identify primary and secondary endemic areas
- undertake a needs analysis and seek resources for a sustained period of 10 years or more
- record in-country and cross-border animal movement patterns and movement management strategies
- implement community awareness and communication strategies
- draw up an epidemiologically based and economically sound long-term project for FMD progressive control, and
- develop a national capacity in public and private sectors to implement a disease control policy that has the support of key stakeholders.

2.7.1 Assessment of Current FMD Control Program

- **Control Strategy**

  General and zonal vaccinations have operated as main tools to control FMD in Iraq. Sometimes vaccination accompanied with other control measures such as quarantine, movement control, focused vaccination and disinfection have been used, depending on the situation.

- **Targeted Species**

  Cattle, buffalo, sheep and goats

- **Vaccination**

  - **Vaccination implementation:**

    Vaccine implemented once yearly on a voluntary basis

  - **Vaccine strains**

    Trivalent vaccine (O, A 22, Asia 1) for cattle and buffalo.

    Monovalent Vaccine (O Manisa) for sheep and goats.

  - **Vaccine producer**

    Trivalent vaccine produced by Rackska / India

    Monovalent vaccine produced by Vital / Turkey

  - **Type of adjuvant**

    Aqueous (Al $(OH)_3$ -saponin)

  - **Verifying the quality of vaccine upon arrival**

    Limited tests for quality assurance evaluation in Quality Control Laboratories (Baghdad).

  - **Storage and cold-chain facilities**

    Upon arrival the vaccine should be stored in a very reliable cool house with technical backup. Current cold-chain facilities are limited in capacity and are insufficient due to the lack of electricity.

  - **Vaccination campaigns**

In Iraq, FMD outbreaks generally occur (or start) in the winter (December or January). Therefore, the annual vaccination campaign is carried out at least 3 month in advance which means September /October.

- **Field transportation**

  Inadequate transportation to cover all parts of the country, particularly to remote villages.

- **Monitoring vaccination campaign**

  Evaluation of animal immune status after vaccination campaigns is unusual in FMD control program in Iraq.

• **Quarantine protocols**

Iraq has 16 border quarantine points. However, the protocols and monitoring systems are presently insufficient to protect the country from new FMD incursions.

• **FMD diagnosis**

- **Specialized FMD Laboratories**

  Unavailable

- **Laboratories used for diagnosis**

  National Center for Transboundary Animal Diseases (Baghdad)

  Central Laboratory (Erbil)

- **Tests Used**

  3 ABC ELISA Test

• **Emergency Response**

- **National Emergency Fund**

  Available

- **Contingency Plan**

  Unavailable

- **Regulation of FMD**

  FMD is a notifiable disease. FMD is denoted as an infectious disease in livestock, bringing it under the scope of the act requires compulsory notification of suspected FMD by the owner/keeper and the veterinarian which means the veterinarian is also obliged to ensure no damage is inflicted for animal health or there is no damage to public health or the national economy (FAO/OIE, 2009).

- **Awareness program**

  Depending on the country situation, the Veterinary Extension Unit is responsible for awareness activates (limited capabilities). The general body for Agricultural Training and Extension organizes awareness during the outbreaks.

- **Annual evaluation and reporting**

  - **Evaluation of monitoring and surveillance systems**

    No Evaluation

  - **Evaluation of the results of vaccination campaigns**

    No Evaluation

  - **Reporting to:**

    - **The ministry:**

      Monthly and Annual reporting

    - **The farmers organization:**

      No reporting

    - **The press:**

Reporting depends on situation

- **The regional FMD organization:**

  Sometimes reports to Arab Organization for Agricultural Development (AOAD).

- **The FAO / OIE and/or sponsoring organizations:**

  Frequently

- **Evaluation and annual planning**

  No evaluation occurs, only annual reviewing for vaccination plan to update the required vaccine quantities.

2.7.2 Requirements of Successful FMD Control Program

For a successful FMD control program that can significantly reduce prevalence or impact of the disease, some pre-requisites should be available to assure a successful of the program. Despite FMD control programs existing for decades in Iraq, the disease is still a major threat to livestock and the economy. The control program should be re-assessed in terms of technical feasibility and likely success. Some critical elements are required for conducting an effective FMD control program. Although it may be possible to successfully control the disease without meeting all criteria listed below, the likelihood of failure increases as more criteria remain unfulfilled (Sergeant, 2005). Pre-requisites of successful FMD control program include the following:

1- Adequate knowledge about the FMD virus and its epidemiology: Knowledge of the cause and epidemiology of the disease are essential for the development of effective strategies for the prevention of transmission and spread of the FMD virus and for the application of screening tests to detect cases. Knowledge about the FMD virus epidemiology, including serotypes, biotypes predominant in Iraq are lacking. This is mainly due to poor surveillance systems, minimal diagnostic methodologies, few intervention strategies, a lack of infrastructure for diagnostics and a lack of effective communication with the FMD regional and world reference laboratories.

2- Adequate veterinary infrastructure and resources, including administrative and operational personnel are essential for effective implementation of a control program. Insufficient staffing of a program is likely to result in failures in the application of selected control measures and significant delays in meeting program objectives. Components of infrastructure required for a successful program include:

   a. Field veterinary staff, Veterinary Services in Iraq employs more than 2300 veterinary staff (veterinarian and support staff), about 70% of them are working in the field. This number would be enough to implement any control program. However, most staff is unqualified and need training in reporting, sample collection and conducting awareness campaigns.

   b. Administrative staff to manage the program, and maintain databases and reporting capability. Administrative staff having the ability to manage the program and maintain records and databases is limited and would need training in data processing.

   c. Regulatory staff to implement and enforce legislative support measures. Veterinary Services do not have adequate regulatory staff for this task; however, they could take support from other governmental institutions such as the Ministry of Interior or local municipalities.

d. Diagnostic and research facilities. Although Veterinary Services has many diagnostic and research facilities, they have limited capabilities to meet the actual needs of a control program.

3- Epidemiological features which facilitate case detection and effective surveillance. FMD may be confused clinically with a number of other conditions, such as vesicular diseases (vesicular stomatitis) and infectious bovine rhinotracheitis, Rinderpest, bluetongue, bovine papular stomatitis, etc. Most FMD cases reported in Iraq are only diagnosed by clinical signs. It is very difficult (impossible) to depend on clinical signs of FMD for the confirmative diagnosis of the disease. In addition, the subclinical phase of the disease nearly always goes unnoticed. The recorded figures do not reflect the actual FMD situation in Iraq because of diagnostic insufficiencies. Diagnostic tests at the herd level are strongly needed for effective surveillance and diagnosis.

4- Control measures that are simple to apply, relatively inexpensive and highly effective at preventing transmission of infection are needed.

5- Supporting legislation to enable the program to proceed. Appropriate legislation is required to implement movement controls, compulsory vaccination, compensation and other measures included in regulatory-type programs. Most official guidelines concerning animal health in Iraq are out dated and do not meet current needs. Veterinary Services of Iraq still work under the umbrella of act No.68 for the year 1936 "Law of Animal Infectious Diseases".

6- Adequate funding committed to the program. Without adequate funding, any FMD control program is doomed to failure. The Ministry of Agriculture must commit to budget for controlling animal diseases, and the present allocation for controlling FMD is inadequate for implementation of an effective program.

2.7.3 Major Constraints of the FMD Control Program in Iraq:

1- Lack of laboratory capabilities for sero-monitoring, virus isolation, and disease investigation.

2- Insufficient staff diagnostic skills.

3- Difficulties in restricting animal movement throughout the country and also with neighboring countries.

4- Lack of an irregular supply of appropriate vaccine. Commercial vaccine suppliers do not have stocks for immediate delivery to countries affected by outbreaks.

2.8 Recommendations:

2.8.1 Laboratories and Diagnostic Capacity

1. Restoration of Al-Dora FMD laboratories to reactivate the facilities for FMD diagnosis and vaccine production. The current FMD situation in Iraq confirms the pressing need for renovation of facilities and laboratories for production of FMD vaccine. This would include:

    - Production of various strains of vaccine to meet actual needs and ensure a basic stockpile to cope with emergency situations;
    - Provision of a capacity for the rapid identification and serotyping of circulating serotypes;
    - Field monitoring for the purpose of assessing and determining the level of immunity of vaccinated animals.

    Renovations should be conducted by specialists and international companies withsupport of OIE and FAO expertise.

2. Strengthening the local and provincial laboratories capability for FMD testing and sero-surveillance programs. In addition, encourage quality assurance program for laboratories from the region (proficiency testing).

2.8.2 Surveillance and Monitoring Program

1. Strengthening disease surveillance, monitoring and early reaction capability. Training activities designed for surveillance programs that are concrete and useful for the National authorities for progressive control of FMD. The proposed training program would include

sessions on the design of surveillance programs and monitoring of control activities, and sessions dedicated to the technical support of laboratory activities for surveillance and monitoring.

2. Monitoring the circulating strains of FMDV through continuous submission of suitable samples to World Reference Laboratories plays an essential role in the control of the disease through vaccination. These samples should be accompanied by comprehensive epidemiological reports, including the geo-reference, to assist early warning and tracing the likely patterns of disease spread.
3. Circulating strains should be constantly monitored and characterized in order for vaccines to be matched with the FMD viruses they are required to protect against.
4. Analyzing the collected data in a regional reference center, to improve early warning and early control of the disease.
5. Establishing a FMD virus network, co-coordinated by the Regional Animal Health Center, to facilitate exchange of information and to respond rapidly to emergence of any new serotype(s) in the region.
6. Developing a national animal health information system in Iraq. This system would support the development of sustainable digital animal health information and field disease reporting. The information would be used in disease surveillance, analysis of disease outbreaks including geographical distribution and the evaluation of disease control programs.
7. Investigating FMD in wild animals, which can play an important role in the epidemiology of the disease, especially in wild boars inhabiting border marshlands.

8. Introducing Geographic Information System (GIS) to be used in animal disease control as a supporting tool. GIS can assist in understanding and explaining disease dynamics and spreading patterns. It can increase the speed of response during an emergency linked with the introduction of disease. GIS can correlate disease trends and be used as an early warning tool or for predicting the evolution of the disease. It is essential to use the global positioning system (GPS) to assist in collecting data for GIS documentation activities and tracking the project in a database.
9. Using satellite imagery in identifying animal health problems, monitoring disease and resources, and tracking animal movement would be especially important for small ruminants involved in nomadic farming systems. Using real-time GPS tracking devices for monitoring livestock herds and providing ongoing real-time data regarding distribution of FMD-susceptible species during implementation of control measures would be extremely valuable, and help in rapid decision making when an outbreak takes place.
10. Improvement of national animal identification and traceability according to OIE standards also would assist in monitoring, planning and controlling an outbreak.

2.8.3 Control Program

1. Developing national FMD contingency plans based on FMD status. This plan would provide a framework that could facilitate early disease detection in an emergency, minimize the risk of establishing and subsequent spread of disease, and provide for a rapid and effective response. The plans should be regularly updated.
2. Ensure long-term and regular vaccine procurement of doses needed in preventative vaccination campaigns, as well as a vaccine reserve for use in emergencies. Procurement of vaccines should consider the recent FMDV antigenic subtypes in countries of the

region, as well as the antigenic relationships of viral isolates circulating in neighboring countries.

3. Vaccine quality assurance is badly needed in the FMD Control Program, and establishment of a center or unit within Quality Control Laboratories in Baghdad for independent evaluation and animal trials on vaccines should be considered.
4. Using FMD vaccine with oil-emulsion adjuvant provides immunization for 8 -10 months rather than a vaccine with aqueous (Al $(OH)_3$- saponin) adjuvant providing duration of immunity for 4 - 6 months.
5. Shifting from a voluntary to a compulsory basis for the vaccination program. A vast majority of Iraqi farmers from the traditional sector have small herds and consider FMD a low priority disease due to its low mortality rate. Thus, reluctance to vaccinate by some farmers has been apparent during vaccination campaigns.
6. Establishing a national antigen bank should be considered to hold sufficient stocks of virus (es) for immediate formulation in emergency situations. The banks could reduce the need to vaccinate against selected virus types (exotic strains).
7. Harmonizing vaccination with countries within the region to ensure coverage against the most prevalent (high priority) viruses.
8. Controlling informal or illegal movement of live animals and animal products across national boundaries. This action would require:
    - More bilateral meetings on measures to protect borders
    - Better communication between Iraq and neighboring countries to develop trust and encourage country collaboration.

- Broader agreement needed on measures regarding movement between countries.
- Harmonize national and international legislation - promoted at a regional level.
- National and/or regional plans to control illegal animal movement.

9. Imposing appropriate quarantine measures on animal movement and animal products whenever the disease is reported, and updating the protocols to be harmonized with WTO/SPS agreements. In addition, strengthen sanitary measures and coordinate actions and activities across borders.
10. Since FMD is endemic and widely spread among multiple animal species in the region, it is very difficult to control the disease at a single-country level. Therefore, implementation of a regional project for control of FMD in the Middle East is strongly recommended.

2.8.4 Veterinary Services and Staff

1. Training veterinary staff to improve technical and management skills in disease recognition, investigation, control and surveillance, and assisting senior veterinary staff in devising disease control and public health strategies would be essential.

Two programs of training sessions should be organized and would address official priorities as follows:

- Training in the design of risk-based surveillance programs. The sessions would assist officials in designing adaptable surveillance programs. Personnel would be dedicated national experts and/or officials who would be in charge of implementing the animal disease surveillance programs in respective governorates. Other training needs would include training in development and testing (simulation exercises) of contingency plans.

- Strengthening the laboratory diagnostic capacity; the training would address methods used for sero-surveillance in the programs adopted by the government. This would include the sampling, risk analysis and confirmation/typing of FMDV in order to support the decisions in outbreak management, including arrangement for FMDV typing.

2. The front-line need and role of Veterinary Services in prevention and control of FMD has been clearly recognized. To fulfill their functions efficiently, Veterinary Services in Iraq needs to be strengthened and provided with the necessary human, technical, financial and legislative resources. This can be achieved if Veterinary Services would be properly evaluated for compliance with OIE international standards on various aspects related to quality. A performance of Veterinary Services tool (OIE PVS) and capacity building could help evaluate Veterinary Services in Iraq, to identify weaknesses and gaps that subsequently could be remedied through resources from national budgets or international aid.
3. Involvement of the private veterinary sector (veterinary clinics and labs), the Iraqi veterinary syndicate, and NGOs in the FMD control program would be beneficial, particularly recruitment of private veterinarians as informants. Most of them would be involved and trusted by owners and farmers, and would have field experience regarding treatment and diagnosis of FMD.

4. Reviewing and amending legislation and regulations related to animal and public health, with updates according to current requirements of the local, regional and/or international situation.

Conclusion

- FMD virus is endemic and periodic devastating epidemics have occurred in Iraq for a long time. The first official reportable cases of FMD were recorded in 1937, with the first record of a specific FMD strain in Iraq was serotype A in 1952. The disease remains a significant drain on the national budget, particularly for Veterinary Services in Iraq and on the livelihood of livestock owners across the country.
- Veterinary Services in Iraq was severely weakened and the veterinary infrastructure has been devastated as a consequence of political conflicts, wars and international sanctions; all significantly affected animal disease control.
- Iraq is presently facing a serious deficit in FMD surveillance and emergency preparedness, both crucial elements in fighting endemic and exotic FMDV strains.
- Limited diagnostic capabilities, difficulties in restricting animal movement, and lack of and/or irregular supply of appropriate vaccines have been key challenges confronting implementation of a successful and effective FMD control program in Iraq.
- The FMD situation in Iraq constitutes a major threat to theregion and entire world. It will require intensified effort and leadership from Veterinary Services to confront the disease and its many significant ramifications. –In addition, strong regional and international support will be essential for true success.

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Appendix A - Iraq Livestock Populations, 1970-2002

	Large Animal1000 heads				Small Ruminant1000 heads		
Year	**Total**	**Cattle**	**Equine**	**Other**	**Total**	**Sheep**	**Goats**
1970	3,104	1,830	720	288	15,400	13,099	2,301
1971	3,095	1,860	720	270	14,305	11,955	2,350
1972	3,068	1,880	718	250	13,210	10,810	2,400
1973	3,065	1,900	715	240	12,170	9,670	2,500
1974	3,130	2,048	708	184	11,110	8,526	2,584
1975	2,823	1,850	647	161	11,255	8,470	2,785
1976	2,646	1,804	556	146	11,390	8,401	2,989
1977	2,622	1,804	543	160	11,820	9,500	2,320
1978	2,496	1,698	538	170	11,782	9,723	2,059
1979	2,468	1,698	531	170	11,835	9,775	2,060
1980	2,437	1,702	495	170	13,080	11,000	2,080
1981	2,453	1,670	533	175	13,700	11,750	1,950
1982	2,462	1,675	533	174	12,545	10,865	1,680
1983	2,473	1,685	533	175	12,291	10,491	1,800
1984	2,441	1,698	503	170	11,333	9,723	1,610
1985	2,345	1,635	500	155	10,050	8,500	1,550
1986	2,264	1,578	503	141	10,457	8,981	1,475
1987	2,270	1,580	505	140	10,500	9,000	1,500
1988	2,302	1,600	511	141	10,550	9,000	1,550
1989	2,306	1,578	526	145	10,457	8,981	1,476
1990	2,259	1,520	530	150	11,150	9,600	1,550
1991	1,534	1,000	410	110	6,870	5,800	1,070
1992	1,794	1,260	419	105	8,775	7,525	1,250
1993	2,019	1,480	423	108	11,050	9,500	1,550
1994	1,890	1,354	442	87	9,825	8,400	1,425
1995	1,720	1,190	454	70	8,850	7,400	1,450
1996	1,530	1,050	425	50	6,405	5,300	1,105
1997	1,808	1,300	439	62	8,050	6,584	1,466
1998	1,837	1,320	446	64	8,200	6,700	1,500
1999	1,829	1,325	432	64	8,300	6,750	1,550
2000	1,861	1,350	438	65	8,380	6,780	1,600
2001	1,861	1,350	438	65	8,380	6,780	1,600
2002	1,861	1,350	438	65	8,380	6,780	1,600
Period	Averages						
1960-69	2,786	1,567	762	246	13,337	11,171	2,166
1970-79	2,852	1,837	640	204	12,428	9,993	2,435
1980-84	2,453	1,686	519	173	12,590	10,766	1,824
1985-89	2,297	1,594	509	144	10,403	8,892	1,510
1990-94	1,869	1,301	445	112	9,534	8,165	1,369
1995-99	1,751	1,249	439	62	7,961	6,547	1,414
2000-02	1,861	1,350	438	65	8,380	6,780	1,600

[1]Livestock populations are inventory averages for the period. [2]Includes donkeys, horses and mules. [3]Includes buffalo and camels. [4]mt = metric tons.

Source: U.N., FAO, FAOSTAT.

Appendix B - Molecular Epidemiology Report Form

Serotype: A
WRL Ref No: IRQ/9/2009
Sender Ref: R9
Date collected: 15/01/2009
Date received by WRLFMD: 28/01/2009
Date received for sequencing: 05/02/2009
Species: Cattle
Material used: BTy1
Region sequenced: VP1
RT-PCR primers: A-1C562F/EUR-2B52R; A-1C612F/EUR-2B52R
No. of Nt determined: 639
No. of ambiguities: 0
Gene length: 639

Report date: 11/02/2009
Reported by: N.J. Knowles
Checked by: D.P. King

Topotype: ASIA
Genotype/strain: Irn-05
Sequence filename: IRQ09-09.SEQ
Date sequence last updated: 11/02/2009
Total no. of comparisons: 990
Min. no. of nt for comparison: 300
Total turn-around time: 14 days
Sequencing time: 6 days

Comments:

Ten Most Closely Related Viruses

Pos.	Virus name	Filename	No. nt compared	No. nt matched	No. of ambiguities	% Identity	% Difference
1	A/IRQ/10/2009	IRQ09-10	639	639	0	100	0
2	A/IRQ/11/2009	IRQ09-11	639	639	0	100	0
3	A/IRQ/12/2009	IRQ09-12	639	639	0	100	0
4	A/IRQ/15/2009	IRQ09-15	639	639	0	100	0
5	A/IRQ/17/2009	IRQ09-17	639	639	0	100	0
6	A/IRQ/19/2009	IRQ09-19	639	639	0	100	0
7	A/BAR/6/2008	BAR08-06	639	634	0	99.22	0.78
8	A/BAR/7/2008	BAR08-07	639	633	0	99.06	0.94
9	A/PAK/5/2006	PAK06-05	639	621	0	97.18	2.82
10	A/AFG/44/2007	AFG07-44	639	619	0	96.87	3.13

Relationships to Reference Virus Strains

Pos.	Virus name	Filename	No. nt compared	No. nt matched	No. of ambiguities	% Identity	% Difference
1	A/IRN/1/2005 (EF208769)	IRN05-01	639	612	0	95.77	4.23
2	A/SAU/41/91	SAU91-41	636	541	0	85.06	14.94
3	A/TAI/118/87* (EF208777)	TAI87-AD	636	537	0	84.43	15.57
4	A/IRN/2/87 (EF208770)	IRN87-02	636	535	0	84.12	15.88
5	A/IRN/22/99 (EF208772)	IRN99-22	636	532	0	83.65	16.35
6	A/IRN/1/96 (EF208771)	IRN96-01	638	532	1	83.39	16.61
7	A/SAU/23/86 (EU414536)	SAU86-23	639	531	0	83.1	16.9
8	A/TAI/2/97 (EF208778)	TAI97-02	636	528	0	83.02	16.98
9	A22/IRQ/24/64 (AJ251474)	IRQ64-24	639	525	0	82.16	17.84
10	A24/Cruzeiro/BRA/55 (AJ251476)	BRA55–C	639	514	0	80.44	19.56

nt, nucleotides
*, not a WRLFMD reference number

Report on FMDV A from Iraq in 2009

(Batch: WRLFMD/2009/00003)

Software: MEGA 4.0
No. of Taxa : 183
Data File : n:\evd\meg\db\fmdv\a\IRQ2009a.meg
Data Title : A Iraq 2009
Data Type : Nucleotide (Coding)
Analysis : Phylogeny reconstruction
Tree Inference : ==============================
->Method : Neighbor-Joining
->Phylogeny Test and options : Bootstrap (1000 replicates; seed=64238)
Include Sites : ==============================
->Gaps/Missing Data : Pairwise Deletion
->Codon Positions : 1st+2nd+3rd+Noncoding
Substitution Model : ==============================
->Model : Nucleotide: Kimura 2-parameter
->Substitutions to Include : d: Transitions + Transversions
->Pattern among Lineages : Same (Homogeneous)
->Rates among sites : Uniform rates
No. of Sites : 645
No Of Bootstrap Reps = 1000
Only bootstrap values of 70% and above are shown

*, not a WRLFMD Ref. No.

N.J. Knowles & J. Wadsworth, 11 February 2009