Food and Agriculture Organization of the United Nations

NO. 46/2016

empres 360
animal health

ISSN 1564-2615

FEATURES

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EMPRES-ANIMAL-HEALTH@FAO.ORG
WWW.FAO.ORG/AG/EMPRES.HTML

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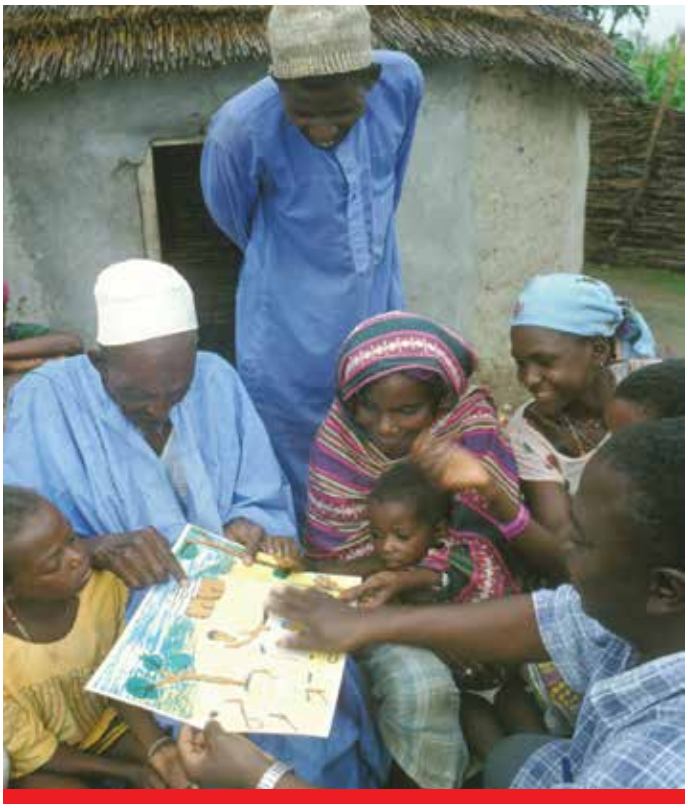

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GUEST EDITORIAL

Broadening scope

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This edition of empres360 reports on African human and animal trypanosomoses. In many ways, the Programme Against African Trypanosomosis (PAAT) represents a forerunner of the One Health initiative. PAAT works across sectors, disciplines, scales and geographic boundaries, while focusing on a composite of sustainable development goals. It is somewhat unusual for an animal health bulletin that concentrates on "emergencies" to pay attention to parasitic or protozoan diseases. After all, infectious diseases are the ones that cause major disease outbreaks and call for immediate attention, while parasites are more likely to be responsible for endemic disease burdens. This situation calls for reflection on the setting of priorities in disease management, within the Food and Agriculture Organization of the United Nations (FAO) and beyond. FAO always seeks to balance emergency response and the need for long-term development efforts. The FAO animal disease portfolio has always featured a mix of infectious disease initiatives, such as those against rinderpest, peste des petits ruminants or foot-and-mouth disease (FMD), along with programmes against African animal trypanosomosis and other parasitic diseases.

In retrospect, the fight against classical infectious livestock diseases has been relatively successful for some time, arguably more so than the efforts against parasitic diseases. A parallel development occurred in the fight against human diseases: the availability of vaccines against well-researched viral and bacterial diseases probably formed a main factor in this success. Rinderpest, contagious bovine pleuropneumonia, FMD, sheep and goat pox, bovine brucellosis, glanders, Newcastle disease, classical swine fever, anthrax and blackleg are among the classical livestock diseases that have started to disappear from a growing number of countries around the world. Gradually, new tools for combating macro-parasites and arthropod vectors have became available, in both the veterinary and human medical fields. The control of river blindness in West Africa, the Roll Back Malaria partnership, and the new world screwworm emergency campaign in North Africa are among the noteworthy late-twentieth-century achievements in both sectors.

However, towards the end of the twentieth century, a counter-force to these achievements became more prominent, changing the global disease landscape forever. A growing number of animal-origin viruses started to infect and spread in humans as viruses were exchanged among the wildlife, livestock and human host domains. With a wildlife sector of more than 5 600 mammal species, 17 or so livestock species and only one human species, the predominant direction of this interdomain virus flow is obvious. Non-human primates, bats, rodents and birds form reservoirs of viruses that cause only inapparent infection in their primary hosts. Humans become infected and clinically ill after direct contact with infected animals, through bushmeat-related practices, bloodsucking arthropods or food and agriculture. The drivers of global disease dynamics are believed to comprise human demographics, pressures on land and water resources, increased mobility, trade and transport volumes, climate change, deforestation and general degradation of natural ecosystems.

Agricultural expansion is a main cause of ecosystem damage, particularly in places where forest is replaced by rainfed crops. The replacement of forest by cropland peaked during the 1990s in Latin America and around 2010 in Asia; in Africa it is projected to peak around 2020 but to remain important until at least 2050. In Asia, livestock or farmed wildlife were involved in most recent virus spillovers from animals to humans: severe acute respiratory syndrome, Nipah, H5N1 avian influenza and other influenza A viruses. The spill-over of influenza is facilitated by the explosive increase in poultry and pig production in China and other Asian countries. An ever-more diverse pool of influenza A virus genes is building up and circulating in humans, swine and poultry. In Asia, food and agriculture systems play an important role in disease emergence, with zoonotic viruses circulating in livestock prior to the jump to humans. In Africa, in contrast, the human immunodeficiency, Ebola, dengue, yellow fever, chikungunya and Zika viruses have all come directly out of the forest to infect humans, so the transmission and disease ecology are accordingly different.

The continuing emergence of animal-origin viruses in humans presents a global health and security risk. For FAO, reducing pandemic threats is a main target, and efforts are currently supported by the United States Agency for International Development. The priority is to build up core veterinary capabilities in the less developed countries where they are most needed, in terms of staff, laboratories and surveillance. In addition, sustained pandemic risk reduction in these settings requires that health protection, food security, natural resource management and opportunities for securing basic income are addressed together. Although international efforts are moving towards global early warning and response mechanisms, novel pandemic threats will continue to emerge unless the livelihoods of the people directly concerned are improved. In many countries the burden of persisting classical diseases is compounded by tropical, arthropod-borne and other infections, helminths and other parasites, which together are responsible for ill-health, hunger and poverty. Hence the need for all development and technical assistance agencies and actors to broaden the scope of their programmes. 360

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PERSPECTIVE

Ecological and epidemiological roles of camels: lessons from existing and emerging viral infections

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INTRODUCTION

Camelids play a crucial role in human communities located in dry, sometimes harsh and even hostile, environments such as deserts or high mountains (small camelids). They provide food (milk, meat), fibre (wool, leather) and draft power (for transportation and cultivation). Their capacity to travel long distances in water-scarce environments is another valuable asset for trade and communication throughout arid and semi-arid ecosystems.

Recently, camelid raising practices have been changing. On one hand, because of urbanization and motorization, traditional cultures that rely on camels and are associated with nomadic, sedentary or partially sedentary lifestyles are facing important changes with the decline of extensive husbandry. On the other hand, because the species can be raised in arid ecosystems and provides food products for millions of people, camel farming (dairy or meat) currently represents a sizeable and growing business, particularly under intensive production in peri-urban zones (Gossner *et al.*, 2016). In the context of climate change, camels also represent a viable option for socio-ecosystems that are facing drier climate scenarios (Faye, Chaibou and Vias, 2012).

Pathogens and diseases related to camelids are less well known than are those of other domesticated species, but have attracted growing attention recently. For instance, several unusual disease incidents caused by *Trypanosoma evansi* or morbillivirus infection, provoking high morbidity and/or mortality rates in dromedary camels (*Camelus dromedarius*), have been reported in the literature. There is increasing need to determine whether camels are clinically susceptible, as potential reservoirs and maintenance or bridge hosts, to viral pathogens affecting small ruminants, cattle and/or humans. Overall, dromedaries seem to be more resistant hosts for bovine, ovine or caprine viral diseases such as foot-and-mouth disease or rinderpest.

The global population of large camelids is estimated to be about 28 million head (excluding Australian "wild" camels), of which 95 percent are dromedary camels and the rest mainly Asian Bactrian camels (*Camelus bactrianus*) (Faye, 2015). The domesticated population of small camelids is about 8 million head. Sixty percent of the world's camels are found in East African countries, which are important exporters of camels to the Arabian Peninsula and Egypt (Figure 1).

This paper focuses on three major viral infections of global concern and sanitary importance for human/animal health. It presents the various roles that camels could play in the epidemiology of these diseases, and identifies the research gaps for better understanding of the health risks represented by this species.

CASE STUDY OF MIDDLE EAST RESPIRATORY SYNDROME CORONAVIRUS

In September 2012, the first case of a human infected by a novel coronavirus, later named Middle East respiratory syndrome coronavirus (MERS-CoV), was identified in Saudi Arabia. By September 2016, 1 806 cases of MERS-CoV have been reported to the World Health Organization (WHO), with at least 643 deaths (case fatality rate: 36 percent), mostly in Saudi Arabia but also touching 26 other countries. MERS-CoV cases directly or indirectly associated with travel or residence in the Near East have been reported from many other countries around the world, but the first large outbreak outside the Arabian Peninsula was recently observed in the Republic of Korea and China, with 189 cases and 36 deaths. It is important to note that the index case in this outbreak had recently travelled to the Near East. Although most documented human infections are nosocomial or, to a lesser extent, within households, dromedary camels are strongly suspected of acting as a zoonotic source for human cases, by either direct contact through droplet infection via mucous membranes or indirect contact through milk, meat or urine of dromedary camels.

At least five arguments suggest that dromedary camels play an important role in

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Camels are used for agricultural work in support of livelihoods

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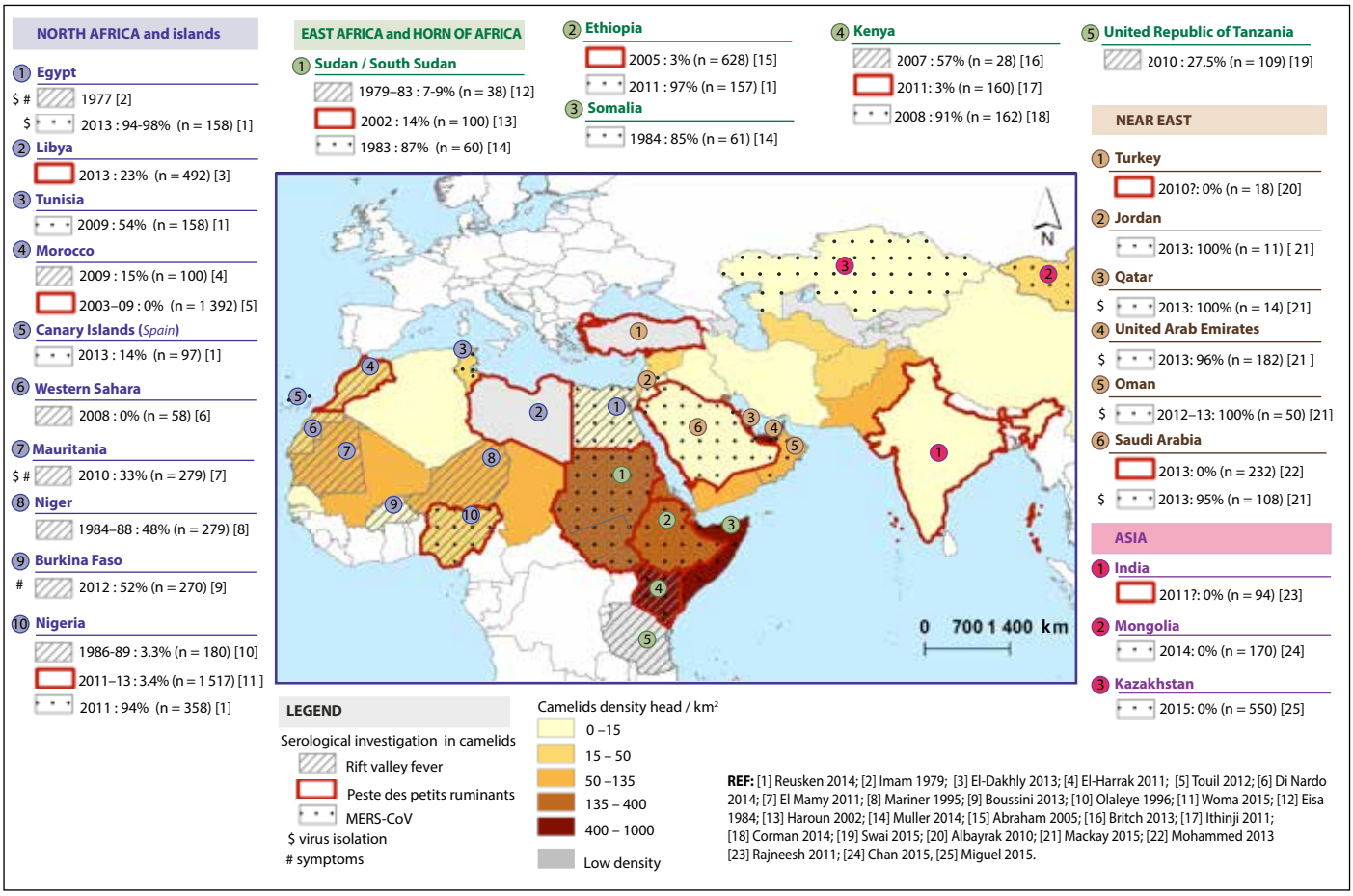

Figure 1: Geographical areas covered by major studies on viral camel infections
Details of all studies are provided in the list of references at the end of this paper. For reasons of space, only the first named author is cited in Figure 1.

the epidemiology of MERS-CoV, possibly as a reservoir host. First, coronaviruses are widespread in the animal kingdom (in bats and livestock), but recent serological screenings indicate that MERS-CoV does not infect the majority of potential animal hosts (e.g. sheep, goats, cattle, chickens, water buffaloes, birds, horses and other camelids such as llamas, alpacas and Bactrian camels) (Reusken *et al.*, 2013; Chan *et al.*, 2015). However high levels of seroprevalence have been observed in dromedary camelids, ranging from 0 percent in Asia to as much as 100 percent in Africa and the Arabian Peninsula, where the mean is 79 percent (Figure 1). Second, the MERS-CoV viruses isolated from dromedaries are genetically and phenotypically very similar or identical to those infecting humans (Chan *et al.*, 2014). Third, retrospective serological studies in Africa going back more than 30 years indicate long-term circulation of the virus in dromedary camels (Muller *et al.*, 2014). Fourth, infection in dromedaries causes no or only mild respiratory symptoms, making it difficult to detect. Finally, Dudas and Rambaut (2015) showed that the MERS-CoV genome has likely undergone numerous recent recombinations, which suggests frequent co-infection, probably in camels, with distinct lineages of MERS-CoV.

Although new research revealed traces of antibodies against MERS-CoV in handlers of indigenous livestock in Kenya in 2013/2014 (Liljander *et al.*, 2016), it is surprising that no locally acquired primary human cases have been reported where humans and dromedary camels are present outside the Arabian Peninsula. Recent workshops on MERS-CoV (Doha in April 2015 and Cairo in May 2015), organized by WHO, FAO and the World Organisation for Animal Health (OIE), have produced recommendations based on research. One of these recommendations is to investigate whether and why MERS-CoV infections of humans do not occur in Africa despite the high levels of infection in dromedaries, and why the virus is apparently absent in camels in Central Asia (dromedary and Bactrian camels, Figure 1). The exact role of dromedary camels as a potential reservoir for MERS-CoV is also still unclear, and further investigations should be carried out to identify the mechanism of virus transmission more clearly. The role of bats – and maybe other micro-mammals such as rodents – should also be investigated. It is now crucial to understand the chain of transmission of the virus among wild/domestic animals and humans and the differences between transmission in Africa and the Arabian Peninsula (where MERS-CoV is now endemic).

CASE STUDY OF PESTE DES PETITS RUMINANTS

Peste des petits ruminants (PPR) virus (PPRV) is a morbillivirus that affects small ruminants. Cattle are susceptible to infection but do not contract the disease or show overt clinical signs. PPR is not a zoonosis; the virus is significantly expanding in small ruminants in Africa, currently spreading from east and central towards southern Africa; the disease is also occurring in Asia, including China. Dromedary camels are known to be susceptible to PPRV (Roger *et al.*, 2001), with an overall serological infection rate of 3.76 percent (n = 3 356) (Figure 1). Most of these studies were conducted on healthy animals. However, outbreaks of respiratory disease with observed mortality of about 7 percent are suspected to be linked to PPRV (Khalafalla *et al.,* 2010). Mixed infections associated with PPRV could also trigger episodes of mortality – the PPRV immunosuppression effect could lead to secondary infections such as with *Streptococcus equi* subspecies *equi* (Yigezu *et al.*, 1997) or bacteria from the *Pasteurellaceae* family. Respiratory syndromes with high morbidity and mortality rates, or mysterious mortalities (Dawo, 2014) occurring in camel populations necessitate better disease outbreak investigations.

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Camels are used for long distance and desert transport

The role of camels in PRRV ecology and PPR epidemiology is largely unknown and the limited information available points to a similar role to that played by cattle or wild ungulate species. PPRV does not appear to be maintained in the camel population alone. Infection in camels may be dependent on concomitant PPRV infection in small ruminants. In Morocco, in regions where there was no PPR in small ruminants, dromedaries were free of antibodies (Touil *et al.*, 2012). However, their susceptibility to PPRV infection raises the question of whether camels have the potential to excrete the virus and, if so, for how long. This might suggest a potential role of camels in the PPR pathosystem in situations where small ruminant populations are below the critical community size to maintain PPRV and the presence of camel populations could result in the creation of a maintenance community; or where the camel population, in interaction with small ruminant populations, could help amplify the virus, increasing the potential for virus evolution and spread. However, up to now, there are no data to support these hypotheses.

The role of camel populations could vary depending on the pathogenicity of the PPRV lineage and strain. Experimental infections with an Ethiopian goat strain of PPRV (CIRAD, unpublished data) in a small number of dromedaries in Dubai did not produce any clinical signs, suggesting that PPRV pathogenicity is low (Wernery, 2011). However, PPR disease is known to be extremely difficult to reproduce experimentally even in sheep and goats with the same degree of clinical signs as seen under field conditions. Wernery (2011) asserts that "there is a need for further infection trials with different PPR strains to elucidate the role of camels in the epidemiology of PPR". PPR is considered a major threat for vulnerable rural populations in the post-rinderpest era in low-income countries. As a consequence, PPR is one of the transboundary animal diseases (TADs) that have been widely considered a priority for eradication. OIE and FAO have recently developed a global strategy for the control of PPR and ultimately its eradication (FAO, 2015;[4] OIE, 2015).[5] The ecological and epidemiological roles of unusual hosts, including wildlife and camels, need to be investigated and addressed in this context (Wohlsein and Singh, 2015).

CASE STUDY OF RIFT VALLEY FEVER

Rift Valley fever (RVF), caused by a Phlebovirus (*Bunyaviridae*) and affecting both livestock and humans, is considered one of the most important arboviral zoonoses in Africa (Chevalier, 2013). The virus is transmitted: i) between ruminants, by mosquitoes and perhaps by direct contact with viraemic blood, abortion products or other excretions and secretions from viraemic animals; and ii) from ruminants to humans, mainly by direct contact but also by mosquito bites. Dromedary camels are susceptible to RVF virus (RVFV) and infections have been recorded in most sub-Saharan African countries, with serological prevalence rates ranging from 3.0 to 51.9 percent depending on sampling period and location (Figure 1). Widespread abortion waves associated with positive serologic test results were observed in dromedary populations during RVF outbreaks in Kenya and Egypt. During the 2010 outbreak in Mauritania, two clinical forms were observed in dromedary camels: i) a peracute form with sudden death within 24 hours; and ii) an acute form with fever, various systemic lesions and abortions. When haemorrhagic signs developed, death usually occurred within a few days (El Mamy *et al.*, 2011). However, mild forms and even a virus carrier state without clinical signs were also described. For instance, RVFV was isolated from blood samples from healthy, naturally infected dromedary camels in Egypt and the Sudan (Eisa, 1984; Imam, El-Karamany and Darwish, 1979) and experimental infections have induced no clinical signs in non-pregnant dromedaries.

Regarding transboundary spread, dromedaries may have brought the virus from north Sudan to south Egypt, where it caused the first Egyptian outbreak in 1977. Dromedary camels enter Egypt officially without any virological investigation and even without a sufficient period in quarantine facilities. A second study showed that RVFV was still circulating in dromedaries in Mauritania when the epidemic was officially declared over (El Mamy *et al.*, 2011).

The potential role of dromedaries as amplifying hosts or virus spreaders therefore remains unclear. Dromedaries may act as amplifying hosts in some areas, but do not seem to be essential to the epidemiological cycle of RVF and its maintenance in all ecosystems. Viral circulation and/or large outbreaks have been reported in "camel-free" countries such as Madagascar or countries in Central and Southern Africa, although the presence of various cycles in specific socio-ecosystems cannot be ruled out. From a zoonotic point of view, it is well known that transmission from cattle/small ruminants to humans occurs via direct contact with viraemic blood or infectious abortion products,

[4] http://www.fao.org/3/a-i4484e.pdf

[5] http://www.oie.int/en/for-the-media/editorials/detail/article/towards-global-eradication-of-peste-des-petits-ruminants/

but there is as yet no specific information about transmission from dromedary camels to humans. It would be worthwhile to explore the sociological and economic impacts of RVF on camel production through a comprehensive approach.

DISCUSSION

The roles of camels in the three viral infections presented are still largely unclear. Filling these gaps in knowledge is important, not only from a public and animal health perspective, but also from a socio-economic one. The cultural and increasing socio-economic importance of camel rearing in some societies makes the human populations involved highly vulnerable to any disturbance to camel health, production and the derived economy. For example, associating camels as a source of a zoonotic disease could put at risk the camel-based socio-economy and camels' viability as a source of livelihood for some populations.

The most important knowledge gap is in the particular role, if any, that camels play in the epidemiology of these viral infections, especially regarding whether they maintain any of the infections. It is important to understand whether camels harbour specific strains or just receive strains from other hosts that are more crucial in maintenance of the pathogen, and the pathological and economic impacts of these infections on camel production. In some ecosystems, the high density of camels may create the conditions for them to amplify viral circulation among other livestock species, thereby increasing the likelihood of transmission to alternative hosts such as humans. Even if the capacity of camels to excrete the virus is small, they may play a role in bridging the gap between maintenance hosts (small ruminants, cattle, bats, etc.) and target hosts (humans, small ruminants). The particularities of camels and the specific culture and associated human behaviour involved in their rearing can create transmission pathways linked to the camelid–human relationship, offering specific routes of spillover for viruses (e.g. among human societies in the Arabian Peninsula and Africa).

As camels are used for trade (in desert caravans in the past, and mainly as live exports for the meat market today), they connect distant human populations and their livestock and may play a role in the large-scale dissemination of viruses if the viruses can survive in the host populations during transport. The oasis systems on which animals and humans rely for drinking-water are thus considered hotspots for pathogen transmission, and favour the exchange of parasites (virus, bacteria) between hosts. Extreme climatic events associated with climate change, which cause long periods of drought followed by short but severe downpours or floods, may also have a severe impact on the health of camel populations, and of humans and other livestock.

Camel movements are considerable but are not properly quantified (Alary and Faye, 2009). For example, estimating the numbers of animals involved and the frequency/seasonality of migratory routes from sub-Saharan countries to northern Africa, from eastern to western Africa, or from the Horn of Africa to the Arabian Peninsula would be a critical element of epidemiological investigations, risk analyses and surveillance implementation. Mapping of camel densities and movements (migration and trade) at finer spatial scales, as has been done for other livestock species, would be important to the design of health management programmes. There is also a severe lack of information on farming practices (herd sizes, grazing and water practices) and lifestyles (nomadic, sedentary and mixed) among human societies in the Arabian Peninsula and Africa.

Monitoring and surveillance systems in the field and at abattoirs should be boosted and are needed for endemic virus investigations (e.g. PPR, RVF), but also to detect new, potentially zoonotic pathogens (e.g. MERS-CoV). They might provide significant information on disease patterns and allow pathogens to be isolated. Cross-sectional studies are generally carried out, but case control and cohort studies are better options for determining and quantifying risk and protective factors.

> "The most important knowledge gap is in the particular role, if any, that camels play in the epidemiology of these viral infectious"

When working with data gaps and frequently small sample sizes, rigorous analysis of the results is needed to depict the real picture. To overcome restraints, well-designed surveillance, monitoring, ecological and epidemiological surveys and studies could provide adequate (representative) and sufficient (of statistical power) data and samples for epidemiology and virology work, including genomic analyses. Exploring the virome of camelids by metagenomics would help improve understanding of the associated pathological conditions and assessment of the risk of emergence and transmission to other species, including humans. Molecular epidemiology and phylogeography could feed hypotheses about the long-distance transportation of viruses. In numerous countries, particularly in Central Asia, epidemiological investigations are not conducted or published, making virus mapping particularly crude.

Serological tests should be developed and adapted to camelids before being evaluated and validated on field samples through epidemiological and modelling approaches such as receiver operating characteristic (ROC) analysis and Bayesian statistics. Bearing in mind the ethical issues, to improve both assess to the clinical effects of viral infection and estimates of specific epidemiological parameters, experimental reproduction should be carried out in premises with high-level biosecurity.

Ecological studies using aggregated data may help to identify drivers and determinants of disease/infection on a broad scale. When joined with spatial multi-criteria decision analyses (MCDAs), such studies would facilitate risk mapping. Modelling could help to explain the role of camels within socio-ecosystems and to forecast the risk of disease extension in time and space by using data on migration and trade. Contact networks at diverse scales among camels, other livestock and human populations should also be modelled using social network analysis (SNA) approaches.

Finally, instead of working at the mono-species scale, it is critical to widen the window and study the global community – domestic and wild animals and humans – within ecosystems (Faye, Waltner-Toews and McDermott, 1999; Caron *et al.*, 2013). There is a clear need for integrated studies that cover health, economic and social issues in the relationships between people and camels and their environments to enable the highlighting and prediction of sanitary risks that new contexts might trigger.

CONCLUSION

Because the ecology and health of camelids are poorly documented, the consequences of global changes regarding dromedary and Bactrian camels are a new focus of scientific attention. The emergence of new pathogens has been increasing recently, most probably because of anthropogenic-related factors (Morse *et al.*, 2012). The camel industry is in transition from nomadism to intensive production on the fringes of growing cities in Middle East, Africa and parts of Asia. These new host densities and the related human–animal interactions create favourable conditions for existing or new viruses to prosper and emergent ones to appear. The position of camels within pathosystems and episystems – as common or unusual hosts, victims or reservoirs for endemic or emerging infectious diseases – requires more attention from the donor and scientific communities. [360]

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PERSPECTIVE

The Programme Against African Trypanosomosis

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This article is based on a presentation at the International Society for Neglected Tropical Diseases, London, United Kingdom of Great Britain and Northern Ireland, March 2015.

African trypanosomoses are a family of parasitic diseases that are unique to Africa, affect both humans and animals and are transmitted by tsetse flies (*Glossina* spp.). The diseases occur across about 9 million km^2 in 39 sub-Saharan countries, corresponding to almost one-third of Africa's total land area. Losses in the livestock sector include deaths, abortions, infertility, weight loss and reduced draught power and milk production, all of which have an impact on people's livelihoods. FAO estimates that direct losses to African trypanosomoses in livestock exceed US$1.5 billion a year. More broadly, trypanosomoses reduce agricultural income by approximately US$4.5 billion a year by limiting or preventing the utilization of land with high potential for agricultural production and by constraining the diversification of crop–livestock production systems. These economic losses are compounded by the impacts of trypanosomosis on human health and by complex socio-cultural and food insecurity dimensions. It is therefore no coincidence that of the 39 tsetse-infested countries, 32 are low-income, food-deficit countries and 29 are least developed countries.

Human African trypanosomiasis (HAT), also known as sleeping sickness, is a devastating and lethal disease that affects mainly isolated populations in rural areas. As a result of reinforced control and surveillance activities, the number of reported HAT cases has decreased substantially over the last 15 years. Nevertheless, in 2012, 70 million people were estimated to be at risk of HAT infection.

The control and eventual elimination of human and animal trypanosomoses would significantly contribute to increased productivity of land and livestock, improved human health and reduced poverty in rural Africa. The Comprehensive Africa Agriculture Development Programme (CAADP) of the New Partnership for Africa's Development (NEPAD) recognizes trypanosomoses as the main constraint in areas that have the greatest opportunities for expansion of livestock agriculture. CAADP also emphasizes the significant role that mixed crop–livestock systems could play in vast areas of the African continent if the burden of trypanosomoses were reduced. Such mixed crop–livestock systems include those of the cotton belt in West Africa and the southern Rift Valley of Ethiopia.

Early and correct diagnosis of trypanosomal infection in livestock is the basis for efficient treatment. Despite the significant progress made in past years in improving disease diagnostic methods, the techniques currently used in the field still suffer from low specificity and low sensitivity. This situation results in drug administration being delayed until treatment is no longer effective, with consequent deaths of animals. Delayed treatment also results in increased losses in milk, meat and draught power and increased infertility.

There is no vaccine against the *Trypanosoma* spp. disease complex. Therefore, along with the control of tsetse vectors, chemotherapy of livestock with trypanocides is by far the most widely used method of reducing the impact of animal trypanosomoses in sub-Saharan Africa. However, resistance to

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A livestock protective fence against tsetse flies, and other vectors and nuisance insects, southern Ethiopia

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Small-scale cattle fattening and beef finishing in a tsetse-controlled area, southern Ethiopia

the veterinary trypanocides currently available is increasing, and no new therapeutic or prophylactic drugs are expected in the next few years. The lack of efficacy of treatment and the development of resistance are exacerbated by frequent under-dosing and/or poor-quality veterinary products with low concentrations of active principle. In addition, trypanosomal infections have an immune-suppressive effect, rendering animals more susceptible to concurrent diseases and/or impairing an effective immune response to vaccination against other diseases (e.g. brucellosis, haemorrhagic septicaemia, foot-and-mouth disease, peste des petits ruminants).

Concerning the human health dimension, correct and timely diagnosis of cases is a key element of the control strategy, which is based mainly on the detection and subsequent treatment of infected individuals. While important progress has recently been made in the treatment of HAT, the tools used for screening and diagnosis have not changed much in decades. In addition, while access to drugs is guaranteed through manufacturers' donations to the World Health Organization (WHO), the lack of funding mechanisms to ensure access to screening and diagnosis is another cause of concern.

Across sub-Saharan Africa, the socio-economic impact of trypanosomoses varies within and among countries, regions and agro-ecological zones. An accurate understanding of the causal relationship between poverty and the development constraints related to trypanosomoses is therefore crucial. Interventions against the diseases and their vectors (tsetse flies) are likely to yield maximum economic returns and growth if adequately embedded in broader national and/or regional policies for the development of livestock agriculture. To this end, it is essential to integrate techniques for tsetse and trypanosomoses control into existing agricultural practices, taking into consideration the overall context of sustainable agricultural and rural development.

Given the geographical scale of the problem and its complex and dynamic medical, veterinary, agricultural, environmental and rural development dimensions, Member Nations of FAO have recognized the need to focus and direct the fight against tsetse and trypanosomoses. For example, in 1997, the Programme Against African Trypanosomosis (PAAT) was established by the 29th FAO Conference (Resolution 5/1997). PAAT provides the umbrella for international alliances and inter-agency collaboration, and its Secretariat comprises FAO, IAEA, WHO and the African Union (AU), through its Interafrican Bureau for Animal Resources (AU-IBAR). Through PAAT, FAO deals with the constraints that trypanosomosis poses to agricultural production, rural development and food security. FAO also hosts the focal point of the PAAT Secretariat. WHO is responsible for managing issues arising from the human form of the disease and the related public health dimensions; various resolutions of the World Health Assembly over the last 15 years have urged WHO to strengthen disease control and to aim at elimination. IAEA is involved through the Vienna-based Joint FAO/IAEA Division, and its main focus areas include disease epidemiology and the development and integration of the sterile insect technique as a component of area-wide integrated pest management programmes aiming at the progressive creation, expansion and maintenance of tsetse-free areas. PAAT's vision is of an African continent where trypanosomoses no longer constrain sustainable agricultural and rural development or threaten human health. Its mission is to assist countries affected by tsetse and trypanosomoses by promoting sustainable agricultural and rural development and human health through partnerships and coordinated efforts.

> "PAAT's vision is of an African continent where trypanosomoses no longer constrain sustainable agricultural and rural development of threaten human health"

Within the remits of their respective mandates and competencies, PAAT members have provided joint technical assistance to countries affected by African trypanosomoses for more than 15 years. PAAT also supports the AU's Pan African Tsetse and Trypanosomosis Eradication Campaign (PATTEC), which was established in July 2000 by a decision of the Heads of State and Government of the Organization of African Unity, now the AU, with the mandate of progressively creating, expanding and maintaining tsetse-free areas.

PAAT is a broad international forum that seeks to bring together all actors concerned with tsetse fly and African trypanosomosis research, control and elimination. It provides expertise on various aspects of tsetse and disease management, and the associated issues of land use, environmental protection and sustainable livestock-agricultural and socio-economic development. The support that PAAT provides to tsetse-affected countries translates into coordinated actions and collaboration at the international, regional and national levels. PAAT also engages with research organizations in applied research and development activities.

Recent achievements of PAAT have included the development and application of novel technologies for improved animal health and production and of internationally agreed standards for the quality control of trypanocidal drugs.

The novel technologies that have been developed and promoted include the livestock protective fence (LPF), which involves the simple but innovative use of insecticide-impregnated nets to protect livestock. The technology is capable of doubling and in some cases tripling milk outputs on smallholder dairy farms, while also reducing mosquito-borne illnesses in

humans. The nets are environmentally safe and they drastically cut the numbers of flies, mosquitoes and other disease-transmitting insect vectors by up to 90 percent. Cases of mastitis, which can be spread by flies and poor hygiene during milking, can also be halved on smallholder dairy farms. Smallholder pig farmers using LPFs in a coastal area infested by tsetse flies in Ghana substantially reduced trypanosomosis prevalence in their pigs and the associated mortality of piglets. Pig farmers using LPFs also obtain higher prices for their animals on the market. Careful management and monitoring of the expanding use of LPFs will be required to avoid the rapid development of resistance in certain populations/species of insect and arthropod.

Activities to promote the quality control of trypanocidal drugs include the establishment of an international alliance among FAO, the World Organisation for Animal Health (OIE), the Global Alliance for Livestock Veterinary Medicines (GALVmed), IAEA, the International Federation for Animal Health (IFAH) and the University of Strathclyde in the United Kingdom of Great Britain and Northern Ireland, and the development of knowledge and analytical procedures on quality control and quality assurance of trypanocides for publication in an international scientific journal (Sutcliffe *et al.,* 2014). This knowledge is being applied in two laboratories – the *Laboratoire de Contrôle des Médicaments Vétérinaires* (LACOMEV) in Dakar, Senegal, and the Tanzania Food and Drugs Authority (TFDA) laboratory in Dar es Salaam, United Republic of Tanzania – which now serve as reference institutions for their respective regions.

In Senegal, IAEA is supporting a project that aims to eradicate an isolated population of *Glossina palpalis gambiensis* in the Niayes area, near Dakar. The removal of trypanosomosis will eliminate the need for constant prophylactic treatment of cattle with trypanocidal drugs, thereby reducing residues of these drugs in the animals' dung, meat and milk. The main beneficiaries of the project are many smallholder farmers, larger commercial farms and the consumers of meat and milk. After eradication of the tsetse fly, farmers will be able to replace their local breeds with improved breeds and increase their annual income by €2.8 million (Bouyer *et al.,* 2014). At the same time, the cattle population will be reduced by 45 percent, which will result in reduced environmental impacts.

Concerning HAT, WHO provides support and technical assistance to national control programmes to strengthen disease control and surveillance in endemic countries. Access to treatment is ensured through public–private partnerships with Sanofi and Bayer HealthCare, which enable WHO to supply all the required anti-trypanosome medicines free of charge. The efforts of WHO, national control programmes, bilateral cooperation partners and non-governmental organizations have made elimination of the disease as a public health problem by 2020 a possible target. In 2014, WHO established a coordination network for HAT with a view to strengthening and sustaining efforts for disease elimination.

The PAAT Information System (PAAT-IS) is a key component of PAAT that plays a crucial role in health surveillance at the continental level by integrating data on humans, livestock and vectors. PAAT-IS comprises a range of open-access resources, including maps, technical and scientific monographs and a biannual bulletin focusing on news and scientific advances in the field of tsetse and trypanosomoses. Two internationally coordinated data management initiatives are ongoing within the PAAT-IS framework: the atlas of HAT and the atlas of tsetse and African animal trypanosomosis (AAT).

The atlas of HAT was launched in 2007 by WHO and is jointly implemented by FAO with the support of WHO Member Nations (Simarro *et al.,* 2010). Its primary objectives are to map, at the village level, all cases of sleeping sickness in endemic areas of sub-Saharan Africa and all screening activities (from 2000 onwards), and to build capacity at the country level for optimal utilization and regular updating of the atlas (Cecchi *et al.,* 2009). The main outputs of the initiative are maps of HAT distribution and risk at the continental, regional, national and focus level (Simarro *et al.,* 2010; 2012a; 2015), as shown in Figure 1. Other products include continental maps of health facilities involved in HAT treatment and surveillance (Simarro *et al.,* 2014) and global maps of HAT in non-endemic countries (Simarro *et al.,* 2012b). The atlas of HAT has become an authoritative

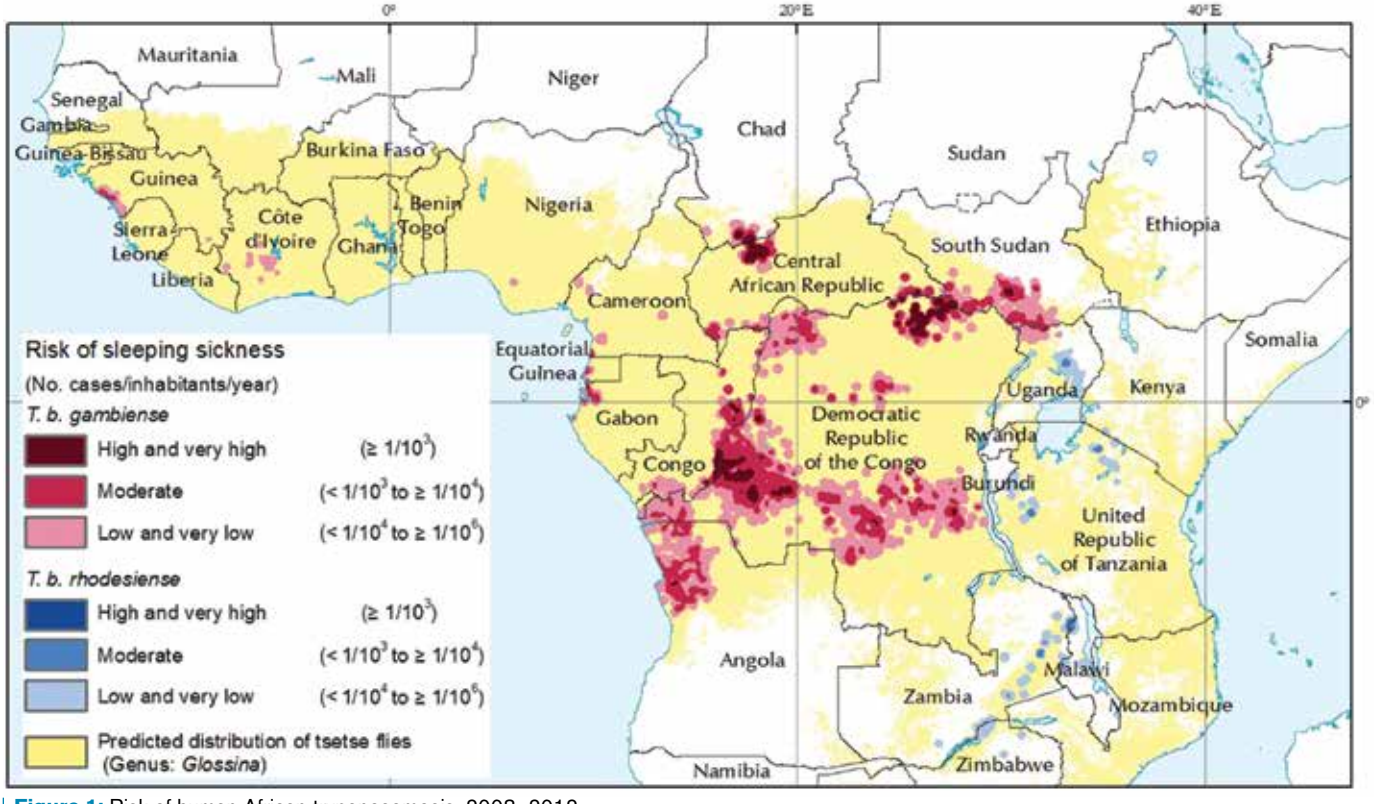


Figure 1: Risk of human African trypanosomosis, 2008–2012
Source: Adapted from Franco *et al.,* 2015.

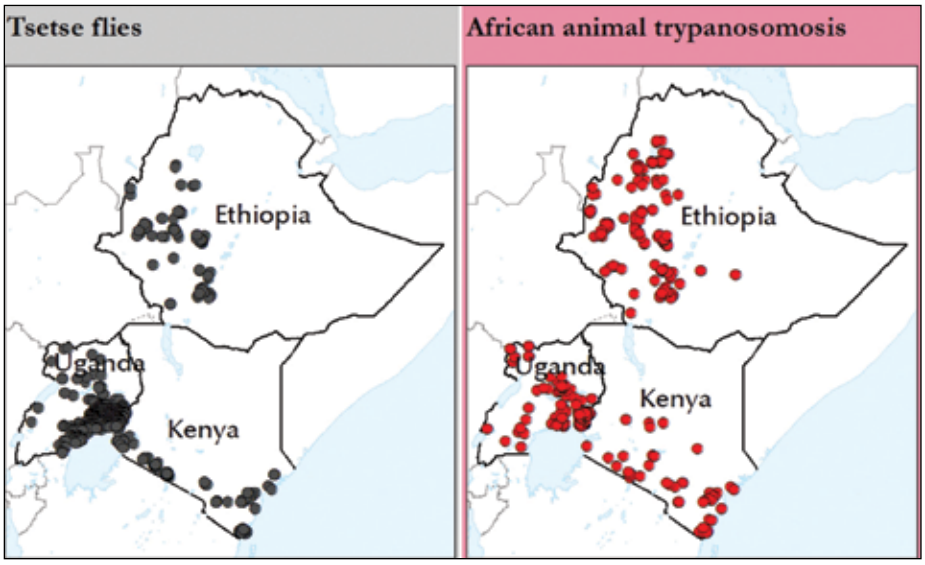


Figure 2: Reported occurrence of tsetse flies (Genus: *Glossina*) and African animal trypanosomosis in Ethiopia, Kenya and Uganda, as published in the scientific literature
Data collected January 1990 to December 2014.
Sources: Adapted from Cecchi *et al.*, 2014 and 2015.

Further information on the various initiatives

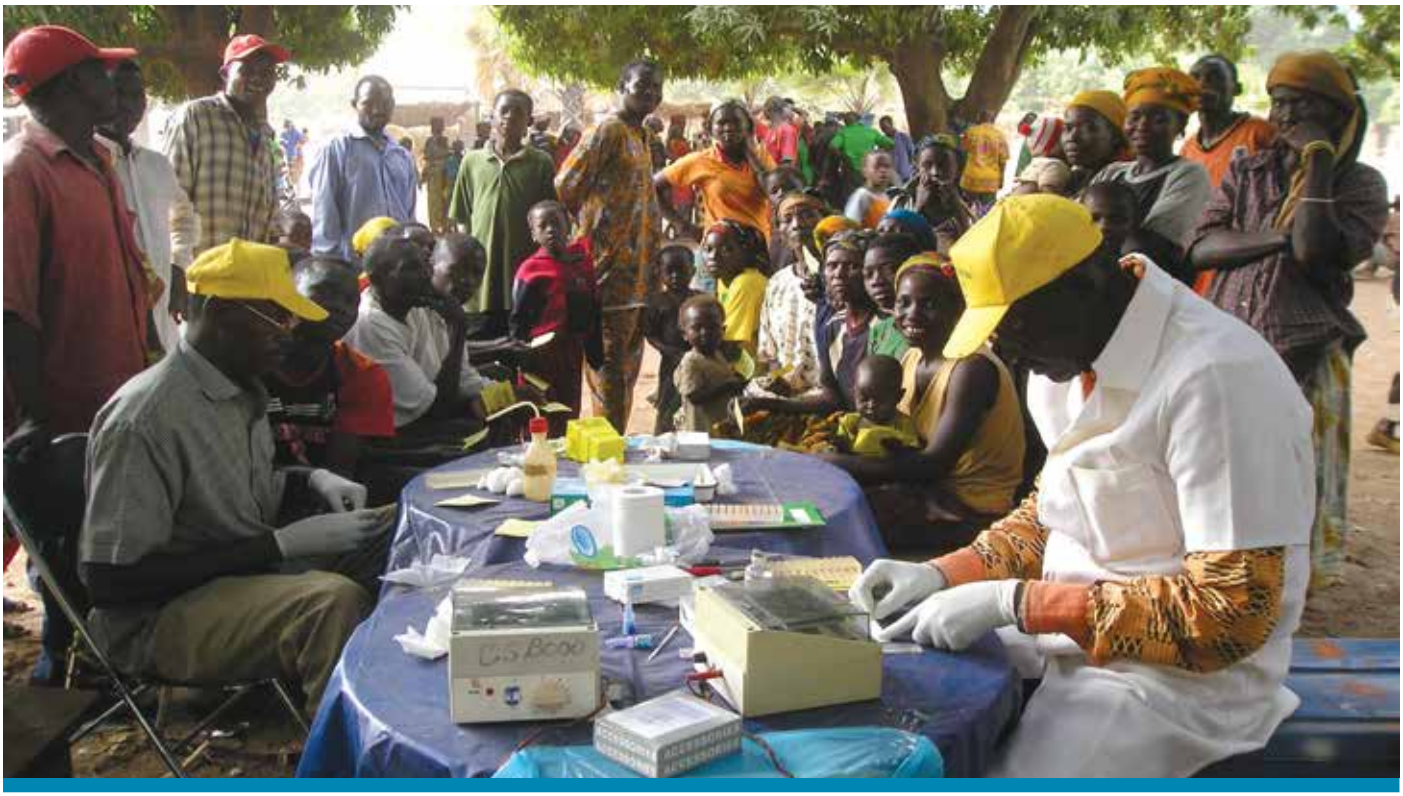
- *Programme Against African Trypanosomosis (PAAT)*
- *FAO/IAEA Programme: Insect Pest Control*
- *World Health Organization – Human African trypanosomiasis*
- *Pan African Tsetse and Trypanosomiasis Eradication Campaign*

reference for all practitioners, scientists and policy-makers involved in the control and elimination of HAT. It also represents an indispensable tool for planning, implementing and monitoring HAT elimination activities.

In 2010, the success of the HAT atlas motivated FAO to launch the atlas of tsetse and AAT, which aims to collate, analyse and disseminate comprehensive and up-to-date information on the occurrence and distribution of tsetse and AAT. This is a FAO-led initiative jointly implemented with IAEA in support of AAT-affected countries. At the continental level, the atlas relies on data published in scientific journals, which are extracted, georeferenced and inserted into a database. Methodologies and preliminary results for Ethiopia, Kenya and Uganda have recently been published (Cecchi *et al.,* 2014; 2015), and are summarized in Figure 2. In addition to the continental atlas based on publications, FAO and IAEA support affected countries in building national atlases, which rely on the sometimes vast amounts of unpublished information available at the national level.

Geospatial information from the atlases of HAT, tsetse and AAT also enables integrated epidemiological analyses of the human, livestock, vector and environmental components.

Capacity building is another essential activity carried out through PAAT. Over the years, hundreds of staff members from trypanosomosis-affected countries have been trained in different aspects of tsetse



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Identifying cases of human African trypanosomosis in a rural area of Chad

Training of staff from affected countries in better management of the African trypanosomosis problem

and trypanosomosis control and elimination. Expertise is drawn from the United Nations (UN) specialized agencies and other PAAT partners, and the PAAT framework ensures harmonization and maximization of synergies.

Beyond its specific technical achievements, PAAT also facilitates effective inter-agency collaboration within the UN system and with other international institutions, which can be a powerful force for innovation and development. [360]

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ADVANCES

Field Epidemiology Training Programme for Veterinarians:

strengthening disease intelligence on emerging and transboundary animal diseases

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THE NEED FOR EPIDEMIOLOGY

Over the past decade, experiences of dealing with avian influenza and other high-impact animal and zoonotic diseases in Asia have demonstrated that national veterinary authorities have often been forced to take difficult decisions about disease prevention and control in their countries without having access to essential epidemiological information. In some instances, before the veterinary services at the central level have conducted any investigations, the local authority has already given instructions for culling and disposing of diseased livestock, resulting in the loss of opportunities for collecting and disseminating epidemiological information to guide evidence-based decision-making. There is a critical need for improved disease intelligence in every country in the region.

Infectious disease intelligence is based on an understanding of epidemic patterns, including animal and zoonotic diseases, and the application of this knowledge to disease control. Disease intelligence is the result of: i) rapid and accurate identification of the disease agent; and ii) a clear understanding of the sample and its epidemiological context (animal, place and time parameters). Over the past decade, progress has been made in strengthening technical capacity and resources to build more effective epidemiological support and to improve disease intelligence. However, there are still very few qualified epidemiologists available. Without good-quality epidemiological information, it is not possible to determine the protective and risk factors associated with the frequency and distribution of diseases in a population of animals (or humans).

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FETPV trainees conduct outbreak investigations under mentorship

ESTABLISHMENT OF THE FIELD EPIDEMIOLOGY TRAINING PROGRAMME FOR VETERINARIANS

In 2008, the Emergency Centre for Transboundary Animal Disease Operations (ECTAD) at FAO's Regional Office for Asia and the Pacific (RAP) started to implement a systematic approach to assess and develop epidemiology capacity in the region. Having forged strong partnerships with Thailand's Department of Livestock Development and Ministry of Public Health, FAO established a regional Field Epidemiology Training Programme for Veterinarians (FETPV). Contributing partners included the United States Agency for International Development (USAID) and other international donors such as the European Union (EU), the United States Centers for Disease Control and Prevention (CDC), the International Epidemiology Consortium, universities and participating countries in the region. FETPV is now a growing branch of the Field Epidemiology Training Programme (FETP) model run by national public health agencies in 55 countries since 1975.[3]

The FETPV process starts with a consultative needs assessment involving country experts and national and international stakeholders and including a gap analysis of the 34 skills covered by the guidelines of the Training Programs in Epidemiology and Public Health Interventions Network (TEPHINET), adapted to veterinary needs. Based on the results of these assessments, curricula and learning objectives are designed for the national and sub-national levels, enabling countries to drive their own harmonized approaches to capacity development. The four main elements of the FETPV curriculum are: i) understanding of basic epidemiological

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An FETPV trainee collects samples and field data as part of an outbreak investigation

concepts and application of these concepts for: ii) surveillance; iii) outbreak investigation; and iv) communication of results to technical and non-technical stakeholders.

APPROACH AND CURRICULUM

The FETPV applies the principle of learning by providing services, which makes no distinction between learning about and working in epidemiology. Trainees both serve as they learn and learn as they serve in their respective governments' core functions related to animal health and production. For example, since its inauguration in 2009, the regional FETPV curriculum has undergone several revisions following rigorous and comprehensive periodic evaluations. Currently the curriculum is divided into three inter-related and sequential modules.

The programme begins with a one-month introductory course on epidemiology, which is organized jointly by the FETPV and the FETP and is based on collaboration between animal and human health. During this introductory course, veterinarians and doctors are trained together, exposing them to the similarities and differences in epidemiological approaches to disease prevention and control and helping them to appreciate and respect each other's professionalism and ethics. The first two modules, on surveillance and outbreak investigation, take approximately a year and a half to complete. Trainees learn about and apply epidemiology through a curriculum that is 30 percent training workshops and field demonstrations and 70 percent practical fieldwork.

> "82 percent had used their new knowledge to inform or mentor colleagues, thereby improving the collection, management and analysis of data"

Trainees who complete the first two modules are then eligible for the third module, which is a Masters programme offered jointly by FAO and two universities in Thailand with M.Sc. programmes in epidemiology or related fields; the Masters programme takes one to two years to complete. At this stage, in line with the principle of learning by providing services, trainees apply their epidemiological knowledge and skills to conduct field research at their home stations, supporting the functions of their respective institutions while under the close supervision of mentors from universities, the FETPV, FAO and the government units for which they work.

IMPACTS AND THE WAY FORWARD

By September 2015, 107 people in 12 Asian countries had benefited from the regional FETPV. In a survey conducted in April 2015, 84 percent of respondents reported that knowledge gained through the FETPV had led to changes in their approaches to epidemiology at work: 90 percent indicated improvements in the implementation of outbreak investigations; 75 percent indicated improvements in the design, implementation and reporting of surveillance; 82 percent had used their new knowledge to inform or mentor colleagues, thereby improving the collection, management and analysis of data; and 23

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FETPV trainees design and deliver questionnaires in order to assess risk factors for disease occurrence

percent considered that their career paths improved after participating in the training.

The regional FETPV has been recognized by the Association of Southeast Asian Nations (ASEAN) as a platform for strengthening epidemiology capacity in the region and was a major catalyst in the development of ASEAN's Strategic Framework for Veterinary Epidemiology Capacity Development and Networking (the Epi Framework), which was endorsed by ASEAN Ministers in 2013. The Epi Framework is complemented by establishment of the ASEAN Veterinary Epidemiology Group (AVEG). This recognition of the regional FETPV demonstrates its high-level political support and helps ensure that it has regional ownership and is sustainable.

A country-specific FETPV has been established in China. After joining the regional FETPV in 2009, China adopted the principle of learning by providing services and applied a similar approach to establish a national-level FETPV, which was launched in November 2010. The two-year programme, comprising a series of workshops and field-based training courses, has so far trained three cohorts of a total of 53 veterinarians from provinces and municipalities. The growing China-FETPV network has become a significant national platform for emergency response and animal health activities in China. The programme has provided government agencies with field veterinary epidemiologists who can respond effectively and rapidly to animal disease events. For instance, China-FETPV trainees played significant roles during recent national responses to outbreaks of avian influenza A(H7N9) and peste des petits ruminants (PPR), and recommendations from their investigations have influenced government policies on these diseases. The China-FETPV network has been described as a "national treasure", demonstrating the impact that it has had in a relatively short period.

Indonesia has also indicated the need for a national FETPV, following successful participation of Indonesian trainees in the regional FETPV since 2009. The country is carrying out a needs assessment to identify the core competencies, skill sets and resources required to establish and maintain such a programme. Based on a roadmap drawn up by core national stakeholders in June 2015, the first training course will be launched as the official inauguration of the Indonesia-FETPV in September 2016.

> "One of the most difficult challenges in developing this applied epidemiology training programme was in building institutional safeguard to enable trained individuals to apply their skills when they return to their workplaces"

One of the most difficult challenges in developing this applied epidemiology training programme was in building institutional safeguards to enable trained individuals to apply their skills when they return to their workplaces. For example, four assessments of epidemiology capacity conducted in 2014–2015 estimated that national epidemiologists spent a maximum of 20 percent of their work time performing technical epidemiology duties directly related to their training. The return on training investment so far remains limited and requires additional institutional prioritization, accommodation and change. Each country needs a plan for linking the training to the post-training environment to obtain maximum benefits from the training of individual epidemiologists. Enhancing both the number of trained individuals and the quality of the training will be necessary to improve the targeting of investments and optimize outputs.

There is growing realization among countries in the region of the value of the FETPV as national programmes continue to develop. At this early stage, it is important to demonstrate the proof of concept, to facilitate high-level commitment from national authorities. The mentorship programme requires dedicated technical support from trainers and mentors with a good technical background in epidemiology, practical field experience, familiarity with government functions and the skills to nurture the valuable national human resources assigned to the programme. Building a critical mass of mentors is a key to success, so it is important to continue strengthening FETPV graduates – as potential future mentors – to ensure that they have opportunities to apply their acquired skills at work and to support their fellow trainees. In the 2015 survey, between 9 and 47 percent of regional FETPV graduates reported various institutional challenges when applying their epidemiological knowledge at work. Institutional change is challenging but necessary to build, maintain and foster the development of a functional epidemiology capacity in the region. [360]

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ADVANCES

A laboratory information management system for Africa

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The control of most animal diseases relies on rapid, accurate and reliable laboratory diagnosis, among other factors. The efficiency of work processes in the laboratory, and therefore the speed and reliability of testing, can be greatly enhanced through the use of an electronic laboratory information management system (LIMS). Such software facilitates the tracking of samples from the collection point through testing and any advanced investigations to reporting, and maintains historical data. It also reduces the potential for manual errors downstream of initial data entry. In addition, the accreditation of a laboratory to International Organization of Standardization (ISO)/International Electrotechnical Commission (IEC) Standard 17025 to support international trade requires an efficient LIMS. By standardizing laboratory diagnostic processes and sample tracking, an electronic LIMS is therefore an excellent tool for managing quality assurance and quality control and can also facilitate the laboratory accreditation process. The use of an LIMS can also facilitate the exchange and monitoring of information among laboratories within a country or region and between laboratories and their disease response partners.

FAO TOOLS FOR LIMS SELECTION AND IMPLEMENTATION

An LIMS is a significant long-term investment that will have an impact on the vitality of the laboratory for many years after its installation. The process for selecting an LIMS should therefore be rigorous and based on a strong commitment to achieving the optimal outcome.

Given the multiple benefits of LIMS, FAO has developed an LIMS assessment tool (available on request) to help laboratories and their partners assess their requirements for an LIMS and select a system that matches their data needs and workflows. This tool provides a structured approach to defining requirements specific to each laboratory in major categories such as the operating system; case, sample and test management; and laboratory workflow. The resulting list of requirements can then be used to assess candidate LIMS and compare the offers of different vendors. FAO has also developed a roadmap for LIMS implementation (Figure 1), which serves as a guide to the necessary steps and phases for implementing a successful and fit-for-purpose LIMS. These products were introduced to participants at an FAO workshop on "Laboratory Information Management Systems: Identifying Needs, Resources, and Ways Forward" conducted with 11 Asian countries in Thailand in December 2011. Workshop participants then applied them to their own laboratory needs.

IMPLEMENTATION OF A LIMS FOR AFRICA

The *Sistema Informativo dei Laboratori* (SILAB – Information System for Laboratories) for Africa (SILABFA) is an Italian-designed LIMS that has been implemented in several African national veterinary laboratories since 2010 (Box 1). The system was developed by the *Istituto Zooprofilattico Sperimentale dell'Abruzzo e del Molise Giuseppe Caporale* (IZSAM – Experimental Institute for the Prevention of Animal Diseases of the Abruzzi and Molise Giuseppe Caporale), Teramo, Italy under a bilateral cooperation programme between

Box 1: SILAB for Africa

Since 2010, SILABFA has been implemented in the national veterinary laboratories of Botswana, Namibia, the United Republic of Tanzania, Zambia and Zimbabwe. Ethiopia, Tunisia and Uganda have officially requested its installation in their national veterinary laboratories.

FAO has provided support through the following activities:

- SILABFA was installed in all sections of the Botswana National Veterinary Laboratory (BNVL) in 2012 and was linked to Botswana's Livestock identification and traceability systems (LITS) in 2014, so that data inserted into one system are also automatically available in the other system.
- SILABFA was installed in the central Tanzania Veterinary Laboratory Agency (TVLA) in 2013 (Box 3) and connected to two of its six zonal offices (provincial laboratories).
- A mission to assess the feasibility of implementing SILABFA in Uganda was conducted in 2014 using the FAO LIMS assessment tool in collaboration with the National Animal Disease Diagnostics and Epidemiology Centre (NADDEC). The potential for linking SILABFA and FAO's EMPRES Global Animal Disease Information System (EMPRES-i) Event Mobile Application (EMA), implemented in Uganda since 2013,[1] is being assessed. Such a linkage would allow more rapid identification and notification of outbreaks.

[1] http://www.fao.org/in-action/new-mobile-application-proves-essential-to-uganda-veterinarians/en/

[1] Food and Agriculture Organization of the United Nations (FAO)

[2] *Istituto Zooprofilatico Sperimentale dell'Abruzzo e del Molise Giussepe Caporale* (IZSAM)

Box 2: Ten steps to SILABFA implementation

1. Official request by a country.
2. Laboratory pre-audit, using the FAO LIMS assessment tool.
3. Project and agreement signed with the country.
4. Installation of server and local area network (LAN) in the laboratory.
5. Installation in pilot section(s) of the laboratory.
6. Training of local administrators, receptionists, technicians, etc.
7. Customization of the LIMS to laboratory needs and specificities.
8. Expansion to other laboratory sections and/or zonal offices.
9. Provision of a help-desk service from Italy via remote access to the African laboratory's server.
10. Annual audits/follow-up visits.

Italy and Namibia and is a Web-based system based on SILAB, which IZSAM uses for its own laboratory management requirements. In November 2011, the Southern African Development Community (SADC) recognized the benefits of SILABFA and recommended its adoption by national laboratories in the SADC region.[3] Regional interest in the system has continued to grow, with other African countries requesting the installation of SILABFA, becoming actively involved in the project and even investing their own resources in it. Box 2 describes the steps towards SILABFA installation and implementation. Given the good feedback from pilot countries, the interest expressed by several other countries and the strong partnerships established between IZSAM and African laboratories, FAO has supported the establishment of SILABFA in additional countries (Box 1). This support aims to strengthen the overall management and quality of laboratory information at both the national and regional levels. Since 2012, IZSAM has used the FAO LIMS assessment tool in all its assessment missions prior to SILAB installation.

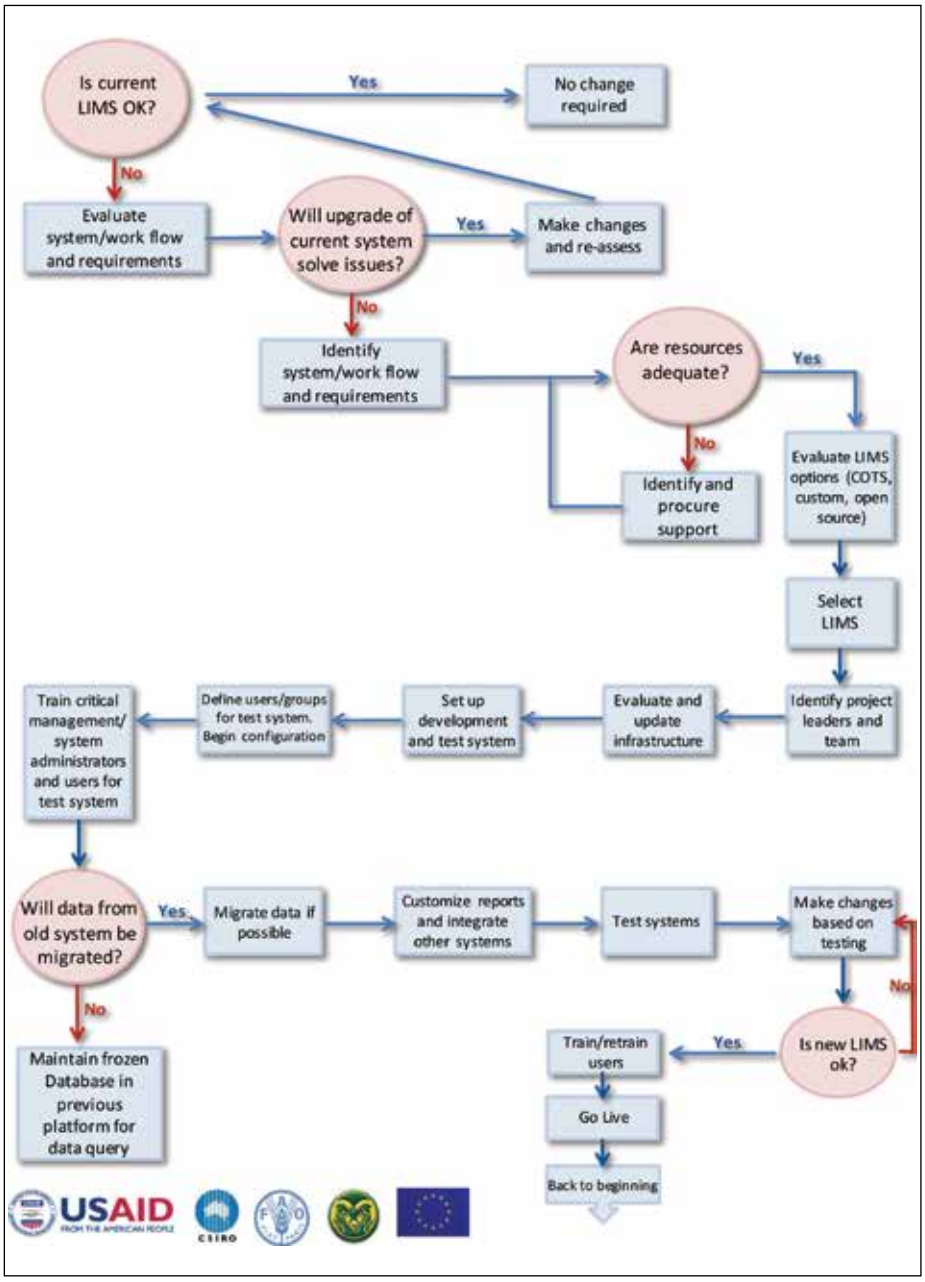

Figure 1: Roadmap to LIMS implementation

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SILABFA in the United Republic of Tanzania

[3] http://www.fao.org/ag/againfo/programmes/en/empres/documents/docs/SADC_2011_Recommendations.pdf

Figure 2: Screen shot from SILABFA

SILABFA is innovative because it has been adapted to African veterinary laboratory settings; can be customized to individual laboratories; and – in many aspects – can be managed directly by an internal administrator (without specific expertise in information technology), using a specially designed form to collect any additional information required for epidemiological reasons. SILABFA is compliant with ISO/IEC Standard 17025 and allows for faster turn-around times, automation, increased productivity, and stricter quality control of data and electronic reporting, with final test reports produced automatically and printed or sent directly by e-mail. The standardization and harmonization of the database language, which uses uniform names, codes and metadata for each entity (species, materials, tests, etc.), fosters data consistency and can facilitate the linking of SILABFA to other databases.

INTEGRATION WITH NATIONAL DATABASES

SILAB is easy to customize and can be connected to external databases such as national tracking systems or mobile applications. It has been linked to the livestock identification and traceability systems (LITS) in Botswana since 2014 (Box 1) and in Namibia since the end of 2015, and the potential for doing so in the United Republic of Tanzania has been examined (Box 3). Connecting SILABFA to an LITS can improve animal health surveillance and certification and enhance export procedures for livestock and livestock products.

Box 3: Benefits of LIMS in a laboratory in the United Republic of Tanzania

Since 2013, SILABFA has been successfully implemented at the Tanzania Veterinary Laboratory Agency (TVLA) in four pilot units: Sample Reception; Pathology; Bacteriology; and Animal Science. A dedicated server for SILABFA has been installed in a safe room, with an information technology expert provided by the Veterinary Services assisted by a specially trained staff member from TVLA. A SILABFA administrator has been appointed and all staff in the pilot units have been trained to use SILABFA. A remote connection from Italy to TVLA provides a daily help-desk service and responds to requests for customization to TVLA's settings. TVLA staff have extended the system to all other laboratory sections of TVLA in Dar es Salaam. The previous, paper-based system has now been almost totally replaced (being used only during power outages), and all TVLA units use SILABFA for their day-to-day work.

SILABFA has also been implemented in two TVLA zonal offices (Arusha and Iringa). In January 2014, TVLA signed an agreement with an Internet service provider on making SILABFA accessible via the Internet as well as through the internal LAN. This new feature makes SILABFA available to the zonal offices through a direct connection to the TVLA headquarters server, without requiring local installation. These developments have facilitated the transmission of information on samples from the provincial to the central level. Future developments will include the installation of SILABFA in the other four zonal offices (Dodoma, Mwanza, Tabora and Mtwara).

The linkage of SILABFA to the Tanzania Livestock Identification and Traceability System (TANLITS),[1] which was developed with FAO support, has been discussed and agreement reached on retrieving data from the TANLITS database, which includes information on establishments (farms, villages, livestock markets, slaughterhouses) and animals of three species: cattle, sheep and goats. These data provide information on livestock identification and registration – farm and location, owner/keeper and address, animal breed and sex, etc.; animal movements – farm of origin, farm of destination, animals involved, date of movement, reason for movement, etc.; and animal health events – treatment, vaccination, test results, etc. TANLITS includes a Geographic Information System (GIS) application that visualizes the locations of establishments and the movements of animals, which will help to define zones or enforce bans on animal movements in disease outbreaks. To connect TANLITS to SILABFA, the database codes of SILABFA will be realigned with those of TANLITS, so that each animal sample and establishment of origin has one code in both databases.

[1] http://www.animaltraceabilitysolutions.net/-/tanzania-established-the-national-animal-identification-and-traceability-tanlits-by-using-the-ats-platform-

An LIMS is part of the continuum of animal health data systems; it provides a bridge between field data and epidemiological analysis. With a well-functioning LIMS, national veterinary diagnostic laboratory activities will be better integrated with epidemiological surveillance systems. The implementation of a common LIMS in several countries of a region harmonizes and optimizes the development and implementation of individual LIMS, and can facilitate integrated animal disease control at the regional level, in line with the Regional Laboratory Network approach that FAO has been supporting in Africa.[4] 360

[4] http://www.fao.org/ag/againfo/programmes/en/empres/news_260914b.html; http://www.fao.org/ag/againfo/programmes/en/empres/news_201213b.html

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ADVANCES

Epidemio-surveillance and mapping of transboundary animal diseases and zoonoses at the wildlife/livestock/human interface in Zimbabwe

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In recent years, following outbreaks of infectious diseases that include severe acute respiratory syndrome (SARS), pandemic influenza H5N1, dengue haemorrhagic fever, Middle Eastern respiratory syndrome (MERS), Chikungunya, Zika and Ebola viruses' the global community has become increasingly aware of the threat of emergence or re-emergence of diseases at the human/livestock/wildlife and environment interface. It is estimated that about 60 percent of known human infectious diseases originate from animals, while 75 percent of emerging human pathogens are zoonotic, with most coming from wildlife (Jones *et al.,* 2008; Taylor, Latham and Woolhouse, 2001; WHO, 2007). The fact that more than 70 percent of new and emerging diseases originate in animals calls for a deeper level of cooperation between the animal and human health sectors at the national and international levels (WHO, 2007).

In Southern Africa, humans and animals have increasingly been competing for limited habitats. Human encroachment into virgin territories not only introduces more vectors and reservoirs of infection to new hosts, but also leads to human/livestock/wildlife conflicts at this highly mobile interface. Animal populations are being pushed into constricted areas, creating geographic zonation that is detrimental to wildlife populations, and altering the structure of animal communities (Patz *et al.,* 2004; Williamson and Williamson, 1981; Taylor and Martin, 1987; Harris *et al.,* 2009; Ferguson and Hanks 2010; 2012; Gadd, 2011; Scoones *et al.,* 2010; Cozzi *et al.* 2013), disrupting natural migratory paths in the process.

The formation of transfrontier conservation areas (TFCAs) or "Peace Parks" ensures joint cross-border management of natural resources among neighbouring countries, while facilitating movement of people and wildlife within a mosaic of protected areas, rural and urban development, subsistence agriculture, and regional infrastructural and economic development, enhancing livelihoods and conserving Africa's wildlife heritage and natural resources. Zimbabwe hosts parts of five main TFCAs: Lower Zambezi–Mana Pools, Mapungubwe–Limpopo/Shashe, Chimanimani, Great Limpopo and Kavango-Zambezi. Disease surveillance studies at the livestock/wildlife/human interface have been carried out where the Great Limpopo (GL) TFCA straddles the borders of Mozambique (Limpopo National

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Driving giraffes with a helicopter

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Restraining an impala

Park), South Africa (Kruger National Park) and Zimbabwe (Gonarezhou National Park), joining together some of the most carefully preserved wildlife areas in southern Africa into a vast conservation zone of 37 572 km² (about the size of the Netherlands) that has one of the world's richest concentrations of wildlife.

In addition to hosting parts of southern Africa's major TFCAs, Zimbabwe has national parks (NPs) and national wildlife protected areas (NWPAs) at Hwange, Gonarezhou, Chirisa, Chizarira, Mana Pools, Matusadona, Mavuradonha and the Save Valley Conservancy, where livestock, wildlife and humans coexist, sharing natural resources such as land, food and water. While these large tracts of land earmarked for mixed conservation and development have enormous potential in connecting wildlife populations and enhancing the integrity and viability of protected areas, they also create substantial intersectoral challenges, with transboundary diseases causing potential flashpoints (Bengis, 2005; DeGarine-Wichatitsky *et al.,* 2012). Many of these multiple-use areas straddle international borders, often in regions of high FMD endemism. Various animal and human disease pathogens and vectors such as ticks, tsetse flies and mosquitoes commonly circulate at the interface between wildlife, domestic animals, humans and the environment. Lumpy skin disease (LSD) and zoonoses such as rabies, brucellosis, bovine tuberculosis (bTB), Rift Valley fever and anthrax have been confirmed in both wildlife and livestock for many years in Zimbabwe (Caron *et al.,* 2013).

FMD, bTB and theileriosis are known to be shared between domestic cattle (*Bos taurus*/*B. indicus*) and the African buffalo (*Syncerus caffer*). African buffaloes that are sero-positive to bTB have been identified in GL-TFCA (Masterson *et al.,* 2014). The free movement of buffaloes from northern Kruger in South Africa into the Zimbabwean portion of GL-TFCA is of major concern regarding not only the potential of spread of bTB to buffalo herds within Gonarezhou NP, but also the impact of the disease on a relatively small and unstable predator population. It is important to note that while an intact, hard-edge fence barrier separates buffaloes in Kruger National Park from cattle on the South African side of the Limpopo, the situation on the Zimbabwean side of the river is characterized by a far more intimate interface and intermingling between cattle and buffaloes, which poses a serious threat of transmission of the disease to communal cattle herds, with subsequent entry into the human food chain (Masterson *et al.,* 2014).

The most recent FMD outbreak, which occurred in Zimbabwe in April 2015 and eventually came to an end in January 2016, was thought to have been caused by cattle/buffalo contact in Masvingo Province in GL-TFCA. Other studies have confirmed the presence of RVF, brucellosis and theileriosis in buffaloes (Caron *et al.,* 2013). A review of the epidemiology and control of rabies in Zimbabwe concluded that rabies virus isolates from domestic and wild canids, such as jackals, are phylogenetically similar and capable of crossing species (Sabeta, Bingham and Nel, 2002). These studies confirm the presence of important transboundary and zoonotic diseases at the livestock/wildlife/human interface in Zimbabwe's major TFCAs and NPs, presenting a high risk of infection in both animals and humans.

Integrated small-scale farming and livestock systems are the main sources of subsistence and cash income for an estimated 80 percent of rural communities in Zimbabwe according to:

- the 2016 National Budget Statement "Building a Conducive Environment that Attracts Foreign Direct Investment";
- the Poverty, Income, Consumption and Expenditure Survey (PICES) 2011/2012 report;
- the Zimbabwe Vulnerability Assessment Committee (ZimVAC) 2015 report;

- the Zimbabwe Agenda for Sustainable Socio-Economic Transformation (Zim. Asset) 2013–2018;
- the Comprehensive Africa Agriculture Development. Programme (CAADP) Zimbabwe Agriculture Investment Plan (ZAIP);
- the 11th National Indicative Programme 2014– 2020 of the European Development Fund;
- the Zimbabwe Country Programme Framework 2016–2020;
- the Zimbabwe United Nations Development Assistance Framework (ZUNDAF) 2016–2020.

The research studies into TADs and zoonotic diseases previously mentioned have found that small-scale livestock enterprises are at higher risk of infection with, and spread of, these diseases, with serious consequences for livestock production and productivity and for human health (Caron *et al.,* 2013; 2016). For instance, bTB is a controlled animal disease that can be carried and transmitted by an array of mammalian species but for which cattle and buffalo are the most important reservoirs in southern Africa. Being closely related to human tuberculosis, bTB is not only transmissible to humans, but also has similar disease progression and outcomes in humans and animals. bTB is therefore a significant zoonosis in pastoral communities with high prevalence rates of HIV infection and malnutrition, two important epidemiological risk factors for humans in the NPs and GL-TFCA (Masterson *et al.,* 2014).The Zimbabwe country office of the Food and Agriculture Organization of the United Nations (FAO) is currently supporting a study under an FAO Technical Cooperation Programme project (TCP/ZIM/3502) and a livestock project that is funded by the European Union (EU) (GCP/ZIM/022/EC) and being implemented in the two districts of Nkayi and Lupane in Matabeleland, North Province. A survey will be conducted to assess the prevalence of economically important TADs, and geomatic information tools will be used to develop a disease distribution atlas for Chirisa and Chizarira NWPAs and Hwange NP, which are adjacent to the two project districts. The disease maps and atlas that are being produced will document the distribution patterns of important vectors and disease pathogens. Once completed, the atlas will be a tool for animal health workers and wildlife management staff to support the prevention, identification, reporting and management of critical animal diseases of economic and zoonotic importance.

The two projects also aim to train hunters and NP personnel in disease surveillance, safe wildlife capture techniques and sampling. Farmers living adjacent to the wildlife protection areas will receive training on disease recognition and participatory surveillance, and animal health workers will receive training in pen-side disease screening, sampling, sample packaging and preservation. The Central Veterinary Laboratory (CVL) will benefit from enhanced testing and diagnostic capacities in the form of laboratory equipment and reagents for carrying out laboratory screening and confirmation of the diseases, including the IFN-γ (gamma interferon) enzyme-linked immunosorbent assay (ELISA) test for bTB. The laboratory will also be equipped to undertake microscopic examination of blood and blood parasites, particularly *Theileria* species. Human health workers will receive targeted training in the management and prevention of critical zoonoses – including bTB, rabies, anthrax, RVF, brucellosis and helminthiases – through improved livestock husbandry, personal hygiene and disease prevention skills based on the "One Health" approach. This training will enrich their understanding of the aims of animal health programmes and the principles that are applied.

Ticks are important vectors for animal and zoonotic diseases such as ehrlichiosis, anaplasmosis and tick bite fever caused by *Rickettsia africae* species in southern Africa. Under the FAO and EU projects, ticks will be collected from cattle and small ruminants at selected communal dip tanks for enumeration, identification and testing for pathogen carriage. In wildlife areas, the dragging technique will be used to sample ticks from grass, and blood and tissue samples will be collected from selected wildlife animal species such as lions, buffaloes and other wild ungulates. Up to 40 African buffaloes will be darted from a helicopter and immobilized with highly potent narcotics. Opioids such as etorphine (an immobilizing drug) and azaperone (a tranquillizer) will be used to start with. For animals that appear too deeply sedated or that have severe respiratory depression, butorphanol may be administered intravenously as a partial opioid antagonist (reversal drug). After sampling, the opioid antagonist Diprenorphine (M5050) will be injected into a vein in the animal's ear (De Garine-Wichatitsky *et al.,* 2010; Masterson *et al*., 2014). Drugs, rifles and helicopter services will be procured through the FAO project for use by trained wildlife veterinarians and hunters, including FAO veterinarians and wildlife experts at the FAO country office and Subregional Office for Southern Africa.

Control of TADs and zoonoses at the wildlife/livestock interface in the area bordering the two districts of Nkayi and Lupane and adjacent communities will ensure improved and sustainable livestock production and productivity, resulting in increased household income and better livelihoods. Livestock keeping is critical for small-scale farmers living in and adjacent to TFCAs in southern Africa, not only from a socio-economic point of view but also from a public health perspective. In these communities, HIV prevalence is often high, and consequences of the immunosupression of human populations – such as higher susceptibility to zoonoses – are likely (Giller *et al.,* 2012; Lloyd-Smith, Poss and Grenfell, 2008). In addition, poor and/or difficult access to health facilities increases the impact of diseases in human populations. The presence of RVF and brucellosis in cattle and the risk of spillover of bTB to cattle from buffaloes increase the risk of transmission to humans. A holistic approach to animal and public health surveillance and control at the wildlife/livestock/human interface will be an

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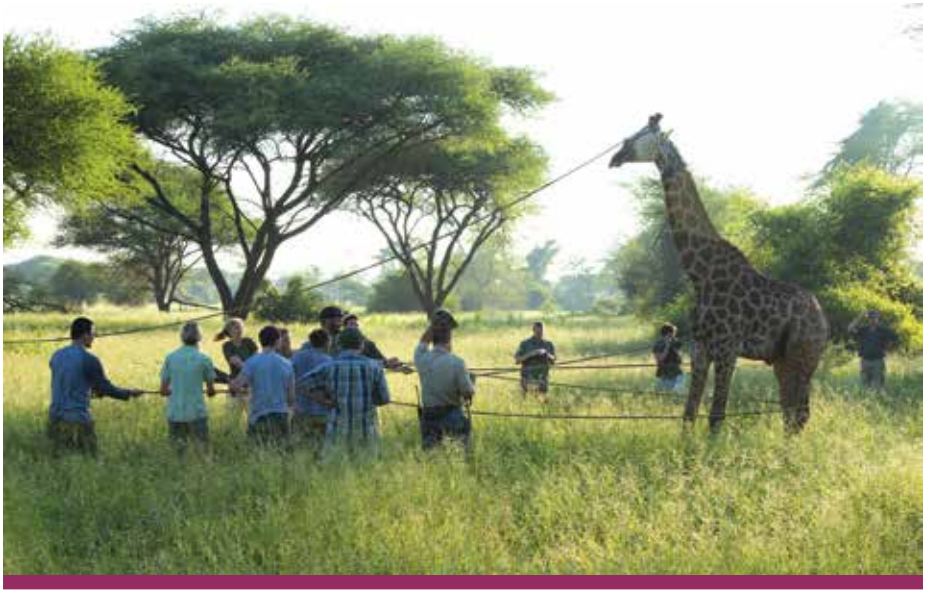
Lioness with dart



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Physical restraint of giraffe using ropes

essential factor for the success of protected areas in southern Africa. Capacity building for farmers and staff from the veterinary services, the Ministry of Health and NPs will lead to better human and livestock health and improved veterinary and medical service delivery.

The advent of integrated multiple land-use policies encapsulated by the strategic vision of "transfrontier conservation" within a One Health framework (Hanks, 2003; Osofsky, Cumming and Kock, 2008) represents a major paradigm shift and step forward in African conservation. 360

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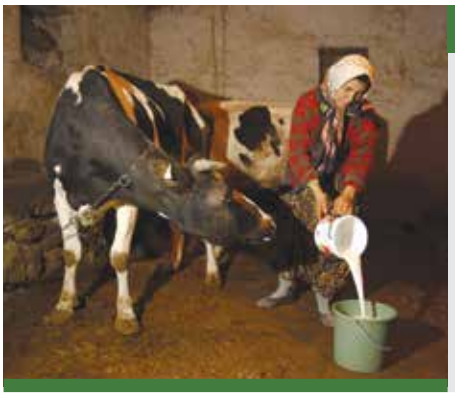

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IN ACTION

Emergence of lumpy skin disease in Asia and Europe

Contributors: Silvia Kreindel,[1] Marius Masiulis,[1] Artem Skrypnyk,[1] Anna Zdravkova,[1] Martina Escher,[1] Eran Raizman[1]

Lumpy skin disease (LSD) is caused by the LSD virus (genus *Capripoxvirus,* family *Poxviridae*) and affects mainly cattle and Asian water buffaloes. LSD is transmitted primarily by mechanical vectors (*Stomoxys* spp., biting flies). Direct transmission can also occur between infected animals, but such transmission is rare and of low epidemiological significance. The disease usually moves from infected to uninfected areas through the transport of infected animals, and sometimes through the introduction of infected vectors. Poorly regulated movements of large numbers of animals, often associated with festivities, represent a risk for introduction of the disease. Outbreaks of LSD require immediate notification under the Terrestrial Animal Health Code of the World Organisation for Animal Health (OIE, 2015b).

LSD is a characterized by substantial economic losses in dairy and meat production and damage to hides. A recent study in Ethiopia estimated that the financial costs related to infected herds were US$5–8 per head of local zebu and US$42–73 per head of Holstein Friesian cattle. The disease can lead to restrictions or total bans in the international trade of live animals and animal products (Gari *et al*., 2011). The incidence of LSD is higher during wet seasons when populations of flies are more abundant (Gari *et al*., 2010; 2011; 2012). In this regard, LSD has been found to be more prevalent in low-lying areas and along watercourses.

LSD was historically endemic in many African countries, but it has now spread throughout the Near East and, more recently, into Asia and Europe (OIE, 2015a). LSD was detected in Egypt for the first time in 1988, and subsequently became enzootic (Ali *et al*., 1990; House *et al*., 1990). In 1989, the disease spread from Egypt to Israel via insects (Davies, 1991). A second outbreak in Israel was reported in 2006 (Brenner *et al*., 2006). Israel experienced 213 outbreaks of LSD from July 2012 to August 2013 (OIE data, 2013).[2] In these outbreaks, the implementation of specific mitigation measures such as LSD vaccination, strict movement restrictions and quarantine successfully controlled the disease (Brenner *et al*., 2006: N. Galon, personal communication). The Islamic Republic of Iran and the Russian Federation reported the disease for the first time in 2014 and 2015 respectively, and Turkey and Azerbaijan have consistently been reporting new cases since 2013. A recent publication indicated that LSD was recognized in Iraq in August 2013 (Al-Salihi and Hassan, 2015).

The disease spreads rapidly in areas of high cattle density. For instance, after Cyprus reported the first six outbreaks in November–December 2014 in the northeastern peninsula, the disease was soon detected approximately 47–52 km from the original location despite animal movement controls. Results of epidemiological investigation were inconclusive and could not rule out disease spread through unauthorized movements of infected cattle.The first incursion of LSD in the European part of Turkey was reported in May 2015. Between May and November 2015, a total of 17 outbreaks were notified in European Turkey. Vaccination of susceptible animals and culling of affected animals were implemented as control measures. Further outbreaks were reported in beef cattle farms in the adjacent Greek region of Evros in August 2015. By the end of 2015, a total of 117 LSD outbreaks were notified in Greece, affecting seven regions: Evros, Xanthi, Rodopi, Chalkidiki, Thessaloniki, Kavala and Limnos island. Stamping out, movement restrictions for live bovines and bovine products and emergency vaccination in the affected regions were implemented.

In September 2015, LSD was reported in the Russian Federation, in Dagestan,

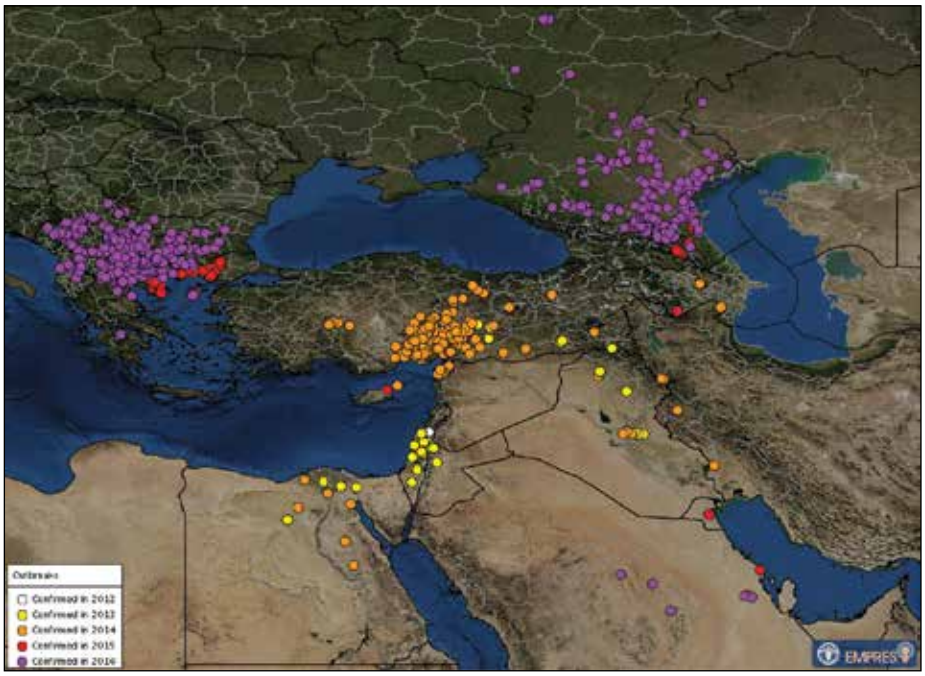

Figure 1: LSD outbreak distribution in Europe, Caucasus and the Near East (as of 18 September 2016)

[1] Food and Agriculture Organization of the United Nations (FAO)

[2] http://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review/viewsummary?reportid=12157

Chechnya and North Ossetia. By July 2016, it had spread to Stavropol, Astrakhan, Krasnodar and Kalmyk regions, resulting in 155 outbreaks.

In April 2016, LSD was reported in Greece in Serres, the region that was not affected and not covered by vaccination in 2015. In total 69 new outbreaks were confirmed between April to the beginning of July 2016 in Greece, in Serres, Pella, Imathia, Drama, Kilkis, Lesbos, Thessaloniki and Kavala regions. During this period, two outbreaks were reported in Edirne, Turkey.

In April 2016, the first LSD incursion was registered in Bulgaria, in Haskovo region, approximately 60 km from the borders with Greece and Turkey, followed by outbreaks in southwest regions; in June 2016, two northern regions were affected. By the end of June, LSD affected 17 regions in Bulgaria, with 201 outbreaks. A total stamping out policy and movement restrictions were applied. Emergency vaccination started in affected villages and in the 20-km protection zones around the outbreaks. This was later extended to blanket vaccination across the whole country.

In April 2016, LSD was registered in The former Yugoslav Republic of Macedonia, and by June, 387 outbreaks were confirmed. Modified stamping out, movement restrictions and vaccination were implemented. By July 2016, 198 and 53 outbreaks were also confirmed in Serbia and in Montenegro respectively, and 1 each in Albania and Kazakhstan.

Figure 2: LSD outbreak distribution in Europe, Caucasus and the Near East (as of 18 September 2016)

TRANSMISSION

The main pathways for transmission are biting and blood-feeding arthropods, including mosquitoes and flies (Gari *et al*., 2010). Disease incidence is highest in wet/warm weather. In some areas, decreases in incidence during periods of low rainfall are possibly linked to declines in insect vector occurrence/numbers.

Although rare, transmission also occurs through direct contact, and the disease can also spread from contaminated feed and water. In the 2013 outbreak in Israel, the virus was isolated from the saliva of cattle, but the epidemiologic importance of this possible transmission route is yet to be elucidated. The virus can remain active in skin scabs and dry hides for up to six months if they are kept in the dark. Nevertheless, in some outbreaks the routes of transmission remain unclear.

CLINICAL SIGNS

The morbidity rate of LSD is between 5 and 45 percent on affected farms. The mortality rate may be as high as 10 percent, even among indigenous cattle. Typically, cattle develop a biphasic febrile response two to four weeks after exposure to the virus. Characteristic skin nodules appear during a second rise in body temperature, four to ten days after the initial febrile response. Nodules involve the skin, subcutaneous tissue and often the underlying muscle. The size of the nodules is generally uniform, although several nodules may fuse to form a larger one. Nodules are firm, round and raised. In cattle, the nodules are often recognized only when the skin is palpated or moistened, and in most cases they are particularly noticeable in the perineum and on the vulva. Acute and subacute nodules are reddish-grey while the dermis and subcutaneous tissue show oedema. Nodular lesions may extend into the tendons, resulting in lameness. Skin lesions resolve and become indurated or sequestrated, leaving deep ulcers partly filled with granulation tissue, which often suppurates.

Clinical signs of LSD may include:

- dissemination of small bumps (nodules) under the skin in the nose and mouth and on the body;
- enlarged superficial lymph nodes;
- swollen and tender udder or testicles;
- discharge from the eyes and nose;
- bulls becoming sterile and cows having abortions.

DEFINITIVE DIAGNOSIS

Initial diagnosis can be made in the presence of typical lesions on the skin and in the mouths of infected animals. However, as other diseases present in similar forms in cattle, but require different methods of control and treatment from those for LSD, a definitive diagnosis can only be confirmed by submitting appropriate samples of skin lesions to a laboratory where the virus can be identified. Molecular diagnostic tests such as conventional and real-time polymerase chain reaction (PCR) assays are rapid and highly sensitive, and are widely used in veterinary diagnostic laboratories.

CONTROL AND PREVENTION OF LSD

LSD can be prevented by implementing biosecurity measures at the farm level and imposing restrictions on the movement of susceptible animals and commodities from infected areas. In endemic areas control is confined to vaccination.

Policies for controlling and eradicating LSD in cases of incursion include *stamping out* and a combination of the following strategies (Coetzer and Tuppurainen, 2014):

- *sanitary disposal* of destroyed animals and contaminated animal products, to remove the source of infection;
- *quarantine and movement controls* of animals, products and other potentially infected items, to prevent spread of infection;
- *decontamination* of facilities, equipment and other items, to remove fomites and minimize spread of the virus from infected animals and premises;
- *control of insect vectors* in the initial stages of an outbreak;
- *tracing and surveillance* to determine the source and extent of infection and provide proof of freedom from the disease;
- *zoning* and/or *compartmentalization* to define infected and disease-free premises and areas;
- *awareness campaigns* to facilitate cooperation from industry and the community;
- *ring vaccination,* as part of a *modified stamping-out* policy.

VACCINES

Currently available vaccines against LSD include:

- Lumpy Skin Disease Vaccine – Onderstepoort Biological Products, South Africa (LSD virus [LSDV] Neethling strain);

- Lumpyvax – Merck Animal Health, Intervet, South Africa (attenuated LSDV field strain);
- Herbivac LS – Deltamune, South Africa (LSDV Neethling strain).

In addition, sheep pox virus (SPPV) vaccines have been used in several countries as a preventive and control measure, and have been shown to be protective against LSDV when the sheep dose is increased three- to tenfold:

- Yugoslavian SPPV RM-65 – Jovac, Jordan and Abic, Israel (ten times the sheep dose);
- Bakirköy SPPV strain – PoxvacTM, Vetal Animal Health Products, Turkey (three to four times the sheep dose);
- Romanian SPPV strain.

As noted by Coetzer and Tuppurainen (2014), Kenyan sheep and goat pox (KSGP) virus vaccine strains O-240 and O-180 have been characterized as suitable for preventing LSDV, but are not recommended for cattle until their safety and efficacy have been tested in challenge experiments.

For a successful prevention campaign, large-scale annual vaccination with a homologous vaccine is preferred. For emergency control, ring vaccination within a radius of 25–50 km from infected zones can be implemented, and temporary or permanent slaughter sites should be established. Sufficient herd immunity (at 80 percent coverage) needs to be created and maintained in large areas around infected zones and on the borders with infected countries. However, it should be kept in mind that the quality of vaccines varies, and live virus vaccine is of low stability in sunlight. SPPV and goat pox virus vaccines can be used at coverage levels of 80–90 percent (FAO, 2015). A recent study in Israel compared the Neethling strain vaccine to the Jovac SPPV vaccine at ten times the sheep dose. While the efficacy of the Neethling strain vaccine was statistically significantly higher than that of the SPPV vaccine, both vaccines were shown to protect against natural exposure to LSDV during outbreaks (Ben Gera *et al.,* 2015). [360]

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Cow affected by LSD, Bulgaria, 2016

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IN ACTION

Eastern Africa regional roadmap for the control and eradication of peste des petits ruminants: support from strong epidemiology and laboratory networks

Contributors: Bouna Diop,[1] Felix Njeumi [2]

The Global Strategy for the Control and Eradication of PPR (also known as the Global Control and Eradication Strategy – GCES) of FAO and the World Organisation for Animal Health (OIE) was endorsed at the International Conference for the Control and Eradication of Peste des Petits Ruminants (PPR) held in Abidjan, Côte d'Ivoire from 31 March to 2 April 2015. The conference recommended that meetings on regional roadmaps be held to ensure the continuous evaluation and monitoring of the PPR situation. Regional roadmap strategies and national strategic plans should be aligned with the global strategy and regional and national contexts.

PPR is one of the most significant small ruminant diseases in the East African region (Figure 1).

Several countries in East Africa have developed, or are developing, national PPR strategies, while the Intergovernmental Authority on Development (IGAD)[3] and the African Union's Interafrican Bureau for Animal Resources (AU-IBAR) have developed PPR strategies for Africa at the regional (IGAD) and continental (AU-IBAR) levels; all of these strategies need to be aligned with the GCES. There are also ongoing PPR control initiatives within the region, mainly supported by IGAD, AU-IBAR and FAO.

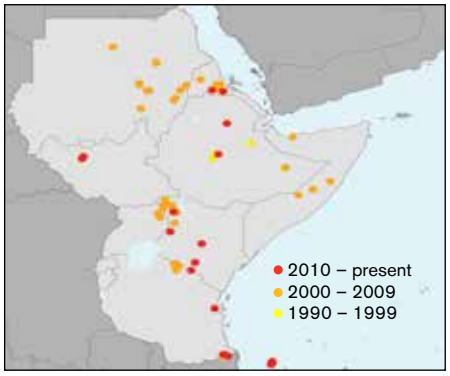

Figure 1: Known PPR outbreaks in the East African region with virus confirmation

Table 1: Schedule of regional PPR roadmap meetings

Region	Date and location
Central Africa	24–25 August 2015, Yaoundé, Cameroon
Eastern Africa	10–11 September 2015, Kampala, Uganda
Middle East	3–5 December 2015, Doha, Qatar
Central Asia	23–25 February 2016, Almaty, Kazakhstan
SAARC[2]	11–12 April 2016, Nagarkot, Nepal
ECOWAS[1]	11–13 May 2016, Dakar, Senegal
SADC[3]	October 2016, to be decided
North Africa	October 2016, Tunis, Tunisia
ASEAN[4], China, Mongolia and Timor-Leste	December 2016, to be decided

PPR ROADMAP MEETING FOR EASTERN AFRICA

The first PPR roadmap meeting for the Eastern African region after adoption of the GCES was held from 10 to 11 September 2015 in Kampala, Uganda as the second in the series of regional PPR roadmap meetings planned for 2015 and 2016 (Table 1).

Mr Alhaji Jallow, FAO Representative in Uganda, opened the meeting, which was attended by chief veterinary officers (CVOs), laboratory representatives and epidemiologists from 11 countries – Burundi, the Democratic Republic of the Congo, Djibouti, Eritrea, Ethiopia, Kenya, Somalia, South Sudan, the Sudan, Uganda and the United Republic of Tanzania – and representatives from OIE and FAO. After presentation of the GCES[8] and the recommendations of the Abidjan conference,[9] meeting participants assessed the PPR situation and the response capacity of the national veterinary services of countries in the region, identified other small ruminant diseases that could be controlled alongside PPR, and formulated a regional roadmap for Eastern Africa outlining a coordinated approach for the control and eradication of PPR throughout the region. It was necessary to obtain countries' commitment to implementing this regional roadmap.

The two main outputs of the meeting were: i) adoption of the PPR Stage Progression 2015–2030 as the starting point for the step-wise GCES approach (Figure 2); and ii) establishment of a regional advisory group composed of three CVOs – from Ethiopia (as chair), Burundi and Uganda – the Coordinator of the CVO Network, the coordinators of the Eastern Africa Region Epidemiology Network (EAREN) and the Eastern Africa Region Laboratory Network (EARLN) and representatives of IGAD, the East African Community (EAC), AU-IBAR and the AU's Pan African Veterinary Vaccine Centre (AU-PANVAC).

The main recommendations adopted by participants included the following:

- *Countries* should take the necessary actions to: i) conduct/update national censuses of small ruminant populations; ii) ensure that their national strategies are consistent and aligned with the GCES, as the reference document; iii) ensure that only quality vaccines certified by AU-PANVAC are used; iv) assess the effectiveness of vaccinations through post-

[1] Food and Agriculture Organization of the United Nations (FAO), Emergency Centre for Transboundary Animal Disease Operations (ECTAD), Nairobi

[2] FAO Animal Production and Health Division, Rome

[3] Member countries of IGAD are Djibouti, Eritrea, Ethiopia, Kenya, Somalia, South Sudan, the Sudan and Uganda.

[4] Economic Community of West African States

[5] South Asian Association for Regional Cooperation

[6] Southern African Development Community

[7] Association of Southeast Asian Nations

[8] http://www.fao.org/3/a-i4460e

[9] http://www.oie.int/for-the-media/press-releases/detail/article/publication-of-the-abidjan-conference-recommendations-adoption-of-the-global-strategy-for-the-contr/

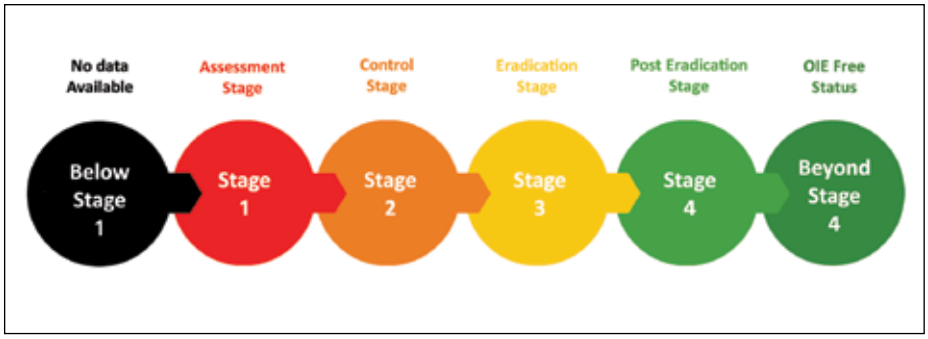

Figure 2: Progressive step-wise approach for the prevention and control of PPR

vaccination evaluation; and vi) commit to adopting the PPR step-wise approach at the national level and to the subsequent PPR regional roadmap process.

- *AU-IBAR, AU-PANVAC, IGAD and EAC* should: i) ensure that the continental (AU-IBAR) and regional (IGAD) strategies are consistent and aligned with the GCES; ii) define their respective roles in implementation of the GCES; iii) establish a roster of regional experts to address countries' needs in epidemiology and to explore the possibility of establishing a regional leading epidemiology centre; iv) map all existing (and planned) national and regional projects related to PPR control and eradication, and identify existing gaps; and v) form a joint Eastern Africa Coordination and Technical Committee between IGAD and EAC, to take advantage of the work initiated by IGAD.
- *FAO and OIE,* together with regional partners and countries, should: i) ensure that adequate financial resources are mobilized for implementing the GCES at the national, regional and international levels; ii) provide further guidance on the potential for combining vaccination protocols for PPR and other small ruminant diseases in the near future; iii) provide countries with the necessary training in post-vaccination evaluation; iv) explore the possibility of developing a tool to help countries estimate the costs and economic impact of PPR vaccination, using the tool developed by FAO for highly pathogenic avian influenza as a model; and v) develop a summarized version of the GCES.

EASTERN AFRICA REGIONAL ANIMAL HEALTH NETWORKS MEETING

The annual meeting of the Eastern Africa Regional Animal Health Network (RAHN) was held on 7–9 September 2015, back-to-back with the PPR Roadmap Meeting for Eastern African. The network comprises CVOs, the national focal points of EAREN and EARLN, and the sub-network coordinators for foot-and-mouth disease (FMD) and African swine fever (ASF). Its annual meeting serves as an important forum for discussion and information sharing on disease control in the region. Sixty-eight participants from 11 countries attended to discuss regional needs and practicalities.

The RAHN meeting prioritized four major diseases for regional attention – PPR, Rift Valley fever (RVF), FMD and ASF – and recommended that: i) IGAD take the necessary action to coordinate and anchor the RAHN, with support from EAC and FAO; ii) the ASF sub-network finalize the regional strategy by December 2015; iii) FAO, OIE, IGAD and EAC support the establishment of a PPR sub-network for Eastern Africa, as recommended by the GCES; and iv) countries take the necessary action to develop/update national RVF contingency plans, given the high chances of RVF occurrence in the near future, based on climate predictions.

Other recommendations included strengthening existing sub-networks (for ASF and FMD) and establishing new ones (for rabies, contagious caprine pleuropneumonia and PPR) with the support of technical partners; addressing the weak disease reporting and information sharing among countries; requesting IGAD to prepare clear rules and principles to govern the management of networks established through a defined charter; requesting Ethiopia's National Animal Health Diagnostic and Investigation Centre (NAHDIC), as the Regional Support Laboratory, to develop an action plan to guide its support to other countries; mapping all ongoing projects and programmes to avoid duplication; conducting antimicrobial resistance (AMR) surveillance activities along livestock value chains, and prioritizing the development of an AMR mitigation strategy; mapping and documentation of One Health activities in the region; and developing national policies, strategies and legislation to rationalize the provision of veterinary services by the public or private sectors or through public–private partnerships.

Additional participants at the RAHN meeting included representatives from AU-IBAR, AU-PANVAC and OIE, and major project implementation partners, including partners of the United States Agency for International Development's (USAID's) Emerging Pandemic Threats 2 (EPT2) Program – PREDICT-2, the Preparedness & Response Project and the One Health Workforce; the United States Centers for Disease Control and Prevention (CDC); the International Livestock Research Institute (ILRI); and the Uganda Virus Research Institute (UVRI). FAO participants included the Emergency Prevention System (EMPRES, Rome, Italy), the Subregional Office for Eastern Africa (SFE, Addis Ababa, Ethiopia), FAO Representation in Kenya (Nairobi, Kenya) and the Emergency Centre for Transboundary Animal Disease Operations (ECTAD, Nairobi, Kenya). 360

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Participants at the Eastern Africa RAHN meeting

NEWS

Expert panel meeting on developing socio-economic guidelines for the Progressive Control Pathway for Foot-and-Mouth Disease, 13–15 May 2015, Rome

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The Progressive Control Pathway for Foot-and-Mouth Disease (PCP-FMD), promoted and launched by FAO and the World Organisation for Animal Health (OIE) in 2012, is a non-prescribed approach to the progressive control of FMD in endemic settings. It defines six stages in which the circulation of first clinical FMD and then FMD virus are progressively controlled and finally eradicated. In **Stage 0**, FMD is endemically present in a country, but there is no available information on its extent, impact and routes of transmission. In **Stage 1**, the focus is on developing an understanding of the endemic FMD virus strain(s), the routes of virus transmission and the livestock production systems in the country. In **Stage 2**, FMD control is implemented to reduce the impact of clinical FMD in the country or in a specific region or livestock sector in the country. In **Stage 3**, the control of FMD becomes more aggressive with the aim of eliminating FMD virus circulation and putting in place a rapid detection and response mechanism for all FMD outbreaks. In **Stage 4**, FMD outbreaks are limited to occasional incursions from neighbouring countries and every incursion is swiftly curtailed. Vaccination is usually still part of the FMD control plan, and the country can apply to OIE for official recognition of its status as FMD-free with vaccination as it moves into **Stage 5**, when the country prepares to phase out FMD vaccination and applies for an official OIE status of FMD-free without vaccination.

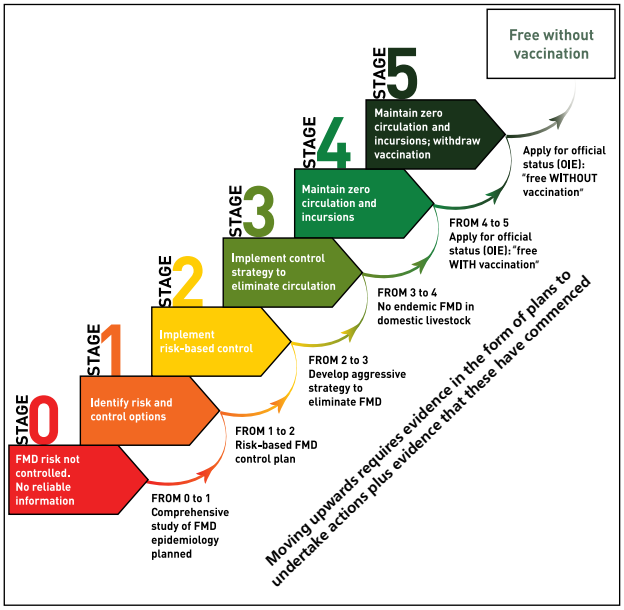

Figure 1: Stage progression in the Progressive Control Pathway

Decisions related to animal disease control involve economic choices at several levels, and a range of alternative approaches need to be evaluated to demonstrate the full economic benefit of a control strategy. The proposed disease intervention should be socially acceptable and should deliver economic benefits that are greater or equal to the extra cost. However, while veterinary services are well positioned to demonstrate the technical and economic benefits of a disease intervention, they do not usually have the expertise to gather information or conduct analyses.

In this context it is necessary for the PCP-FMD approach to include consideration of the socio-economic impacts of both the disease and the control measures at each stage. Economic methods and analysis can be used to determine key policy requirements for moving from one PCP stage to the next. Guidelines are therefore required to assist countries in assessing the impact of the disease and obtaining economic data to support policy and the design of sustainable control programmes. For these reasons, in April 2015 an expert panel met in Rome to explore the development of guidelines for socio-economic assessments that assist countries in determining the impact, costs and benefits of interventions along the PCP-FMD pathway. The expert panel discussed the methods and tools available for conducting socio-economic analyses to provide evidence from different production systems and to support investments in control programmes.

The expert discussion recommended that a literature review be conducted to improve understanding of the most up to date economic analysis and methods in animal health and their application to FMD issues. The review showed that most economic analyses so far have been conducted using a cost–benefit analysis framework, and many have not taken into account the socio-economic impact and value of interventions and their adoption by farmers. Any FMD control strategy or eradication plan has to pay attention to the engagement of livestock owners, so studies are required to build understanding of the impacts on this stakeholder group of implementing and continuing the disease prevention or control strategy, i.e. of each stage of the PCP-FMD. Demonstrating the potential positive impact of an FMD control strategy is essential in helping decision-makers to determine the best way of allocating limited resources.

The socio-economic guidelines discussed by the expert consultation will include sections on each PCP stage, and will describe the likely socio-economic issues to be taken into account in the design and implementation of national FMD control plans. At each stage, considerations for this socio-economic analysis include stakeholder identification, socio-economic indicators and data requirements. Application of the socio-economic guidelines is expected to lead to more robust and sustainable national control plans that will expedite achievement of the objectives and milestones of the Global FMD Control Strategy. 360

REFERENCE

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In memoriam: Ali Gholam Kiani (1951–2015)

Doctor Ali Gholam Kiani left us in December 2015. He left us silently, with discretion, coherently with how he was in life. A dear friend to all, he was also a dedicated professional and an ambassador of good will.

Dr Kiani was born in 1951 in Tehran, where he received his veterinary training. He began his professional career in 1978 in Elam Province of the Islamic Republic of Iran, first as a provincial field veterinary officer and then as an Officer for Quarantine Affairs responsible mainly for controlling animals and animal products for export and compliance with World Organisation for Animal Health (OIE) requirements. He received training in microbiology and quality control at the Meat Research Institute of New Zealand, and throughout most of the 1990s Dr Kiani worked for the national veterinary service of the Islamic Republic of Iran, developing a robust veterinary service and being responsible for animal disease prevention and control. It was here that he became involved with professionals from the Food and Agriculture Organization of the United Nations working on the establishment of a national animal disease surveillance system to support the national rinderpest control plan. By the end of the second five-year national plan for rinderpest control and eradication (1998–2003), the Islamic Republic of Iran had received official recognition as rinderpest-free. In the intervening period, Dr Kiani also contributed significantly to rinderpest control programmes in Afghanistan, including training veterinary field units, conducting field and village investigations, and carrying out vaccination and surveillance activities and FAO follow-up projects (in 1996 and 1997) in the aftermath of rinderpest outbreaks in eastern parts of Afghanistan linked to the illegal movement of infected cattle from Pakistan. From 1998 to 2002, Dr Kiani served as Director of the Central Veterinary Laboratory for Diagnosis and Veterinary Drugs, Vaccine and Biological Quality Control under the Iran Veterinary Organization (IVO).

Under the supervision of Dr Mark Rweyemamu, and later Dr Juan Lubroth, Head of the Emergency Prevention System (EMPRES) at FAO, Dr Kiani coordinated the work of the Regional Animal Disease Surveillance and Control Network (RADISCON), which was a precursor of the Global Framework for the Progressive Control of Transboundary Animal Diseases (GF-TADs) in scope, strategy and regional approach and covered 21 countries in the Near East and North Africa, including the Islamic Republic of Iran. He led this initiative aimed at establishing veterinary epidemiology units in the central veterinary services of beneficiary countries and improving disease information systems and disease reporting – both national and to OIE – through capacity building in disease surveillance and control activities for transboundary animal diseases such as rinderpest, foot-and-mouth disease (FMD), peste des petits ruminants (PPR), sheep pox and brucellosis. When RADISCON ended, Dr Kiani returned to IVO as Director of Animal Disease Surveillance, Prevention and Control, a position he held until the outbreaks of H5N1 highly pathogenic avian influenza (HPAI), when he was commissioned by FAO to serve as Regional Animal Health Adviser and technical manager for Central Asia.

At the Global Declaration of Rinderpest Freedom, in Rome in 2011, FAO recognized Dr Kiani with a medal for his work in Afghanistan, Kazakhstan, Kyrgyzstan, Pakistan, Tajikistan, Turkmenistan and Uzbekistan as well as the Islamic Republic of Iran, and his contributions to global solidarity.

In November 2015, in Afghanistan, Dr Kiani concluded his professional career. He was in Kabul a month before his death working on FMD, PPR and HPAI management and control; one photo shows him a bit tired but very present and ready to hear from field veterinarians about their needs and challenges in completing their daily activities and preparing for the next stage. The chapter closes with Dr Kiani as a great professional – not only because of his experience and technical skills, but also because of his capacity to listen with humility, always showing great interest and participation in whatever his interlocutors had to tell him as a sensitive educator.

Ciao Dr Kiani. Ciao Ali. We will miss you, and your flame will continue to burn and inspire.

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The Emergency Prevention System (EMPRES) is an FAO programme, founded in 1994, with the goal of enhancing world food security, fighting transboundary animal and plant pests and diseases and reducing the adverse impact of food safety threats. EMPRES-Animal Health is the component dealing with the prevention and control of transboundary animal diseases (TADs).

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Recommended citation
FAO. 2016. *EMPRES-Animal Health 360*, No. 46. Rome

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I6184E/1/09.16