

Review of the foot and mouth disease situation in North Africa and the risk of introducing the disease into Europe

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Summary

Foot and mouth disease (FMD) is a highly contagious disease of cloven-hoofed animals, including cattle, pigs, sheep, goats, and certain wildlife species. The disease can cause massive economic losses when introduced into countries that were free from the infection, generating negative effects due to reduced animal productivity and restrictions on international livestock trade.

Following 15 years of FMD absence, Tunisia and Algeria experienced an incursion of the disease in 2014. The epidemiological situation and disease control measures in operation for FMD in the North African region are not homogeneous. The FMD virus detected in Tunisia and Algeria during the epidemic in 2014 showed 99% identity with a strain isolated in Libya in 2013. Morocco was not affected by the 2014 epidemic but it started a preventive vaccination campaign for cattle in August of that year.

The relatively short distance between the North African continent and southern Europe may facilitate the introduction of pathogens, including FMD virus. The history of infectious diseases demonstrates

that the Mediterranean Sea is not a sufficient barrier to viral infections.

Considering the geography and the FMD situation in North African countries, strong and coordinated intervention strategies are required, including economic, political and disease control aspects, to prevent the spread of FMD to other countries in North Africa or to other regions, e.g. southern Europe. Regional platforms such as the Mediterranean Animal Health Network (REMESA) could play a crucial role in coordinating and managing animal health crises, such as the 2014 FMD epidemic.

Keywords

Animal movements – Foot and mouth disease – North Africa – REMESA – Risk of introduction – Vaccine bank.

Introduction

Foot and mouth disease (FMD) is a virus of the family *Picornaviridae*, genus *Aphthovirus*, which includes seven immunologically distinct serotypes: A, O, C, SAT1, SAT2, SAT3, and Asia1, which do not confer cross-immunity. Some FMD virus serotypes are more variable than others but, collectively, they contain more than 60 strains. The disease is endemic in parts of Asia, Africa, the Middle East and South America. Serotypes O and A are widely distributed, while SAT serotypes occur mainly in Africa, and Asia1 is currently found only in Asia (1, 2).

The FMD virus causes a highly contagious disease of cloven-hoofed animals, including cattle, pigs, sheep, goats, and certain wildlife species. The disease can cause massive economic losses when introduced into countries that were free from the infection, and can generate negative effects due to reduced animal productivity and restrictions on international livestock trade. The FMD epidemic that occurred in the United Kingdom in 2001 had an estimated cost of around €12–14 billion, and approximately six million animals were

destroyed (3). The last FMD outbreak in a European Union Member country occurred in Bulgaria in 2011 (4).

The FMD virus has been eradicated from some regions, including Western Europe and North America, but unless firm precautions are in place, FMD can be readily reintroduced into disease-free regions/countries, mainly via illegal trade of animals and animal products. Once the disease has been introduced, the virus can spread rapidly in the absence of rapid detection, containment and response. The disease shows a low mortality rate in adult animals but there is often higher mortality in young animals, due to myocarditis (1). Cattle are usually the main host species, although some strains appear to be specifically adapted to domestic pigs, or to sheep and goats. Wildlife, with the exception of the African buffalo (*Syncerus caffer*) in Africa, has not so far been shown to maintain FMD virus (1).

When considering the losses incurred as a result of an outbreak, it is of paramount importance to consider the impact of the economic consequences due to the direct, visible losses, including reduced milk production. The *Global Foot and Mouth Disease Control Strategy* document issued by the World Organisation for Animal Health (OIE) and the Food and Agriculture Organization of the United Nations (FAO) in 2012 reported that the reduction in milk output can reach 33% in endemic areas (5).

Since 1998, the OIE has had the mandate from the World Trade Organization (WTO) to officially recognise countries or zones as free from FMD with or without vaccination. The official recognition of the disease status of Member Countries is of great importance for international trade and constitutes one of the most important legal links between the OIE and WTO, in the framework of the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement), which entered into force in 1995. For this purpose, the OIE has put in place a specific procedure for official recognition of disease status for selected diseases, including FMD.

By acquiring and maintaining official disease-free status, a given country can demonstrate its ability to comply with relevant chapters of

the OIE *Terrestrial Animal Health Code (Terrestrial Code)* and ensure the good governance of their Veterinary Services. These chapters lay down requirements for transparency and describe the capacity needed to protect and promote animal health and public health worldwide, so compliance with these requirements enables countries to gain the trust of their trading partners as well as of the international community.

Figure 1 shows the worldwide distribution of countries or zones with officially recognised FMD-free status from the OIE (data up to May 2015). More information is available on the OIE official disease status webpage dedicated to FMD (www.oie.int/en/animal-health-in-the-world/official-disease-status/fmd/).

The strain that circulated in the North African region in 2014 (O/ME-SA/Ind-2001 – serotype O) was introduced into Libya in 2013 (most probably from the Middle East). The sequencing of the strain showed that it was distantly phylogenetically related to the serotype O strain that had circulated in the past (2010–2012), which possibly indicates that the susceptible population in the area was not adequately protected despite a vaccination programme. The FMD virus detected in Tunisia and Algeria during the epidemic in 2014 showed 99% identity (of capsid protein VP1) with the strain isolated in Libya in 2013.

The OIE Sub-Regional Representation for North Africa (OIE Regional Office), which is in direct and constant liaison with the OIE Headquarters based in Paris, has been heavily involved in assisting countries in the North African region to better coordinate their actions in facing the spread of the disease and in facilitating the exchange of information and data among countries. The OIE Regional Office also encourages countries in the region to strengthen surveillance (clinical and serological), to document the prevalence of the disease or the absence of virus circulation in cattle and small ruminants, and to carry out surveys for post-vaccination monitoring following emergency vaccination campaigns. The objective of this review is to update and consolidate the information made available through the regular

meetings organised by the OIE Regional Office with the Chief Veterinary Officers in the North African region. This information will provide an update on the situation for the international community in light of the recurrence of FMD in the area in 2014, after 15 years of absence.

The OIE has also introduced a system for the endorsement of official national disease control programmes for FMD. Although this does not constitute recognition of disease status per se, it serves as an incentive for Member Countries to move towards obtaining country or zonal freedom from the disease. During the OIE General Session in May 2012, Algeria, Morocco and Tunisia were the first OIE Member Countries to have their official FMD control programmes endorsed by the World Assembly of Delegates.

The animal population in North Africa and the contribution of livestock to food security

Livestock contributes directly to the livelihoods and food security of almost a billion people by affecting their diet, wealth and health (6).

United Nations projections show that the world population could reach 9.15 billion by 2050 and indicate that global agricultural production in 2050 will be 60% higher than in the years 2005–2007, raising the concern of how this increase can be achieved sustainably. If these projections are correct, meat production, for instance, will increase from 258 million tonnes in 2005–2007 to a total of 455 million tonnes in 2050 (7). In this context, FMD threatens food security and the livelihoods of smallholders and prevents animal husbandry sectors from developing their economic potential (5).

The livestock in the North African region is composed of approximately 7 million large ruminants and 75 million small ruminants (>12% of the small ruminant population of Africa). This represents an essential resource for domestic economies, and for poor rural populations in particular, by contributing, on average, about 40–80% of the gross agricultural product. Table I shows the estimated number of animals in North Africa, by species and by country, and

highlights the fact that the predominant livestock species in the region are small ruminants.

Animal farming and livestock production in the region are characterised by a significantly extensive and nomadic system, which, under specific circumstances, can increase the risk of spreading diseases in the region. In all these countries, the major distribution of the animal population is in the northern zones.

The foot and mouth disease situation in North Africa

The Chief Veterinary Officers (CVOs) of the Member Countries of the Mediterranean Animal Health Network (REMESA), which consists of 15 countries of the Mediterranean Basin, consider FMD to be one of the priority animal diseases for the region. The objective of REMESA is to improve the prevention and control of the major transboundary animal diseases and zoonoses through the harmonisation and coordination of the surveillance and control activities of the countries around the Mediterranean Basin.

The epidemiological situation and the animal disease control measures in operation for FMD in North African countries, particularly their vaccination strategies, vary to some extent. In Tunisia, Algeria and Morocco there was an epidemic in 2014–2015 (serotype O); before that, these countries had been free of the disease for about 15 years. In Mauritania the disease is considered endemic, although there are no specific monitoring and/or control programmes in place, and the disease has not been officially reported since 2007. In Libya, the disease re-occurred in 2009 and persisted until 2013 with the three serotypes A, O and SAT2. Given the political situation in that country, there has been no official disease information reported since 2011. Although recent data – based on a specific survey conducted in collaboration with the FMD OIE Reference Laboratory in Brescia – suggest that serotype SAT2 is no longer circulating in Libya, the disease is still considered endemic. FMD is also endemic in Egypt, and in 2013 serotypes A and O were reported to be circulating, while in 2012 the presence of serotype SAT2 was also notified. Table II

shows the circulation of different FMD serotypes in North Africa. It is evident that serotypes A and O have been the prevailing serotypes circulating over the past 40 years, with sporadic occurrences of SAT2.

As mentioned earlier, the vaccination control strategy against FMD varies among countries within the region. Algeria and Tunisia carry out annual vaccination campaigns against FMD, while Morocco stopped annual vaccination in 2007. In addition, there are some differences among the countries applying an annual vaccination campaign (e.g. Algeria and Tunisia), in relation to the target vaccinated species and serotypes used. Table III summarises the details of the vaccination strategies used in the region.

It is worth considering that Morocco hosted an FMD-naïve animal population until the middle of August 2014, when it started immunising against FMD (serotype O), but only the bovine population was vaccinated; therefore, small ruminants continue to be susceptible. In Algeria, the vaccination strategy has, over the years, also targeted only the bovine population, so when the 2014 epidemic began, small ruminants were a susceptible population.

Foot and mouth disease in Tunisia in 2014

Prior to the 2014 epidemic, which started on 25 April with an outbreak in Nabeul Governorate in the north-east of the country, Tunisia had been free of the disease since 1999. The fragility of the animal control movements system in the region played a major role in re-introducing the disease to Tunisia.

Although the sequencing of the strain isolated in Tunisia (O/ME-SA/Ind-2001 – serotype O) was very similar to the one circulating in Libya, there was no confirmation that the virus had been introduced from Libya.

Despite the ongoing collaboration between the Tunisian and Libyan Veterinary Services, the current political and administrative situation in the Tunisian–Libyan border area is a problematic factor in the control of animal movements. In addition, these areas are sparsely

populated, making the implementation of effective controls more difficult.

From 25 April 2014 (the date of the outbreak in Nabeul Governorate), FMD spread throughout Tunisia (Fig. 2). By 4 November 2014, a total of 150 outbreaks had been reported through the OIE World Animal Health Information System/Database (WAHIS-WAHID). The Tunisian Veterinary Services considers an outbreak to be closed once three weeks have passed since the last recorded clinical case.

Figure 2 shows the wide and rapid spread of FMD in Tunisia in 2014. The Veterinary Services faced severe difficulties in controlling animal movements, since this action was not considered a priority because of the political situation.

Table IV shows some details of the total number of outbreaks reported to WAHIS-WAHID up to 4 November 2014. After the detection of the first outbreak in Tunisia, an emergency vaccination campaign was started in response to the outbreaks, utilising the vaccines stored for the annual vaccination campaign, which was due to be conducted in September 2014. In addition to vaccination, the Government ordered the immediate implementation of the following measures:

- activation of crisis management cells at national and regional level
- a ban on animal movements from the affected governorate to other governorates (there are a total of 24 governorates in Tunisia)
- the establishment of disinfection posts for all vehicles leaving the affected governorate
- vaccination of all the animals entering markets (the vaccination was administered at the markets)
- vaccination around the outbreaks (5-km radius).– compulsory vaccination of all animals sent for fattening before being moved for Eid al-Adha (the ‘feast of sacrifice’ based on the lunar-based Muslim calendar; in 2014 it was held on 4 October).

During the Eid al-Adha period, it is estimated that more than 12 million small ruminants (mainly sheep) are traded through the markets to be sacrificed.

In addition to the above measures, a military zone and physical barriers were established along the border with Libya to better control any movements of people, goods and animals.

Based on the statistics shown in Table IV, the overall FMD morbidity in Tunisia is about 20% in cattle and 10% in sheep and goats. A stamping-out policy could not be applied, because there were no funds available to compensate the farmers. In parallel, it was also decided not to close all the animal markets, to avoid the opening of new illegal markets, which could have increased the risk of disease spread. Therefore, vaccination was, and still is, the major control measure applied to prevent further spread of the disease in Tunisia. If the vaccination campaign had not been well designed and implemented, and in the absence of supplementary disease control measures, there could have been a risk of FMD becoming endemic in the country. The following factors increased the risk of long-term circulation of the FMD virus in Tunisia – with a high risk also of spread to the rest of North Africa:

- the failure of animal movement controls and the absence of other effective disease control measures in Tunisia (e.g. a stamping-out policy, compensation programmes)
- the absence of emergency funds for implementing intensive and active surveillance for monitoring the outbreaks and for post-vaccination monitoring
- the high permeability of the south-eastern border with Libya (for the reasons mentioned above), with the constant risk of re-introducing FMD virus to Tunisia.

Therefore, to prevent any future incursions of the disease, it is critical that countries on the northern border of the Mediterranean recognise the urgent need to reinforce surveillance for FMD in their countries

and support the countries of the southern shore of the Mediterranean Basin in their surveillance and control activities for major animal infectious diseases, including FMD.

Foot and mouth disease in Algeria in 2014 and 2015

Prior to 2014, the previous outbreak of FMD in Algeria had occurred in 1999, at the same time as in Tunisia. The 2014 epidemic started on 23 July with an outbreak in Setif zone, which is located in the north-east of the country, relatively close to the border with Tunisia. Illegal introduction of animals from Tunisia was reported to be the source of the re-occurrence of FMD in Algeria. The sequencing of the strain isolated in Algeria showed that it was similar to the virus circulating in Tunisia (O/ME-SA/Ind-2001 – serotype O).

The outbreak occurred on a fattening cattle farm with 14 animals. Four animals were clinically affected; the clinical signs included fever, blisters, lameness and mammary lesions. The outbreak occurred in an area with a high concentration of cattle (30,000 cattle in an area of 20 km²) belonging to many different farmers. Given the large number of animals, it was not possible to cull all the cattle in a few days. The same area included several cattle markets and, during the first week of the epidemic, their presence facilitated the spread of the disease across the country.

The farming systems and related production chains for cattle and small ruminants follow two different and separate pathways, which make contact between the two species unlikely. In addition, 20 million of Algeria's 25 million small ruminants are farmed in the south of the country, bordering the desert area, which is far from the northern area in which the entire cattle population is located. In 2014, only on a few farms was there proximity between cattle and small ruminants – in these cases, when FMD was detected, stamping-out of all susceptible species was immediately applied.

Following the detection of the outbreak in Algeria, the Veterinary Authority ordered that the following measures be implemented:

- controls on the movement of animals inside the country, including a ban on the movement of animals within the infected *wilaya* (the administrative division in Algeria) and movement control in the neighbouring *wilayahs*, until the event was considered resolved by the Veterinary Authority
- screening (clinical and serological)
- vaccination in response to the outbreak(s)
- vaccination of the national herd (cattle) in all the *wilayahs*, except in the *wilayahs* in the south
- disinfection of infected premises/establishment(s)
- a stamping-out policy where all the susceptible animals in the outbreaks were slaughtered
- closing of livestock markets in the affected *wilayah* and the neighbouring *wilayahs* until the event was considered resolved by the Veterinary Authority
- strengthening of investigations.

From 23 July 2014, the infection was reported to be spreading (Fig. 3), and by 22 October 2014 a total of 420 outbreaks had been reported. In follow-up report No. 5 (submitted to the OIE on 22 October 2014) Algeria declared that no new outbreaks had been detected since 22 September 2014 and that all outbreaks had been resolved. Table V shows some details of the outbreaks reported up to 22 October 2014, with an overall morbidity in cattle of about 40%. No cases were reported in small ruminants.

Whereas in 2014 Algeria reported FMD outbreaks only in cattle, in 2015 the country experienced new outbreaks detected mainly in small ruminants. In response, the Veterinary Authority of Algeria applied, among other measures, peri-focal vaccination of small ruminants around the outbreaks.

Disease control measures in Morocco

The FMD vaccination programme in Morocco had stopped in 2007, but a preventive vaccination campaign was launched, along with other disease control measures, after the detection of the first outbreak in Tunisia. To reinforce their surveillance strategy and to prevent the incursion of the disease from neighbouring countries, several animal disease control measures were implemented:

- strengthening of vigilance at national level and especially at the border areas
- advising all actors (e.g. local authorities, farmers' representatives) to increase vigilance and report rapidly any suspicion of FMD
- involvement of the relevant departments (e.g. Ministry of Interior, customs, police) to strengthen border control and prevent illegal introductions of animals and their products
- a ban on imports of animals and derived products
- the establishment of crisis management cells at a national level for monitoring the situation in the North African region
- a communication campaign
- a vaccination campaign.

The preventive vaccination strategy was started on 18 August 2014.

Because of limited antigen stocks in the country (1,000 doses), the vaccination campaign consisted of two phases, still with the objective of vaccinating the entire cattle population in Morocco (about 2.7 million head of cattle):

- the first phase (started on 18 August 2014): regions at the border with Algeria (approximately 1 million head)
- the second phase (started on 22 September 2014): the rest of the territory (approximately 1.7 million head).

In the framework of the surveillance strategy, Morocco also implemented serological surveillance to assess virus circulation and the efficacy of the vaccine and to elucidate the role of small ruminants in the epidemiology of this epidemic.

Despite the vaccination campaign, the FMD virus (O/ME-SA/Ind-2001 – serotype O) reached Morocco in 2015, probably as a result of the epidemiological factors linking the North African countries. According to the notifications submitted to the OIE, a total of six outbreaks were recorded in cattle in a zone located on the Atlantic coast. The Moroccan Veterinary Services, in response to the outbreaks, implemented – among other measures – surveillance and protection zones, stamping-out of the susceptible animals present on the farms and official destruction of animal products.

Animal movements in North Africa related to the risk of spreading foot and mouth disease

It is estimated that animal movements occur frequently among the countries in the North African region. There are regular animal movements at the borders between Algeria, Tunisia and Libya, and especially between Algeria and Morocco, because of meat markets and the exchange of animals between families residing along the borders (e.g. for special occasions such as weddings). However, the absence of an effective and efficient animal identification system in these countries creates difficulties in animal traceability. In addition to the regular animal movements, it is also estimated that there is a significant number of illegal animal movements in the region. For example, sheep from Mali were found in the centre of Tunisia, which demonstrates the fragility of the control measures in the entire region. Figure 4 indicates the main routes for exchange of animals and products.

Libya is one of the major importing countries in the region: at least 75% of its domestic food consumption is imported. As a consequence, there are a large number of animals introduced from Egypt, Chad and Sudan, as shown in Figure 4. It is also worth noting that there are illegal exports of small ruminants from Algeria to Tunisia and

Morocco, and – although it is rare – imported cattle can be moved between Tunisia, Algeria and Morocco. Usually, there are no major movements of domestic cattle between and across these three countries. Animal movements – mainly small ruminants – tend to increase significantly during certain periods of the year, such as during Eid al-Adha. This event serves to further amplify livestock movements across all the countries in the North African region. These additional animal movements tremendously increase the risk of disseminating FMD among countries in North Africa, if the disease outbreak is not resolved or controlled adequately.

Trade relations between North Africa and Europe

The consequences of globalisation are affecting the countries in the Mediterranean Basin, where trade has increased with other partners, mainly European Union (EU) countries. A report published by the International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM), confirms that Euro-Mediterranean trade – mainly in agricultural products – is focused on an axis running from North Africa (Morocco, Algeria and Tunisia) to the European Mediterranean countries (Italy, Spain and France), due to their geographical proximity (8).

In 2012, the EU was a significant trading partner of both Tunisia, with a total trade in goods accounting for 62.9% of Tunisian trade, and of Morocco, with a total trade amounting to approximately €24 billion. This demonstrates that there is a constant and significant exchange of people, vehicles and merchandise between the two shores (9).

Risk of introducing foot and mouth disease into Europe from North Africa

The dissemination of the FMD virus is not a negligible risk. The history of infectious diseases demonstrates that the Mediterranean Sea, separating the shores of southern Europe and North Africa, does not represent an effective barrier to the introduction of viral infections. The distance between Morocco and Spain is relatively short (14 km), as are the distances between Tunisia and Italy (about 155 km) and

between Tunisia and Malta (about 300 km). Furthermore, there is a strong trade relationship between Malta and Libya, with regular exchange of goods and people on a daily basis. The increased permeability of the Sahara Desert (e.g. new roads, more and more suitable vehicles available), which now allows pathogens previously confined to the south of the desert to arrive and spread across the North African countries, is an epidemiological factor to be considered (10). In addition, the traditional trade between the shores of the Mediterranean, with movements of people, commodities, vehicles and other transport (both legal and illegal), may play a role in disseminating diseases, especially when there is endemic infection in the North African region (this is an unquantified risk). The illegal migration flows from Africa to Europe must also be considered a risk factor, as Europe has long been a favoured destination for migrants from the African continent.

Today, it is acknowledged that a significant number of people from North Africa have migrated into Europe. Some of the migrants bring with them agri-food products, in particular lamb meat, during their regular round-trip flights (as shown during the FMD outbreaks that occurred in North African countries in 1999 [personal communication, R. Bouguedour, CVO of Algeria]).

Conclusion

Considering the geography of North Africa and the current FMD situation in the region, strong and coordinated intervention is required by the economic, disease control and political actors in various countries, including Libya, Tunisia and Algeria, to prevent further spread of FMD to the other countries in North Africa and to other regions, e.g. the south of Europe. This risk of spread may increase if FMD becomes endemic in the North African region: new FMD outbreaks were reported in Algeria in 2015. In addition, some countries in the North African region are facing severe challenges related to political instability that may negatively affect the control of animal diseases, both exotic and endemic.

In this situation, the REMESA network, which over recent years has become an official platform for sustainable cooperation between the CVOs on both sides of the Mediterranean, should play a crucial role in coordinating and managing animal health crises such as the FMD epidemic that occurred in 2014.

Furthermore, the OIE Reference Centres may play an important role in developing and implementing common activities among countries and laboratories in order to support the continuous improvement and development of harmonised national and regional animal disease surveillance activities, in line with international standards.

Finally, a regional vaccine bank managed by the OIE, with the support of its Regional Office in Tunis and under the coordination of REMESA, would be a key tool for the prevention of FMD around the Mediterranean.

In 2006, the OIE set up a series of global and regional vaccine banks for major diseases such as avian influenza, FMD, rabies and peste des petit ruminants. The experience of the countries that benefited from these vaccine banks revealed several advantages for the beneficiaries:

- high-quality vaccines, complying with international standards, are provided free of charge to developing countries (the cost of vaccines and transportation to the nearest airport is covered by the vaccine bank)
- the beneficiary country can concentrate its efforts and limited resources on implementing the vaccination campaign or on contracting public/private partnerships with selected non-governmental organisations
- easy procurement and delivery systems: bypassing (national) administrative delays, bureaucracy and costs associated with multiplication of local registration and purchase of vaccines
- easy customs clearance

– reduction in risks associated with storage of large quantities of vaccines in sub-optimal conditions; instead countries have the benefits of:

i) virtual stocks

ii) production on demand

iii) storage by the selected vaccine supplier(s) rather than by the beneficiary countries

iv) extended shelf life of the vaccines delivered.

Finally, an OIE vaccine bank may allow cost reduction per vaccine unit by benefiting from economies of scale (a call for tender and contracts for large quantities enables a reduced fixed cost), as well as ensuring the timely dispatch of emergency stocks in line with field needs. A combination of production of vaccines on demand (strains from an antigen bank) and use of pre-formulated vaccines (emergency deliveries) is also possible.

References

1. World Organisation for Animal Health (OIE). – Technical disease cards on foot and mouth disease. OIE, Paris. Available at: www.oie.int/fileadmin/Home/eng/Animal_Health_in_the_World/docs/pdf/Disease_cards/FOOT_AND_MOUTH_DISEASE.pdf (accessed on 10 November 2014).

2. Center for Food Security and Public Health (CFSPH) (2015). – Technical disease fact sheet on foot and mouth disease (Revised version: March 2015). CFSPH, Iowa State University, Ames, Iowa. Available at: www.cfsph.iastate.edu/Factsheets/pdfs/foot_and_mouth_disease.pdf (accessed on 10 November 2014).

3. Webb D. (2008). – The economic and social impact of the Institute for Animal Health's work on foot and mouth disease. Report prepared for the Institute for Animal Health by DTZ Consulting and

Research, London. Available at:
www.pirbright.ac.uk/ecosoc/docs/Foot-and-Mouth-Case-Study.pdf
(accessed on 10 November 2014).

4. Department for Environment, Food and Rural Affairs (United Kingdom) (2014). – FMD Data Archive. Available at:
<http://footandmouth.fera.defra.gov.uk/> (accessed on 1 August 2016).

5. World Organisation for Animal Health (OIE) & Food and Agriculture Organization of the United Nations (FAO) (2012). – The global foot and mouth disease control strategy: strengthening animal health systems through improved control of major diseases. OIE, Paris. Available at:
www.oie.int/eng/A_FMD2012/FAO_OIE_Global_Conference2012_in_Thailand/FMD_Global_Control_Strategy_&_Annexes.pdf
(accessed on 21 August 2015).

6. Robinson T.P., Wint G.R.W., Conchedda G., Van Boeckel T.P., Ercoli V., Palamara E., Cinardi G., D’Aielli L., Hay S.I. & Gilbert G. (2014). – Mapping the global distribution of livestock. *PLoS ONE*, 9 (5), e96084. doi:10.1371/journal.pone.0096084.

7. Alexandratos N. & Bruinsma J. (2012). – World agriculture towards 2030/2050: the 2012 revision. ESA Working Paper No. 12-03. Food and Agriculture Organization of the United Nations, Rome. Available at: www.fao.org/docrep/016/ap106e/ap106e.pdf (accessed on 21 August 2015).

8. Centre International de Hautes Études Agronomiques Méditerranéennes (2014). – MediTerra 2014. Logistics and agro-food trade: a challenge for the Mediterranean. Presses de Sciences-Po, Paris. Available at:
www.iamm.ciheam.org/en/publications/mediterrra/details?pub=Mediterrra_2014&id=14 (accessed on 21 August 2015).

9. European Commission (EC) (2014). – Trade section. Available at: <http://ec.europa.eu/trade/> (accessed on 10 November 2014).

10. Paweska J.T. & Jansen van Vuren P. (2014). – Rift Valley fever virus: a virus with potential for global emergence. *In* The role of animals in emerging viral diseases (N. Johnson, ed.). Academic Press, 169–200. doi:10.1016/B978-0-12-405191-1.00008-9.

Table I
Estimated numbers of animals in North African countries

Country	Species	Number of animals (×1,000 head)
Algeria	Cattle	1,650
	Sheep and goats	25,000
	Camelidae	290
Libya	Cattle	150
	Sheep and goats	6,300
	Camelidae	47
Mauritania	Cattle	1,700
	Sheep and goats	13,000
	Camelidae	1,600
Morocco	Cattle	2,700
	Sheep and goats	25,200
	Camelidae	70
Tunisia	Cattle	600
	Sheep and goats	8,000
	Camelidae	200

Table II
Foot and mouth disease serotypes circulating in the North African region since the 1960s

Country	Year	FMD serotype
Algeria	1966, 1990, 1999	O
	1977	A
	2014	O
Libya	1959, 1960, 1962, 1967, 1968, 1972, 1981, 1982, 1983, 1988, 1989, 1994	O
	1979, 2009	A
	2003	SAT2
	2009, 2013	A-O-SAT2
Mauritania	1975, 1976	SAT2
	1997	A
	2000	O
Morocco	1991, 1992, 1999	O
	1977, 1983	A
Tunisia	1965, 1967, 1969	C
	1970, 1975, 1989, 1990, 1994, 1999	O
	1979, 1982	A
	2014	O

Table III
Vaccination strategies against foot and mouth disease in the North African region: target species and serotypes

Country	Species	Serotypes
Algeria	Bovine	O, A
Libya	Bovine	A, O, SAT2 (Nov 2012 to Jan 2013)
	Bovine	A, O (from Nov 2013)
	Small ruminants	A, O
Morocco	Bovine	O (stopped in 2007 but started again in 2014)
Tunisia	Bovine	A, O, SAT2
	Small ruminants	O, SAT2

Table IV**Details of outbreaks of foot and mouth disease in Tunisia ($n = 150$)
from 25 April to 4 November 2014***Source:* OIE World Animal Health Information System

Species	Susceptible animals	Cases	Deaths	Destroyed	Slaughtered
Cattle	2,590	460	0	0	12
Goats	698	64	0	0	0
Sheep	6,565	641	0	0	1
Sheep/goats*	764	5	0	0	0
Total animals	10,617	1,170	0	0	13

*As it is not always possible for countries to provide separate figures for sheep and goats, the OIE World Animal Health Information System includes the option of reporting both together

Table V**Details of outbreaks of foot and mouth disease in Algeria ($n = 420$)
from 23 July to 22 October 2014***Source:* OIE World Animal Health Information System

Species	Susceptible animals	Cases	Deaths	Destroyed	Slaughtered
Cattle	7,087	2,759	162	413	6,512
Goats	200	0	0	0	200
Sheep	1,572	0	0	0	1,572
Sheep/goats*	—	—	—	—	—
Total animals	8,859	2,759	162	413	8,284

*As it is not always possible for countries to provide separate figures for sheep and goats, the OIE World Animal Health Information System includes the option of reporting both together

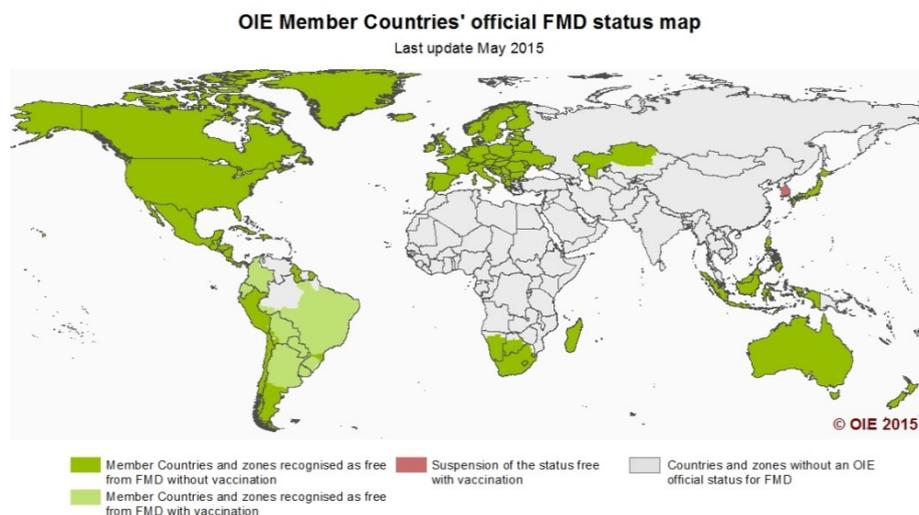


Fig. 1
Official recognition of disease status for foot and mouth disease from the World Organisation for Animal Health
(updated to May 2015)

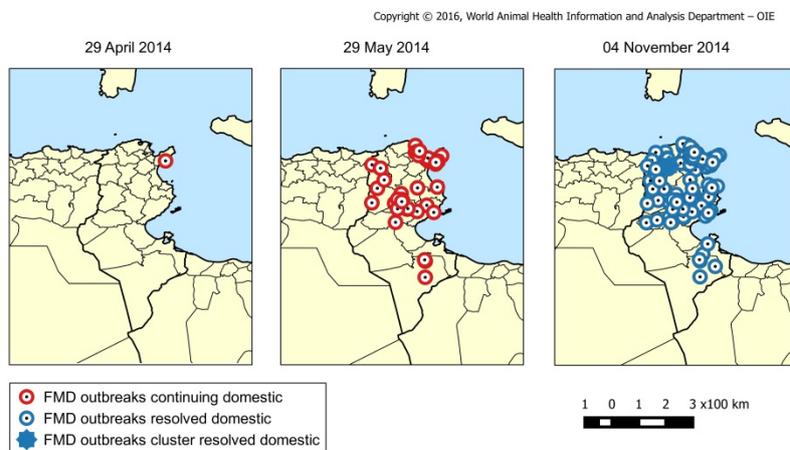


Fig. 2
Evolution of the outbreaks of foot and mouth disease in Tunisia in 2014

Source: OIE World Animal Health Information System

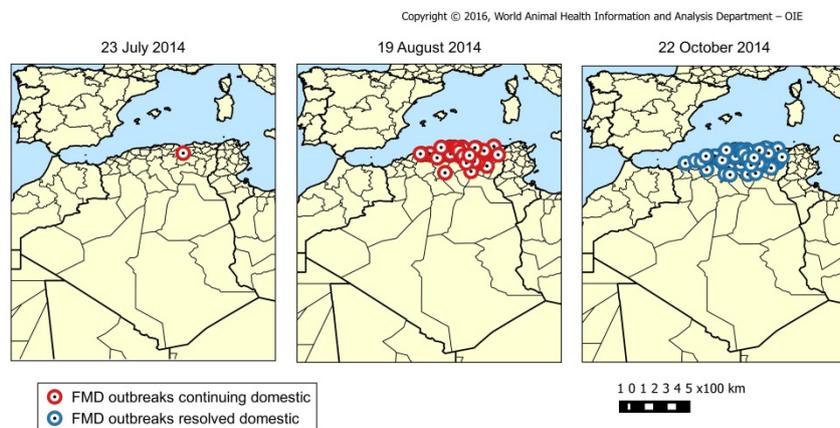
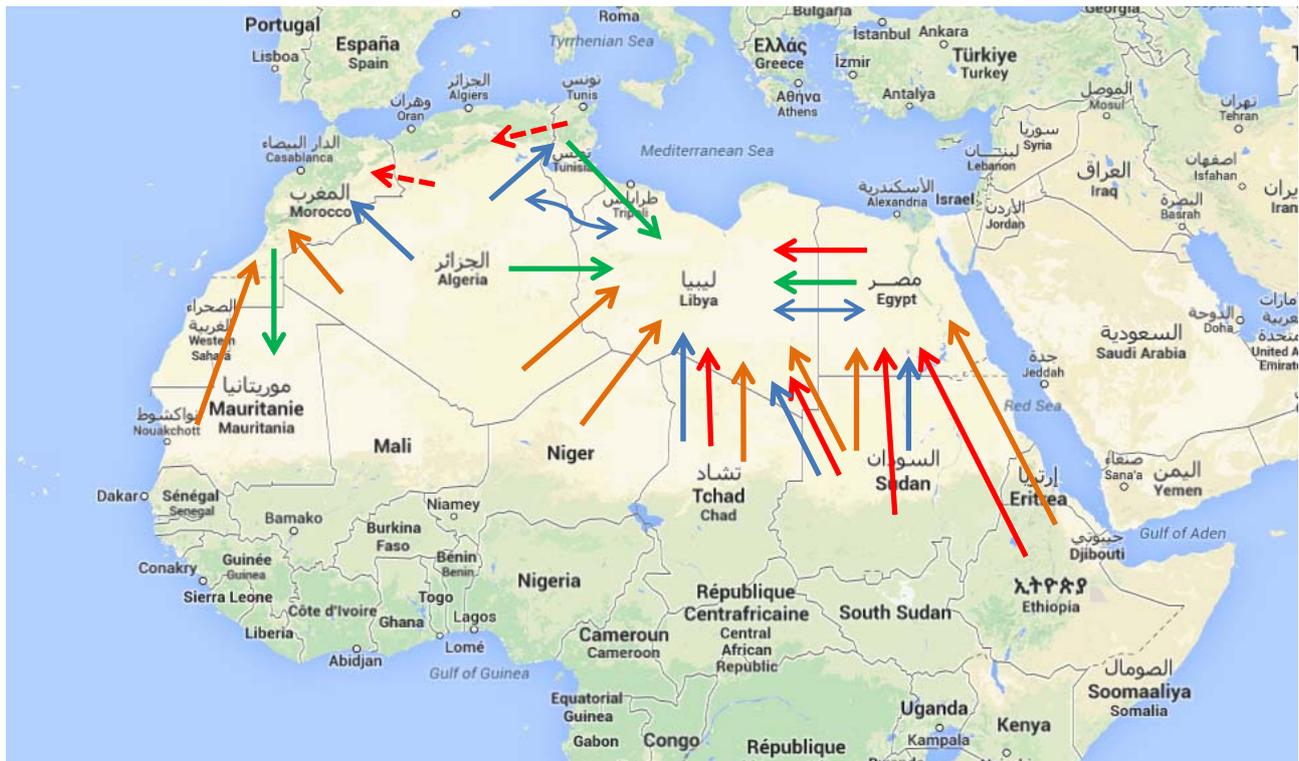


Fig. 3
Evolution of the outbreaks of foot and mouth disease in Algeria in 2014

Source: OIE World Animal Health Information System



- - - - -> Imported bovine
- > Domestic bovine
- > Small ruminants
- > Camelidae
- > Dairy products

Fig. 4
Animal movements in the North African region, including dairy products

Data obtained from the OIE Sub-Regional Representation for North Africa following the collection of information (historical and recent) from the Chief Veterinary Officers of the region. This map was agreed by the Member Countries of the Mediterranean Animal Health Network at the 9th meeting of its Joint Permanent Committee, which was held in Tunis, Tunisia, 3–4 November 2014 (*Source: www.rr-africa.oie.int/en/news/20141104_2.html*)