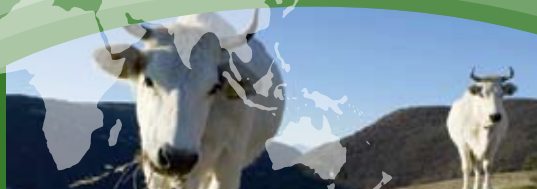




FOCUS ON...



Foot-and-Mouth Disease

Situation worldwide and major epidemiological events in 2005-2006

*Prepared by FAO EMPRES and EUFMD Commission Secretariat
Contributors: Keith Sumption, EUFMD Commission; Julio Pinto EMPRES;
Juan Lubroth, EMPRES Coordinator; Subhash Morzaria, FAO Regional
Office for Asia and the Pacific; Tom Murray, EUFMD Commission;
Stephane De La Rocque, EMPRES; Felix Njeumi, EMPRES*

No. 1 - 2007

TABLE OF CONTENTS

1. Significant FMD epidemiological events in 2005-2006	1
2. Situation Worldwide	4
3. Perspectives	11
4. FAO activities and response	12
5. References	12

I. SIGNIFICANT FMD EPIDEMIOLOGICAL EVENTS IN 2005-2006

Foot-and-mouth disease (FMD) is the most contagious transboundary animal disease (TAD) affecting cloven hoofed animals. Significant economic losses are produced by its high morbidity and the export trade restrictions imposed on affected countries. There are seven recognised serotypes of FMD (O, A, C, Asia 1, SAT 1, SAT 2 and SAT 3), which differ in distribution across the world. Serotypes A and O have the widest distribution, occurring in Africa, Asia and South America. Types SAT 1, 2 and 3 are currently restricted to Africa only and Asia 1 to Asia; the capacity to invade free areas is common to all types and periodically SATs are introduced into the Near East, and Asia-1 into western and eastern parts of Eurasia. Infection or vaccination against one serotype does not provide protection against the other serotypes.

Since surveillance intensity and reporting is less in the least developed regions, traditional mapping of FMD outbreaks underestimates the presence and incidence of the disease, especially in the most heavily affected locations. Therefore FAO has used an approach based on expert opinion over the last 5 years, and on global livestock distributions, to map the expected FMD incidence and prevalence for the major species. For cattle, the assessment suggests that the highest FMD challenge is in sub-Saharan Africa and in south Asia (Figure 1). These areas can provide a long term reservoir for neighbouring regions, as can be seen from epidemiological events in recent years.

The years 2005-2006 have seen some dramatic, in places devastating events in FMD epidemiology in the Near East, Far East and Africa. Since these each occurred in areas not considered officially free (by the OIE) of FMD, international attention has been limited compared to the epidemic in north-west Europe in 2001. In the same period, three incursions of FMD were reported in countries or zones declared officially free by the OIE in Argentina (type O in february 2006), Brazil (type O in september and october 2005) and Botswana (type SAT 2 in april 2006). The unstable epidemiological situation in endemic regions is highlighted by this review, which analyses the distribution of the FMD serotypes in 2004-2006, and assesses the risks posed by FMD in specific regions, including the emergence

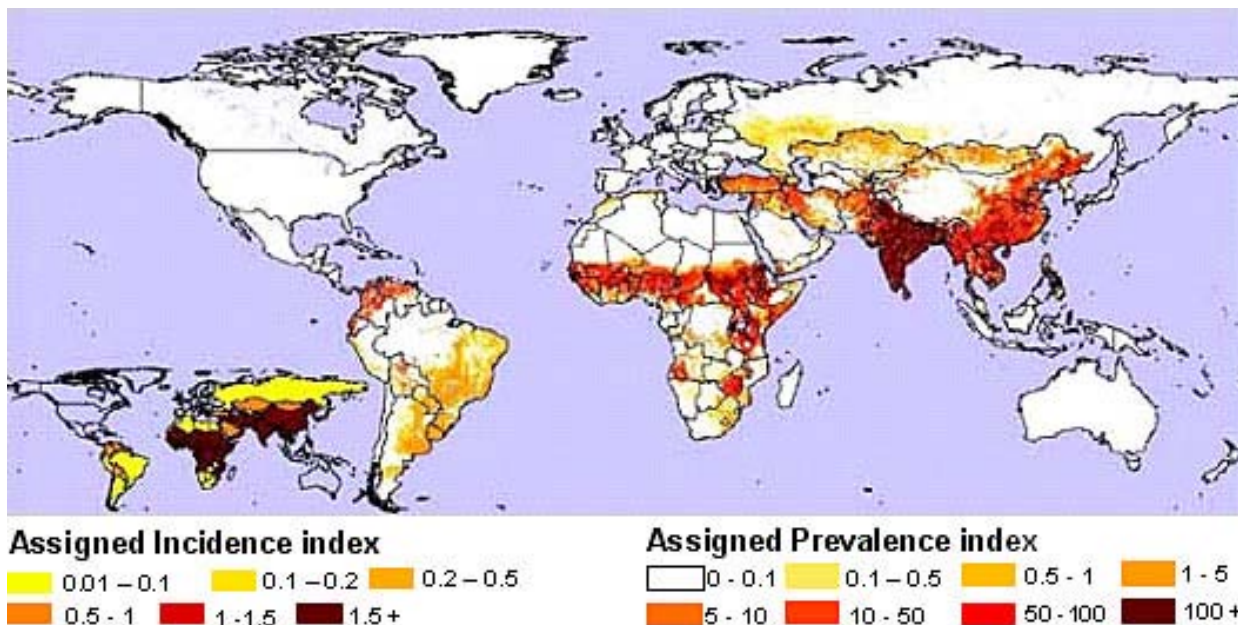
and spread of a serotype A virus in the Near East; the resurgence of FMD different lineages of type Asia 1 in Asia (China and Vietnam) and part of Russia and Mongolia; the introduction of type A into Egypt from sub-Saharan areas and the increased distribution of outbreaks caused by type O in the Great Lakes region of Africa.

The situation of FMD in infected areas indicates that FMD types continually spread within endemic regions, and periodically and unpredictably give rise to virus types that "break immunity" and cause regional epidemics. Prevention of FMD epidemics requires a good understanding of the virus types within a country or region and sufficient surveillance to identify emergent infections before regional spread occurs.

FMD in the Near East; regional epidemic caused by spread of the A Iran 05 strain of FMD serotype A

In mid-2005, a rapid escalation of type A outbreaks occurred in Iran, for which locally produced vaccines provided no protection; spread occurred across western Iran with severe impact in all ages of animal. Turkey was affected in the autumn, with first outbreak in November, and widely dispersed in December 2005; the routine vaccination (to types A Iran 96, O and Asia-1) provided little effective immunity against the variant virus. Following the animal movements associated with the Kurban festival in January 2006, type A outbreaks occurred in most regions of the country, including the strategically significant region of Thrace, which adjoins the non-vaccinating European region (Greece and Bulgaria). International response to the incursions in Turkey were delayed, since notification to the OIE occurred only after outbreaks occurred in Thrace; once notified, and as a result of immediate FAO (EUFMD Commission) missions, 2.5 million doses of emergency vaccine were provided by the EU vaccine bank to Turkey, which were used under FAO direction and succeeded in halting outbreaks in Thrace, but the epidemic continued and spread in Anatolia, peaking in June 2006, and resulting in over 800 confirmed type A outbreaks in the first 10 months of 2006, the worst situation for over 15 years (Figure 2).

Figure 1. FMD incidence and prevalence indices, based on a weighting of reported data and expert opinion - Cattle
Note: Attention is drawn to areas with a prevalence index > 1 (dark orange to brown), where FMD epidemics are frequent, whereas regions with < 1 are characterised by episodic incursions from endemic areas. Based on country level data in the 5 year period 2000-2004, and expert opinion where data was lacking, and did not take into account within country (zonal) differences in status; the map should not be interpreted as an official view on disease occurrence or distribution within the countries shown.



The new situation required a switch in the serotype A antigen of the vaccine (to A22) and, in order to meet the high demand, international agencies (EC/FAO) provided additional vaccine in August and November 2006 (2.7 million doses) mainly for use in western-central Anatolia. This region is at high risk from the regular inward movement of animals from endemic regions in the east (Figure 3) into fattening areas from where infection can spread to the significant bovine populations in the west (Figure 4).

The virus strain involved has been named A Iran 05 by the FAO World Reference Laboratory; outbreaks in 2006 in Saudi Arabia and Pakistan and most recently Jordan (in December 2006) indicate a wider distribution and capacity of the strain for further spread.

The regional epidemic can be seen as the emergence of an antigenically distinct virus that breaks through the immunity from the routine vaccination; this is a feature of type A epidemics and similar events have occurred around 5-10 year intervals in the region.

In 2006, as a result of a new FAO project with Iran on virus surveillance, an escalation of a possible new threat caused by a type A variant, and a highly virulent type O virus, was recognised in epidemics that spread in western Iran in the autumn of the year 2006. As a result, FAO issued a warning of spread of these viruses into Turkey, and taken steps to ensure Turkish authorities access to epidemic viruses in order to gauge the need for a further change in vaccine specification.

The difficulty in controlling livestock movement across the borders of Near East countries is a continuing risk; as a consequence of the above epidemic, FAO organised a regional meeting in Iran in June 2006, and a regional roundtable on FMD risk with OIE in November 2006 in Damascus (FAO/OIE 2006).

To reduce the risk of spread from Turkey and Iran, FAO (with EC financial support) supports maintenance

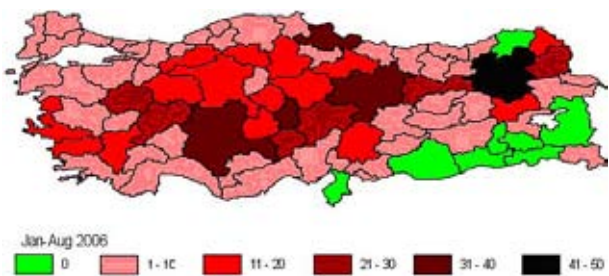
of a buffer zone of FMD vaccination across the south Caucasus (Georgia, Armenia and Azerbaijan); in 2006 no FMD outbreaks were reported, despite significant incidence in neighbouring regions of Turkey and Iran. A revised vaccination strategy was adopted to counter the A Iran 05 threats, with a vaccine reserve (200,000 doses) kept with the FAO supplier.

African FMD type A in Egypt

Prior to 2006, Egypt had not reported cases of FMD (type O) to the OIE since 2000. The national vaccination programme in large ruminants in place prior to 2006 included only type O. In January 2006, outbreaks of FMD were reported which, within days, involved a significant part of the Nile delta region; the index cases occurred close to quarantine stations where animals from Ethiopia were held. Virus typing indicated a type A virus of an African topotype which had not previously been seen north of the Sahara, with high similarity to isolates from outbreaks in Eritrea and related to older viruses from East Africa (Kenya). From the index case and virus type, it is clear that officially imported animals were the likely source, although it cannot be ruled out that infection may have been picked up en route rather than at origin. Since initial reports suspected also the presence of type SAT 2, FAO (EUFMD Commission) sent three missions: one for immediate diagnostic support, which confirmed only type A infection; one that focused on epidemic control measures; and one on scaling up local vaccine production of a homologous type A virus. A request to FAO for vaccine could not be satisfied since vaccine suppliers did not have a suitable vaccine in production and sales to Africa are very limited.

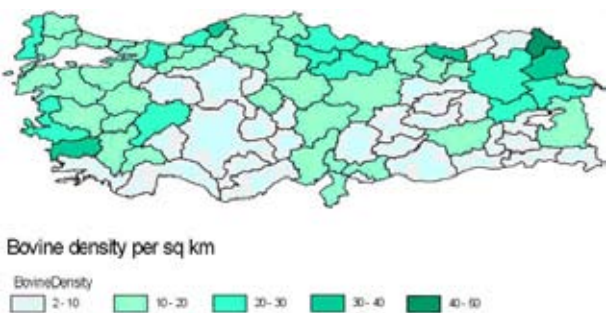
The rapid spread of infection occurred through market movements in January and continued during February and March, causing severe mortality in calves, and affecting all ages, typical of infection in a population

Figure 2. FMD cases by province January-July 2006



Source: map taken from a FAO report

Figure 4. Bovine density



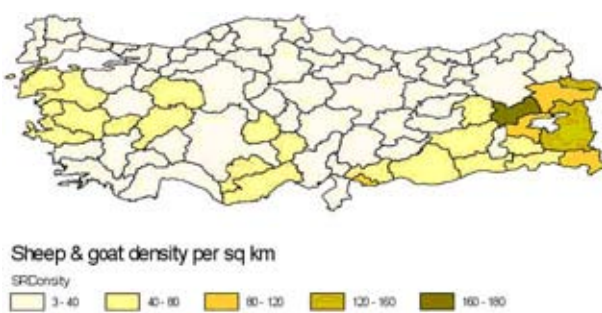
Source: map taken from a FAO report

Figure 3. Livestock movement (blue arrows: cattle; red arrows: sheep and goats movements)



Source: map taken from a FAO report

Figure 5. Small ruminant density



Source: map taken from a FAO report

with no immunity; spread was consequently rapid, and reported in cattle and buffaloes in Egypt between February and April 2006 in the governorates of Alexandria, Behera, Cairo, Dakahlia, Dumyat, Fayum, Ismailia, Kalubia and Menofia (Figure 6). After March, a decline in cases was reported; since the decline occurred before significant type A vaccination occurred, the infection may have been self-limiting as a result of the exceptional speed of earlier spread and by other factors, including higher temperatures. Even if circulation of virus ceased and verification is needed, the high exposure must have resulted in a large number of persistently infected animals acting as a possible source for recurrence of infection.

FAO provided information and advice to neighbouring countries, and additional measures at borders appear to have been successful since type A Egypt 06 infection was not detected in other countries.

As a result of the severe impact, animal importation from Ethiopia was suspended, leading to a major loss in income and a significant reduction in live animal value in that country. The incident serves as warning that virus circulation in sub-Saharan Africa is mostly unrecognised since closely related viruses had not been received by FAO/OIE reference laboratories for 8 years.

The spread of type Asia 1 in Eurasia and Southeast Asia

FMD type Asia 1 is largely limited to South Asian countries, from which periodic, dramatic excursions have occurred into west Eurasia (as far as Greece in 2000) and eastward. These excursions are often short-lived, but severe, as was the epidemic for example between 1999-2002 in Turkey.

In the past three years, a number of previously free countries in central and Far East Asia have been affected, with the most uncertainty and impact relating to infection in China. Since several genetically distinct topotypes of Asia-1 have been isolated in the past three years, the recent spread is considered to involve simultaneous epidemics that have extended their range to affect historically free areas. Dispersed infection in China appears to be the source for far eastern parts of Russia and Mongolia, and Hong Kong SAR.

In Figure 7, the main geographical clusters of Asia 1 infection are shown;

1. India
2. West/central Asia
3. Southeast Asia
4. China

In 2004, extension of infection from Pakistan into Tajikistan introduced the virus into Central Asia; since the same strain was later found in Hong Kong (early 2005) wider infection in China may have occurred. Subsequently, widespread epidemic of a distinct virus, possibly arising from the vaccine itself, were reported in China, with apparent spill-over into Russia and Mongolia. Information on FMD type occurrence in China prior to 2005 is very scarce. The spill-over infections in Hong Kong suggested the predominant problem prior to 2005 was type 0 infection, but given the huge ruminant population and borders with infected countries, the potential involvement of other species is apparent.

The upsurge of FMD Asia 1 virus in a wide geographical area during 2004-5 is not surprising; epidemics arise from primary areas that maintain infection. What is significant is the involvement of the huge ruminant population of China, which previously reported infection

Figure 6. Governorates affected in Egypt by FMD type A in early 2006

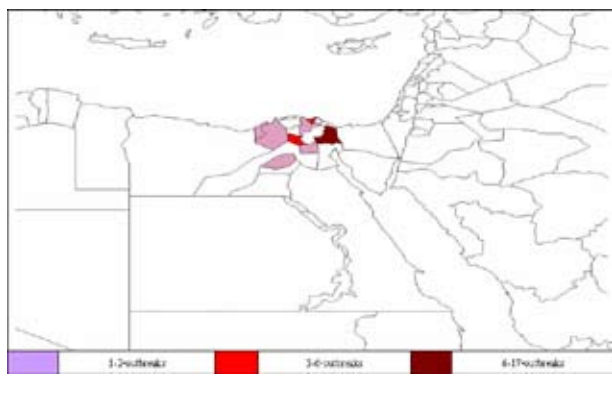
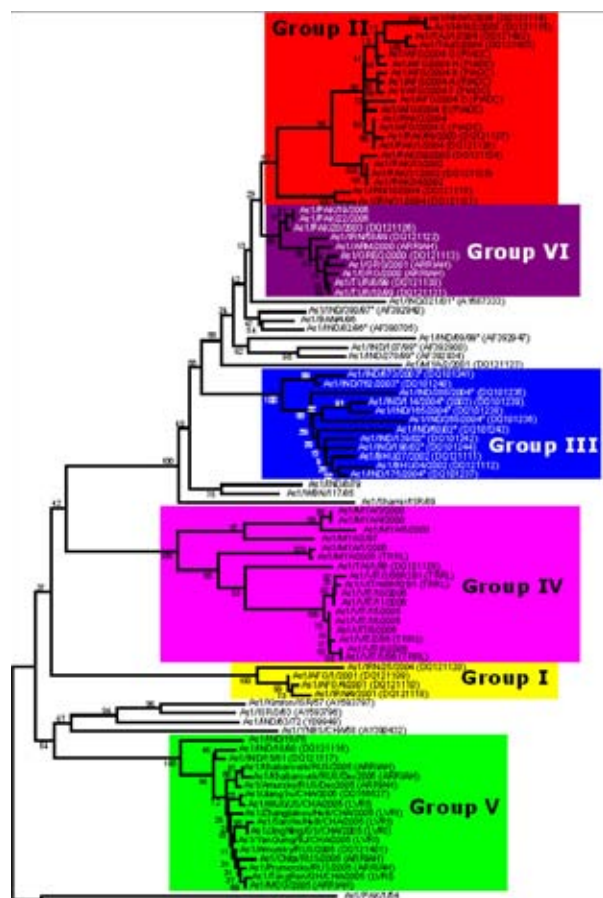


Figure 7. Neighbor-joining tree showing relationships between isolates of FMD Asia 1



Source: Knowles et al. (2006).

only in pigs, if at all. It is unclear if this new incursion of Asia-1 will disappear from China, as it has done from Turkey and Iran in West Asia. The scale of population at risk, which includes species such as buffalo that appear important for persistence, suggests China may have a continuing problem with Asia-1 for some time.

The involvement of South East Asia is also highly significant; this areas has rarely observed Asia-1 epidemics before, with types O and A predominating. The genetic sequence of two Asia 1 isolates (Asia1/VIT/15 & 16/2005) and two isolates from Vietnam were closely related with viruses from Thailand (1998) and Myanmar

(2005) (Figure 7). This lineage could be circulating only in South East Asia and it is different from other lineages spreading through China, India, Pakistan, Mongolia and Russia.

The toptype involved appears restricted to the region, and since the viruses in Myanmar and Vietnam are related, there may be additional populations in the common border region affected or at risk.

Vietnam, Myanmar, Mongolia, Russian Federation (Amurskaya Oblast, Chitinskaya Oblast, Khabarovskiy Kray, Primorskiy Kray), China (Hebei, Jiangsu, Jiangxi, Ningxia, Qinghai, Shangdong, Beijing, Xinjiang Uygur and Xizang Zizhiqu (Tibet), Iraq, Iran (Islamic Republic of), Pakistan, Afghanistan, India and Tadzikistan reported outbreaks of FMD type Asia 1 in 2005-6.

At least six different lineages of FMD type Asia 1 virus have been identified in outbreaks confirmed in Asia (Figure 7 and 8). The identification of these different Asia 1 lineages should help to understand the transmission routes and the origins; separate virus populations can, if proven, lead to area specific control programmes. Since the separate vaccines are not needed against the Asia-1 toptypes, control is simplified, with breaking critical transmission routes the key.

II. SITUATION WORLDWIDE

FMD types O and A are present in South America, Asia and Africa. FAO receives regularly information from its World Reference Laboratory (WRL) (Figure 9). According to virus submissions to the FAO WRL at Pirbright, viruses in the type O pan-Asia toptype remain widely distributed and constitute the most prevalent type O strain; in the late 1990s rapid extension of the range of this virus took place into the Middle East, Europe, North Asia, Southeast Asia and South Africa, and has been responsible for outbreaks in several free countries [e.g. Republic of Korea (2002), Japan (2000), United Kingdom (2001), France (2001) and The Netherlands (2001)].

An upsurge in type O cases in Iran was reported (FAO/EUFMD project) in autumn 2006, with high virulence in affected villages and herds; virus typing indicates extension of a new pan-Asia lineage, again moving East to West. Previous type O epidemics in the Near East, and other areas have occurred when the pan-Asia toptype invaded an area (even where type O vaccination or endemicity was present), or when strains of higher virulence were involved.

Viruses of serotype C now appear extremely rare; the last confirmed case was Kenya in 2005 and the Amazon region of Brazil in 2004. Possibly type C is extinct in the wildlife in 2006, although surveillance in the remaining foci remains poor; some evidence from virus typing indicates that re-introduction of type C vaccines is a distinct possibility, at least in Africa. In 2007, FAO intends to hold an expert meeting on the removal of the remaining risks of type C infection, including cessation in type C vaccination.

a. Situation in South America

The number of outbreaks of FMD in this region has decreased during the last two years and the overall situation of FMD has improved. However, FMD virus appears to persist in some animal populations in

Table 1. Outbreaks of FMD by serotype in South America in 2005

Country	Type O	Type A	Total
Brazil	15	0	15
Colombia	0	1	1
Ecuador	41	27	0
Venezuela	0	2	2

Source: Panaftosa 2005

restricted areas, particularly the Amazon region of Brazil, and parts of the northern Andean countries. Recognising these areas and addressing the factors that have compromised control is critical. These areas provide the probable source for outbreaks in free areas, such as an outbreak of serotype O that was confirmed in October 2005 in the zone officially recognised as "FMD free zone with vaccination" in Matto Grosso, Brazil.

During 2005, 43 outbreaks caused by serotype O and two outbreaks of the serotype A were confirmed in Brazil, Ecuador and Venezuela. Types A and O continue being the most prevalent types in South America.

The last reported outbreak of FMD type C in South America occurred in 2004 in Amazonia, Brazil, after almost 10 years without having been recorded in the American continent. Epidemiological investigation was unable to establish a close relationship with any of the isolates of the PANAFOTSA-PAHO/WHO data bank (maximum sequence homology of 89 percent). Results of the comparison between the isolate C3/Careiro and C3/Indaial/Bra/71 (vaccine strain) showed a genetic difference of 13 percent from the outbreak virus. It is possible that the virus type C virus circulated without detection for more than 10 years although the small size of the animal population in Amazonian would not make an obvious reservoir population. Other possible hypotheses are that the virus could have resulted through an escape from the vaccine industry at some point with sufficient circulation over time thereafter to develop a genetic distance from the vaccine strain.

In Ecuador (serotype O) and Venezuela (serotype A) an increase in the number of outbreaks was observed in 2005. This epidemic wave of FMD outbreaks is the result of lower vaccination coverage than required and the lack of targeted disease surveillance and containment.

b. FMD Situation in Asia

Central Asia

In Afghanistan, FMD is endemic but there is no reliable information on its distribution since surveillance systems are not fully in place and it seems very inefficient. Recently, diagnostic facilities have been upgraded but a regular submission of samples to the laboratory is still to come; however serotypes A, O and Asia 1 are known to be prevalent.

FMD outbreaks have not been officially reported from Uzbekistan since 1991, Turkmenistan since 2000 and Tajikistan since 2004. Pakistan reports outbreaks of FMD every year with serotypes A, O and Asia 1 being more prevalent. FMD infection is maintained within the dairy cattle as the main source of virus.

Table 2. Types isolated in 2005 from samples sent to FAO-FMD World Reference Laboratory

Country	Type O	Type A	Asia 1
China (Hong Kong)	7	-	8
Iran	20	20	-
Malaysia	7	1	-
Pakistan	19	-	2
Philippines	3	-	-
Vietnam	5	-	-

In Pakistan's Punjab region, the risk is considered high since a very high density of animal (23 million buffaloes and cattle) with low vaccination coverage. This region is important because connecting Pakistan with Afghanistan, Iran and the Middle East. FMD virus spread is associated with the unrestricted movement of animals within the region. More recently in Pakistan, an FMD type A has been identified that is genetically related to the A Iran 05 type virus.

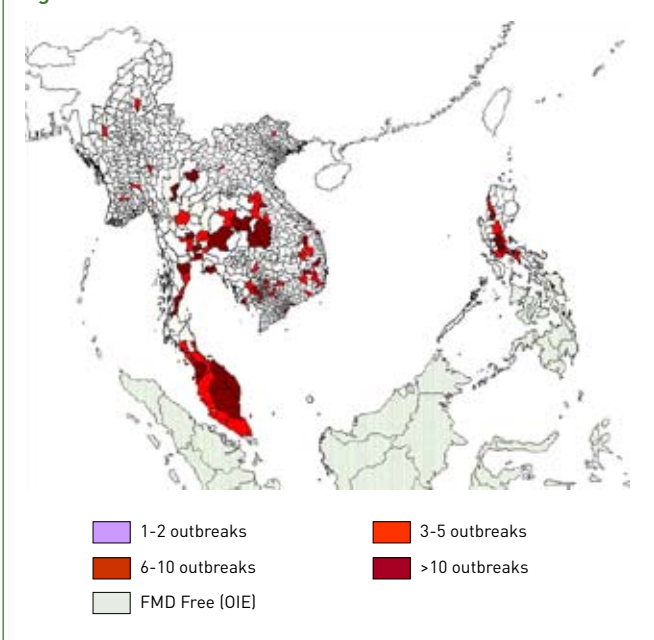
Table 2 shows the isolates identified from samples sent by countries in Asia. Asia 1 was identified in Pakistan and Hong Kong; however serotypes O and A are predominant.

South East Asia

Serotypes O, A and Asia 1 are endemic in seven of the 10 Southeast Asian countries. These are Cambodia, Lao People's Democratic Republic (PDR), Malaysia, Myanmar, Philippines, Thailand and Viet Nam while Brunei, Indonesia and Singapore are free of FMD. It must be noticed that parts of Philippines and Malaysia are also internationally recognised as free of FMD. Serotype O is currently the most prevalent in Southeast Asia followed by serotypes A and Asia 1. The FMD type C was historically endemic in Philippines, but has not been detected since 1995. Serotype C now seems to have disappeared from the sub-region. During late 2005 and most parts of 2006, there was a significant resurgence of FMD in Southeast Asia. Viet Nam experienced an epizootic of FMD with over 800 outbreaks all over the country. The epizootic was predominantly associated with the Cathay toptotype of type O (porcinophilic FMD O virus), but the South East Asia toptotype O was also isolated. FMD serotype Asia 1 has also been reported in Viet Nam but the strain affected cattle rather than pigs and the virus lineage is different from the Asia 1 virus lineage reported in China. The FMD serotype Asia 1 is found in the north of Viet Nam that borders with China and one province in the south bordering Cambodia. The outbreaks are suspected to have originated from unregulated movement of cattle and buffaloes from China and Cambodia.

From mid-2006, several FMD outbreaks were also reported in neighbouring Cambodia mainly due to type O (Cathay and Southeast Asia toptotypes), suspected to have been brought in through importation of pigs from neighbouring Viet Nam. Lao PDR experienced several outbreaks of FMD in late 2006 due to serotype A, which is suspected to have been brought in through movement of

Figure 10. FMD outbreaks in Southeast Asia in 2005-2006

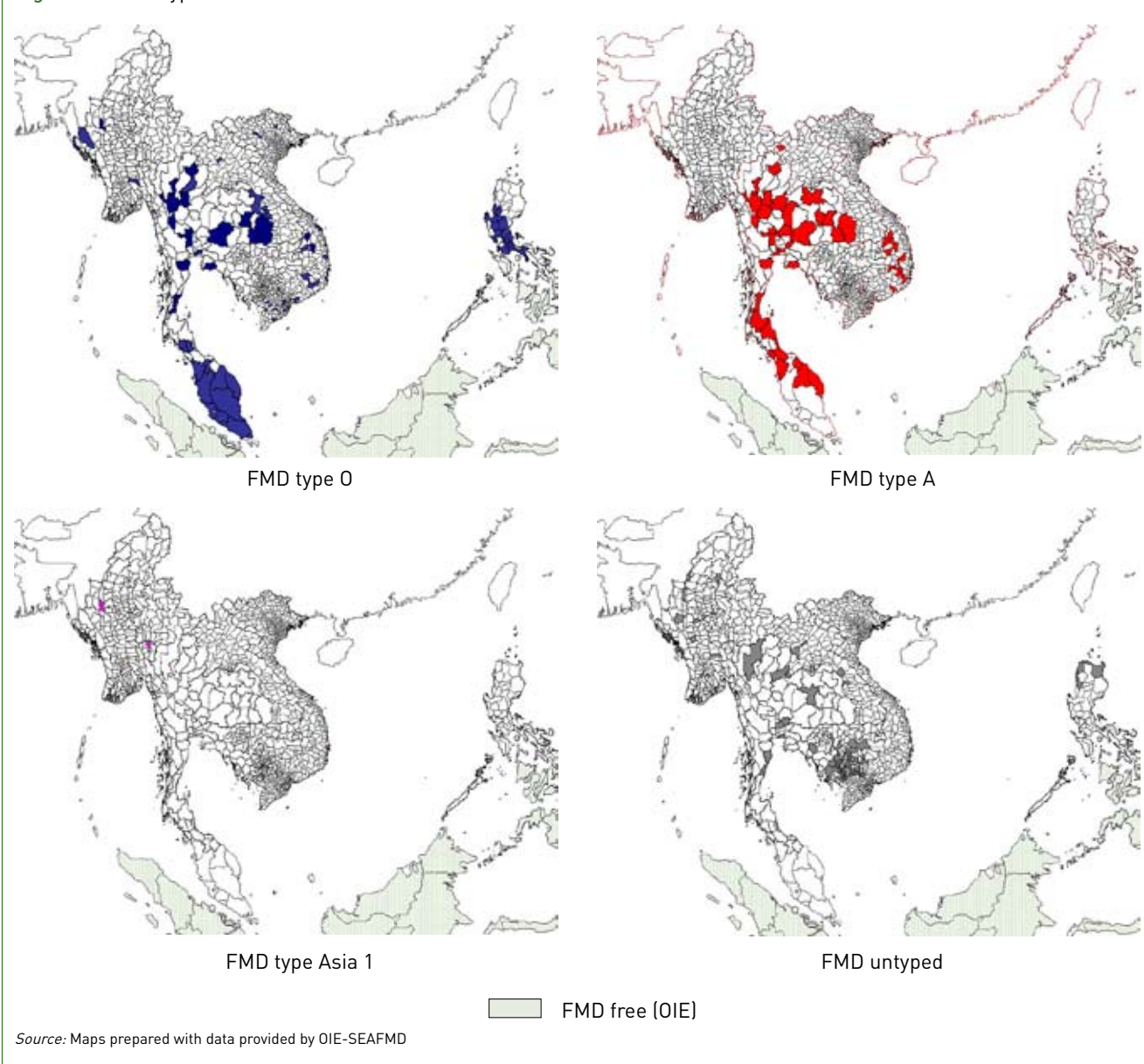


animals from Thailand. Type A has been absent from Lao PDR for several years. Between 2004 and 2006, regions of Malaysia, Philippines, Cambodia and zones of Viet Nam were mostly affected by FMD outbreaks (Figure 10) mainly caused by types O and A, which are prevalent in the Mekong area (Figure 11). Livestock movement (both formal and informal) plays an important role in the spread and epidemiology of FMD. The livestock trade is active and dynamic and predominantly driven by price differential. Currently Viet Nam is experiencing a significant upsurge in cattle and buffalo imports from China, Cambodia and Lao PDR. However, there is also active importation of pigs in Cambodia and Lao PDR from Viet Nam and Thailand. Viet Nam has a pig population of 23 million heads, Thailand around seven million and Cambodia two million.

The FMD situation is dynamic in Southeast Asia. A complete picture of the strains circulating in the region is difficult to obtain since there is under-reporting and a large number of samples taken from FMD outbreaks are either not typed or unsuitable for typing.

FAO is currently implementing the "Control of

Figure 11. FMD types identified in Southeast Asia between 2005 and 2006



Transboundary Animal Diseases in the Greater Mekong Sub region project funded by the Asian Development Bank. Under this project, a sero-surveillance study in the Upper and Mekong area is being carried out. Between March and June 2006, a total of 974 samples from cattle and buffaloes and 483 from pigs were collected from each of the disease control areas in northern Viet Nam, northern Lao and Cambodia. These samples were processed by the Regional Reference Laboratory in Pak Chong, Thailand. In Myanmar, in an extensive surveillance area bordering China and Thailand, the results of sampling indicate that 24% of the sera were positive to serotype O and 6% of serotype A or Asia 1. Data from the Southeast Asia FMD programme confirmed that 51.3% of the outbreaks between 2005 and 2006 were untyped (Figure 11), 19% were caused by type A, 28.8% by type O and 1% by type Asia 1. Regarding species affected, bovines were the most frequently affected species in FMD outbreaks (in 65.7% of these outbreaks bovines were the main species affected); others were buffaloes (20.3%), pigs (12.1%) and small ruminants (1.8%).

Reasons for being unable to identify the FMD type in half of FMD outbreaks in this zone included lack of sampling, samples that were unfit for typing or the impossibility of typing even if samples had been adequately taken.

c. FMD situation in the Middle East

FAO (EUFMD Commission) is implementing a project in Iran aimed at strengthening surveillance for epidemic FMD viruses in Iran (under Phase I), which may be extended to interested neighbouring countries in west Asia and the Middle East in Phase II. This project is in line with other EUFMD Commission actions to strengthen surveillance for FMD in the European neighbourhood region, including Caucasus and parts of the Middle East.

In 2006, this project organised regional meetings on FMD surveillance and control in Teheran in June (FAO, 2006) and in Beirut (with OIE) in November (FAO/OIE 2006), necessitated by the scale of type A epidemics in the Middle East in 2005-6 (reported in the first section).

FMD serotypes A and O are circulating actively in the Middle East. Type O is considered endemic by most Middle East countries. Israel pursues a rigorous vaccination policy, but nevertheless confirmed outbreaks of FMD in December 2005 (and January 2007) caused by serotype O. A specific vaccination response was made in border populations following the type A outbreaks in Egypt in 2006. Palestinian Autonomous territories reported FMD outbreaks caused by type O in Hebron, Gaza and the greater area of Jerusalem in February 2006.

Most countries in the Middle East have adopted a vaccination policy, but vaccine selection has been poorly coordinated in the past and countries tend to respond slowly to change in risk; given animal importation from Africa and west Asia, new viruses remain a threat. Improving early warning will assist, but only if there is a credible emergency plan to carry out the scale of vaccination or other control measures to counter new epidemics. At present, none of the countries in this region has a vaccine bank to assist in the control of epidemic viruses.

Annual meetings of a new regional FMD network are

planned by FAO with OIE to address identified gaps in coordination and planning of FMD control.

d. FMD situation in Africa

Overall situation

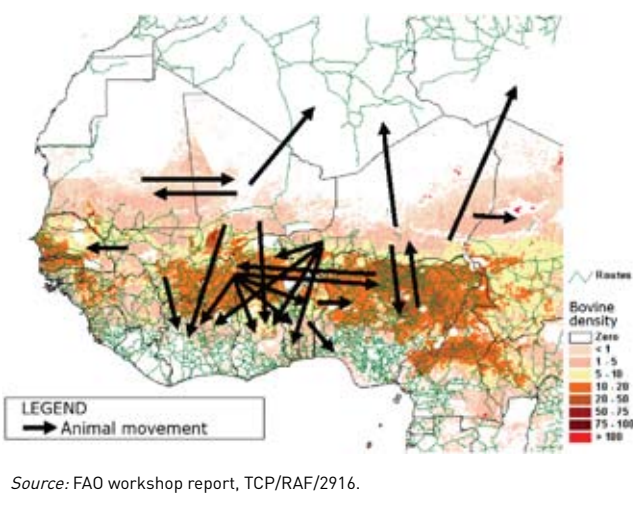
FMD is endemic in most sub-Saharan African countries. It has been effectively controlled in South Africa, Botswana, Namibia, Swaziland and Lesotho, which manage to maintain FMD freedom without vaccination in large zones of their territories through control zones in which vaccination is routinely practised and cordon fences prevent entry into free zones from the wildlife reservoir. The Maghreb countries (Libya and Egypt) have each been affected by incursions from sub-Saharan Africa in the period 1999 to 2006, involving types A, O and SAT2; in the past two years (2005-6), only type A incursion (into Egypt) was reported from the northern African countries, but the scale of problem that occurs highlights the ongoing problem.

Since 2005-2006, only limited official information is available from West and East African countries although FAO has supported several initiatives to provide FMD virus information. In West Africa, types O, A, SAT 1 and SAT2 are considered endemic, and risk zones were mapped in an FAO TCP (TCP/RAF/2916) (Figure 12).

However the spatial and temporal events in virus circulation are not clear; FAO has supported submission of samples from this region to the FAO World Reference Laboratory (WRL) and missions to risk zones to address information gaps. Type O isolates submitted to the WRL in 2005-6 were of the typical West African toptotype, indicating endemic circulation, and a SAT2 isolate from Niger revealed a similarity to the SAT2 virus from Libya in 2003, and to other SAT2 viruses from Cameroon in 2000. The extent, spread and variation of SAT2 across the Sahel is uncertain and requires further work, since this type is antigenically variable, constraining vaccine selection.

Virus type and antigenic diversity in East Africa (Kenya, Uganda, Tanzania) remains high, with types A, O, SAT 1 and 2 being recovered from outbreaks in 2005-6; some molecular evidence suggests additional introduction of SATs from wildlife occur, although the circulation

Figure 12. Commercial movements of live animals in West Africa.



of types O and A in domestic animals is considered the mechanism for persistence in the region. Severe outbreaks associated with type O in Sudan occurred in 2005-6; this country also reported some serological evidence of SAT infection (OIE/FAO Roundtable on FMD control in NENA, 2006).

An FMD epidemic affecting parts of Uganda, Rwanda and the Democratic Republic of Congo (DRC) followed introduction of cattle into Uganda across the Kagera river in 2006; virus typing from the DRC indicated a type O virus. FAO assistance was requested by the three countries and a regional expert meeting immediately convened in Nairobi. FMD is endemic in West African countries and four serotypes have been identified (A, O, SAT-1 and SAT-2). The majority of FMD outbreaks are not notified in a timely fashion due to trade restrictions and pastoral systems where disease surveillance is inadequate and sometimes absent; the transport of sampling material is difficult and expensive, few African laboratories are able to confirm the diagnosis of FMD.

The Great Lake countries of Congo, Uganda and Rwanda are currently experiencing a severe number of outbreaks of FMD type O. This upsurge of cases is explained by the lack of immunity in the animal population and frequent cross border trade. The FMD situation in the Great Lakes countries of Africa is complex, with several types circulating in domesticated animals and wildlife. Transboundary live animal movements are part of the main characteristics of husbandry systems in many African regions and drought conditions and refugee movements across borders have probably increased the risk of the entry and spread of FMD.

In the Democratic Republic of Congo, samples were collected in 2005 with SAT-1, SAT-2, SAT-3 and Type A viruses identified. The last outbreak reported in Malawi (Chikwawa) was in 2003 (SAT-2). In Mozambique outbreaks were recorded in April 2005, in Bobobo M. Ribwe, Nalazi in May, Chicotane in August and J. Nyerere in Gaza Province in September 2003. This was the last FMD outbreak recorded and disease surveillance continues to target the areas at risk. In Tanzania, FMD was reported in 68 out of 121 districts of the mainland during 2004. The 56,610 cases reported included FMD virus types O, SAT 1 and SAT 2.

Table 3 shows the relatively low number of isolates identified from samples sent by African countries to the FAO World Reference Laboratory (WRL), except for Cameroon where types O, A and SAT 2 were identified in 2005.

The outbreak in Zambia was first reported in Namwala and Itezhi-tezhi in July 2004, in Mumbwa (Central Province) in Chibombo, in August 2004, in Monze in September 2004, and, in Nega-nega in October 2004. Prior to 2004, SAT2 and type O were isolated and the same strain was circulating in 2004. In Zimbabwe, more than 300 foci were reported between 2004 and 2005. In Uganda, a recent epidemic of FMD type O was reported in 2006 and this followed the movement of refugees moving with their livestock from Tanzania into southern Uganda, apparently related to spread of a type O virus into Rwanda and Democratic Republic of Congo.

In Kenya, there is a risk of spread of an epidemic of type SAT 1 and SAT 2 to neighbouring areas in Great Lakes countries attributable mainly to uncontrolled

animal movement. The FMD type virus C sequence isolated from the last outbreak in 2004 showed that it is very close to a vaccine strain. Likely wild reservoir species harbouring SAT type viruses in countries of this region makes FMD very difficult to control. In Kenya, as in other part of Africa, the use of vaccines is sub-optimal in relation to the size of population and most of the FMD susceptible animal populations are at risk. In Ethiopia, the serotype C identified in 2005 (Table 3) from the virus isolates was identical to a virus from Ethiopia in 1971.

In the SADC region, South Africa reported an outbreak of type SAT 3 in Limpopo in July 2006. This outbreak occurred in the buffer zone between the FMD free and the FMD infected areas adjacent to the Kruger National Park, therefore this has not affected the FMD free status of this area. The link with infected Kruger National Park African buffalo (*Syncerus caffer*) and cattle could be the source of the outbreak.

An outbreak of FMD in the Central Region (Selibe Phikwe District) of Botswana was confirmed in April 2006 and suspended the status of the 'FMD free zone without vaccination' as recognised by the OIE.

III. PERSPECTIVES

FMD virus still is very active in all continents. FMD-free areas are investing enormous resources to maintain their status to prevent the introduction and potential spread by implementing comprehensive disease surveillance, improving quality of laboratory diagnosis, inspection at points of entry, or educating farmers and travellers. In general, FMD-free areas are well prepared with updated contingency plans for possible incursion and potential spread of FMD virus.

The risk of FMD entry into free areas is low through legal trade of animal and animal products from zones or countries officially recognised as FMD-free by the OIE. However, there is evidence of high volumes of animal products entering free countries by various routes, some of which are likely to carry infection. In 2005-6 most of the international spread of the disease has been attributed to movements of live animals but the risk of movement of meat products remains, and is highest

Table 3. Samples received in 2005 by the World Reference Laboratory for Foot-and-Mouth Disease at Institute of Animal Health, Pirbright (UK)

Country	Type O	Type A	SAT 1	SAT 2	C
Botswana	-	-	-	8	-
Cameroon	25	3	-	54	-
Ethiopia	22	9	-	-	4
Kenya	-	-	1	-	-
Mali	3	-	-	-	-
Sudan	3	-	-	-	-
Togo	4	1	-	-	-
Zambia	-	-	2	-	-

where the recipient countries do not practise strict controls on feeding of waste foods to pigs. Smuggling of animal products is a significant issue and the probable main route of virus introduction into FMD-free areas [e.g. United Kingdom (2001)].

Two factors could explain the upsurge of outbreaks of FMD in some endemic areas worldwide. One factor is the low level of immunity caused by inadequate vaccination strategies (quality, coverage and timing). The other is uncontrolled animal movement and products. Animal diseases such as FMD can only be successfully controlled if there is a strong regional focus and integrated regional strategies to improve biosecurity and regulatory oversight of the movement of animals between and within countries.

The situation of FMD merits better understanding and preparedness of countries that are already infected and the investment of significant resources to control and eradicate this important transboundary animal diseases. The lack of detailed data of FMD outbreaks in Handistatus (www.oie.int) concerning FMD in endemic countries between 2005 and 2006 has created difficulties in risk analysis for FMD. This two-year gap of knowledge regarding FMD disease data generates high uncertainty on the FMD situation in most of those endemic zones where serotypes are still circulating. In this period FAO therefore focused its efforts on gaining information from other sources, including field projects and the tracking and verification of rumours (from the media, ProMED, etc.)

Availability of relevant and effective vaccine against FMD serotypes is a prerequisite for control of this transboundary animal disease in most endemic settings, where the capacity to control through animal movement restrictions and other biosecurity measures is not present. Vaccine quality differs greatly between producers and those procuring vaccine should follow or exceed the OIE requirements for FMD vaccines. In addition, the cold chain system to point of delivery and post-vaccination monitoring applied to measure the impact of vaccination programmes on population immunity are important. At regional or country level, national quality control mechanisms other than the manufacturer of the vaccine can be important in improving quality standards in producers towards OIE requirements. Vaccines should be formulated with knowledge of the circulating virus subtypes but since the risk changes, vaccine banks are increasingly seen as essential for FMD-free countries to ensure supply of vaccine in crisis situations. These are equally relevant for endemic countries or regions, since emergencies can occur in endemic countries faced with new strains.

More efforts need to be placed on FMD epidemiology in endemic settings. The submission rate of virus to reference laboratories remains poor, and for this reason FAO has established a mechanism to support sample submission.

Typing of epidemic strains within epidemiological regions is a prerequisite for FMD control by vaccination. Some many countries are still not using vaccination systematically; virus typing provides additional information that can assist in designing risk reduction strategies. Improving laboratory capabilities for rapid detection of serotypes at regional and national level is

one of the priorities to overcome information gaps and achieve early warning of the emergence of FMD subtypes in different regions.

The development of control strategies against FMD types requires a better understanding of the epidemiology of each type. For instance, determining the role of wildlife reservoirs of FMD virus is essential in some areas such as southern and eastern parts of Africa (types SAT 1-2-3) as is identifying, and on which the ecosystems on which the FMD type persists and circulates. One lesson from Rinderpest eradication is to consider virus persistence, surveillance and control in "ecosystems" whose boundaries are defined by trading partners rather than national borders. Development of an ecosystem approach to surveillance approach and control strategies for FMD in endemic areas was proposed at the FAO/AU-IBAR/PACE meeting on FMD in August 2006 (FAO/AU-IBAR/PACE, 2006).

On the other hand, disease reporting and disease information should be improved from endemic regions for adequate monitoring, evaluation and response. In Africa, for instance, there is a lack of information of the situation of FMD in West, Central and East Africa. In Asia, further and timely information on FMD types in order to identify the geographical foot print and seasonal occurrence of FMD types in Uzbekistan, Kazakhstan, Russia Federation, Tajikistan, India, Pakistan and China is essential and could help to understand the dynamics of Asia 1 spread or even to know whether FMD type C is still circulating or has been eradicated.

IV. FAO ACTIVITIES AND RESPONSE

Improving disease reporting, surveillance, detection, preparedness and rapid response are key elements to tackle epidemics of FMD worldwide.

Since the signing of the Global Framework for the Progressive Control of Transboundary Animal Diseases (GF-TADs) agreement with the OIE, effort has been placed on developing a coordinated approach to global and regional networking to address FMD surveillance gaps, and promote the communication and coordination of control measures. The approach builds on successful models for regional FMD control, such as that coordinated in the European region by the FAO EUFMD Commission. The challenge of FMD control in endemic settings will require active partnerships to overcome the limitations of insufficient epidemiological information from these regions on the basis of which to develop targeted measures, and limited capacity and national resources to apply control measures based on mass vaccination or effective movement control. As a first step, FAO actions are mainly aimed at addressing information gaps needed to develop effective national and regional strategies, and at the same time, when required, assisting in emergency response.

Current initiatives include:

1. Establishment (in 2005) of the OIE/FAO FMD Reference Laboratory network, to produce an annual combined surveillance report and to develop a standardised typing approach in reference laboratories (currently four OIE and two FAO laboratories);
2. Supporting FMD epidemiology through funding

sample collection and shipment to reference laboratories in priority endemic areas (ongoing, using EUFMD and EMPRES funds, mostly for Africa);

3. Establishing active technical networks in the GF-TADS regions;
 - FMD network for European and neighbouring regions (EUFMD Commission; ongoing)
 - FMD network for Near East and North Africa (first meeting in Damascus, November 2006)
 - with AU-IBAR/OIE, establishing regional networks for FMD surveillance and control, in East Africa, West Africa and SADC region
 - with SAARC, promotion of a regional network to support laboratory confirmation and surveillance in the SAARC region
 - with OIE, coordination of actions in Southeast Asia;
4. FAO external quality assurance support for FMD laboratories (ongoing, and contracted to WRL Pirbright);
5. Development of a coordinated research programme with the FAO/IAEA Joint Division on FMD diagnostics and vaccination monitoring

An example of a longstanding and successful partnership in identifying and funding of actions against FMD is that operated by the FAO/EUFMD Commission with funding from the European Commission (EC). In 2006, in response to the dynamic epidemiologic situation, the funding agreement was revised to € 8 million for the period to 2009.

FAO experience in 2005-6 has proved the importance of vaccine banks to rapidly deliver vaccine for emergency control, in days not months; but at present almost no endemic countries have access to these banks, and their capacity is currently limited. Promotion of national, regional or world vaccine banks is needed, and coordination to ensure coverage continually reviewed against risk. Donor agencies or governments could be asked to support the establishment of such an initiative, especially for the least developed countries which are where FMD is typically endemic.

Where identified as a regional priority, FAO is also supporting provision of diagnostic assistance to countries with endemic FMD, including provision of kits for virus confirmation, and support for vaccine matching to identify optimal vaccines for epidemic control.

Global and regional FMD serotype surveillance should be improved by increasing the efforts for sample submissions from regions or countries affected by outbreaks. Since in some primary endemic areas the cost of sample transport is prohibitive, FAO will work with the regional networks to develop an active sample collection and typing programme, and at the same time respond to ad hoc requests for support for shipment. EMPRES has recently launched a dispatch service for sample submission to OIE and FAO reference laboratories and centres for FMD viral analysis and vaccine research. (Contact: Empreshipping@fao.org).

Under the GF-TADs platform, reducing the impact of regional FMD emergencies should be possible, through strengthening the capacity of the regions to recognise and respond to FMD threats. FMD continues to be one of the most important TADs and FAO, with its partners, will

need to seek additional funds to support both regional actions and global coordination. A programme for FMD research, both basic science and applied technical studies, is also required to ensure practical answers to questions such as improving coverage of vaccines against strain variation, and the inclusion of different species in vaccination schedules. These questions will be taken up in the context of an alliance of research and funding bodies (Global FMD Research Alliance and Global Roadmap for development of a tool to control FMD in endemic settings).

V. REFERENCES

- DEFRA.** 2005. International Animal Health Division. Foot and Mouth Disease Virus type Asia 1 in Central and East Asia. An update and commentary.
- FAO.** 2003. Animal Disease Dynamics on the Eurasian Ruminant Street.
- FAO.** EMPRES WATCH. FMD in China. Also available at: http://www.fao.org/docs/eims/upload/191450/FMD_China_EMPRES.pdf
- FAO.** 2006. FAO/OIE/EC Tripartite meeting on control of Foot-and-Mouth Disease and other exotic diseases in the southern Balkans Ankara, Turkey, 17 November 2006. Also available at: http://www.fao.org/ag/againfo/commissions/en/eufmd/event/2006/Final_Rec-TPTAnkara_2006.pdf
- FAO.** 2006. FAO/AU-IBAR/PACE Joint Meeting on Foot-and-Mouth Disease; Regional Co-ordination and emergency control in the African Great lakes countries of Rwanda, Burundi, Democratic Republic of Congo, Tanzania and Uganda. Nairobi, Kenya 3-4 August 2006. Also available at: http://www.fao.org/ag/againfo/commissions/en/eufmd/event/2006/FMD_Meet_Final_Rec.pdf
- FAO,** 2006. Report of the Workshop on FMD virus circulation in Iran and neighbouring countries, held June 2006 in Karaj, Iran. FAO/EUFMD Central Asia FMD Observation project. Also available at: <http://www.fao.org/ag/againfo/commissions/en/eufmd/event/2006/FirstScientificMeetingFMD.pdf>
- FAO/OIE.** 2006. Report of the 3rd Roundtable on FMD control in the Middle-East and North Africa, held Damascus, Syria, November 2006. Also available at: <http://www.fao.org/ag/againfo/commissions/en/eufmd/event/2006/ReportFMDMENA.pdf>
- Knowles *et al.*** 2006. Recent Molecular epidemiology of foot and mouth disease virus Asia 1. EU-FMD Commission.
- J. F. Valarcher, N. J. Knowles, N. P. Ferris, D. J. Paton, V. Zakharov, A. Sherbakov, Shang You-jun, Liu Zai-xin, Liu Xiang-tao, A. Sanyal, D. Hemadri, C. Tosh, and T. J. Rasool.** Recent spread of FMD virus serotype Asia 1. *Veterinary Record*, July 2005; 157: 30.
- OIE.** Handistatus. Also available at: www.oie.int
- OIE-SEAFMD.** Database 2004-2006.
- World Reference Laboratory for Foot-and-Mouth Disease.** 2005. Pirbright. Annual Report 2005.
- World Reference Laboratory for Foot-and-Mouth Disease.** Pirbright. Quarterly Reports. Also available at: http://www.iah.bbsrc.ac.uk/virus/Picornaviridae/Aphthovirus/ref_labs/fmd_ref_lab_reports.htm
- World Reference Laboratory for Foot-and-Mouth Disease.** 2007. Pirbright. Report to FAO, January 2007. Also available at: http://www.iah.bbsrc.ac.uk/virus/Picornaviridae/Aphthovirus/ref_labs/World2006.pdf