REPORT OF THE COMMITTEE ON FOREIGN AND EMERGING DISEASES

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The Committee met on October 28, 2008 at the Sheraton Greensboro Hotel in Greensboro, North Carolina, from 8:00 a.m. until 5:45 p.m. There were 142 members and an estimated 50 guests present. The Chair introduced the new Vice-Chair, Dr. Paul Gibbs and both the Chair and Vice Chair thank Dr. Corrie Brown (unfortunately absent at this meeting) for her many years of service as the Chair of this Committee and for her work in making the 8th Editions of the Foreign Animal Disease book a reality. A summary of the discussions and resolutions was presented before the start of the presentations. A summary of the presentations, in chronological order, is presented here. Except for one presentation, all authors provided copies of their presentations for posting at the Committee page of the USAHA website, at http://www.usaha.org/committees/fe/fe.shtml.

National Bio and Agro-Defense Facility (NBAF) Program Update was presented by Dr. Tam Garland, Science and Technology Directorate, U.S. Department of Homeland Security (DHS).

Dr. Garland summarized the reasons of why the United States needs a new biocontainment facility, known as NBAF to replace the Plum Island Animal Disease Center (PIADC). The Homeland Security Act of 2002 recognized that protection of US agriculture is a critical element of Homeland Security and transferred ownership from the United States Department of Agriculture (USDA) to DHS in 2003. PIADC is a critical national asset and essential to protecting the US agriculture economy and food supply. It has served our nation well for over 50 years as our first line of agro defense. However, with expanding mission as well as facility limitations at Plum Island, such as no BSL4, the need has been identified to enhance the current research capabilities in the animal agricultural field to protect the nation and surrounding communities. Plum Island is also an aging facility that is costly to maintain, because of its outdated infrastructure and design. Therefore, DHS initiated a competitive selection process to select additional alternatives to the Plum Island Site. This was required so we could consider a range of alternatives for the NBAF which includes Plum Island.

DHS published a request for Expressions of Interest in Jan 2006. DHS originally received 29 expressions of interest from across the Nation, and narrowed down the sites to 18 sites to compete in the 2nd round. Following evaluation of the additional information, DHS visited 17 sites in April and May this year, and at the end of this process selected six sites for Environmental Impact Statement (EIS) analysis. Because the proposed NBAF is a major federal agency action, DHS is required by the National Environmental Policy Act (NEPA) to conduct an EIS to evaluate its potential impacts.

The mission of the NBAF is to study animal infectious diseases that threaten our agricultural livestock and agricultural economy. These diseases include: Nipah virus, African swine fever, classical swine fever, contagious bovine pleuropneumonia, foot-and-mouth disease (FMD), Hendra virus, Japanese encephalitis virus, and Rift Valley fever. Zoonotic diseases would be studied and diagnosed in livestock; however, the NBAF would not study anthrax, Ebola, plague or smallpox, as these diseases are already studied at other Federal laboratories. The NBAF is committed to maintain the research, diagnostic and teaching missions of USDA, Agriculture Research Service (ARS) and USDA, Animal and Plant Health Inspection Service (APHIS), and will add biocontainment capabilities at the BSL-4 level, not currently available in the US for work with livestock species.

It is estimated that the NBAF will have 504,000 gross square feet (GSF) of construction allocated as follows: 30,000 GSF (6 percent) of BSL-2 space; 372,000 GSF (73 percent) of BSL-3 space; 55,000 GSF (10.9 percent) of BSL-4 space; 12,000 GSF (2.4 percent) for vaccine production; and 35,000 GSF (6.9 percent) for administration and office space.

The NEPA specifically requires that federal agencies evaluate the range of all "reasonable alternatives" to the proposed action. NEPA guidance defines reasonable alternatives as those which are "practical or feasible from the technical and economic standpoint and using common sense, rather than simply desirable from the standpoint of the applicant". Because of that there are two decision alternatives: One is a "No action alternative" and the other one is "Build the NBAF". The Animal Disease Center on Plum Island is considered the "no action" option. In other words, if no site within the continental U.S. is found to be acceptable upon which to build NBAF, then Plum Island will continue to operate within its current mission capabilities. In evaluating reasonable alternatives for constructing and operating the NBAF, DHS conducted a competitive selection process to identify and evaluate potential candidate sites, in addition to Plum Island. DHS announced on July 11, 2007 five "Site Alternatives" that are reasonable prospective locations for the construction and operation of the NBAF in addition to Plum Island:

- South Milledge Avenue Site – Athens, Georgia
- Manhattan Campus Site – Manhattan, Kansas
- Flora Industrial Park Site – Flora, Mississippi
- Umstead Research Farm Site – Butner, North Carolina
- Texas Research Park Site – San Antonio, Texas

Final selection will be determined after review of the following reports:

- NBAF Environmental Impact Statement (including agency and public comments)
- Threat and Risk Assessment
- Site Cost Analysis
- Site Characterization Study
- Plum Island Facility Closure and Transition Cost Study

It was indicated that if Plum Island is selected, the NBAF located there will be a completely new facility

Dr. Garland indicated that due to the very large number (>20,000) of comments received for the final EIS, and the need for DHS to answer all of them, the final decision may not take place during this Presidential administration. She also indicated that all this information has been posted at the DHS website.

Foot-and-Mouth Disease (FMD) Response Planning Update was presented by José R. Díez, Emergency Management and Diagnostics (EMD), Veterinary Services (VS), Animal and Plant Health Inspection Service (APHIS), USDA.

Dr. Díez explained that the Emergency Management & Diagnostics (EM&D) section of APHIS Veterinary Services has three divisions: 1.)The Interagency Coordination (IC) responsible for creating partnerships with Federal, State, and local entities to strengthen early disease detection and rapid response at all levels taking the lead role for the implementation of the National Incident Management System. The group has staff liaisons working directly with Department of Homeland Security, US Department of Health and Human Services, Centers for Disease Control, and the Department of Defense to ensure that subject matter expertise is available within these agencies for all necessary planning and communications activities. 2.) The Preparedness and Incident Coordination (PIC) staff The PIC staff that develops agency response plans for the most dangerous animal diseases that pose a risk to US agriculture. This staff works closely with industry and stakeholders to identify the highest risk diseases, resource availability, and best strategies in disease mitigation; and 3.) The National Veterinary Stockpile (NVS) that is tasked with providing the best possible protection against an intentional or unintentional foreign animal disease (FAD) introduction or the occurrence of a natural disaster affecting animal agriculture and the food system, as well as tasked with establishing methodology needed to address the most important FADs and has begun to stockpile identified supplies, vaccines, and materials needed for a response to these FADs.

APHIS Emergency Response Plans are based on some key aspects that include partnership between State, Federal, industry, and Tribal entities; an integrated and coordinated response to emergencies, a plan to communicate, prepare, assess, test, and exercise; response capabilities (Finance/Administration-Logistics-Ops-Planning), and a commitment to integrate, synchronize, and cooperate. He also indicated that while the old approach was response oriented, the new approach is prevention, preparedness, mitigation, and recovery oriented, with a focus on being an all-hazards and multi-agency plan, applicable to intentional and catastrophic incidents, designed to operate with large scale interagency coordination and applicable to incidents with single or multiple sites. Several examples on the advances on the preparation and distribution and implementation of the FMD response plans were presented. Those included revisions of policy memoranda, development of animal disease models, tests exercises, and the enhancements of the North American FMD Vaccine Bank, coordination with the DHS, and continuity of business plans.

Potential Strategies for the Detection, Monitoring, and Management of Selected Diseases in Wildlife was given by Dr. Jack C. Rhyan, USDA-APHIS-VS

Dr. Rhyan briefly reviewed the need for studies of the impact of FADs, particularly FMD on wildlife using historical examples. He then reported on the "Workshop on the science of surveillance, control and eradication of catastrophic diseases in wildlife" held in Colorado on Aug 7-9, 2007.He then summarized for the audience the advances in newer technologies to conduct work on diseases of wildlife that included infrared imaging as a screening tool for the early and remote detection of animals with fever, particularly by observing the heat images of feet and coronary bands. Another technology being developed includes the use of drones or unmanned aerial vehicles that could serve as a tool for carrying infrared cameras used for census and disease detection. A third novel technology is the use of delivery systems for the targeted oral or intranasal (nebulized) vaccines to wild species.

Dr. Theresa Bernardo, College of Veterinary Medicine, Michigan State University presented Collaborative Technologies for Disease Prevention, Early Detection and Rapid Response

Dr. Bernardo presented an excellent summary of modern internet-based technologies with great applications in our animal health fields. Using examples she illustrated how the use of the Web have evolved from being used to find information, like using Wikipedia or Google searches, to now being about interacting with each other through the use of blogs, wikis, Facebook, MySpace, Twitter, texting, web-enabled cell-phones and many types of PDAs. Today, people on the field could, with very simple and ubiquitous hand-held devices, could update a blog, send a picture and consult an expert. Several examples of the use of these technologies for animal health were presented. These technologies have an animal health corollary, in the development of collaborative tools leading to enhancement of rapid response to emergencies. Other evolving technologies are available through internet corporations like Google in the form of improved internet search engines with the ability to receive electronic messages with alerts about events of interest. Dr. Bernardo also illustrated the increase benefit of using Google maps, HealthMaps, and other collaborative tools. Finally she suggested that wikis could be used for the development of regulations. One example mentioned was the project of New Zealand of using a wiki-based system for the development of new laws.

Dr. Kenneth J. Linthicum, Center for Medical Agricultural and Veterinary Entomology, USDA-ARS, presented a Time Specific Paper, titled, Rift Valley Fever (RVF) Overview and Recent Developments at USDA. Dr. Linthicum divided his presentation into four components: (1) RVF ecology and epidemiology in Africa and Arabian Peninsula; (2) Prediction of recent RVF outbreaks in Africa; (3) RVF threat to U.S.; and (4) RVF interagency working group. The full paper of this presentation is provided following this Report.

Rift Valley Fever Outbreak in East Africa, 2006-2007 was presented by Linda L. Logan, USDA APHIS Attaché, North Africa, East Africa, Middle East. The primary author of the paper is Sherrilyn H. Wainwright, Centers for Epidemiology and Animal Health, USDA-APHIS-VS.

Dr. Logan presented this paper on behalf of the main author who could not attend the meeting. This paper provided an overview of the 2006-2007 Rift Valley Fever (RVF) outbreak in East Africa; identified the response and control measures used during the outbreak; and outlines the lessons learned for better prevention and response to future RVF outbreaks. These outbreaks occurred from November 30, 2006 until March 12, 2007. During this period of time there were countless of animal cases in four provinces in eastern Kenya that generated 684 human cases with 155 deaths. The calculated case-fatality rate was 23%. However, it is estimated that this value is inflated due to the lack of a real denominator, not knowing how many people were infected. Only the seriously ill people sought medical attention. A large number of Kenyan and international agencies, including several from the US (DOD, CDC, USAID, USDA, NAMRU-3) were involved in different aspects of these outbreaks. A number of animal interventions implemented included: livestock movement controls imposed on infected Districts; slaughterhouses were closed and home slaughter was banned; bans were enforcement through education and use of Imams and Law enforcers. Thiis was a challenge due to the major Muslim holiday of Eid-ul-Azha (Dec 12, 2006), ending a time of fasting, resulting on the ban of the traditional sacrifice of young lamb or calf was banned. Export markets were closed, and due to the closure of the border with Somalia by the government of Kenya on 2 January 2007 further investigations were hindered. Vaccination with the Smithburn live-attenuated vaccine began on January 8, 2007 in the Northeastern Province and extended to other known endemic districts. Vaccination was carried out in herds of goats, sheep, cattle and camels. A total of 2,550,330 doses of RVF vaccine used in the control efforts. Many lessons were learned, particularly in regard to the lack of laboratory capacity, lack of coordination and preparation to deal with an outbreak of this magnitude. The value of the early warning system based on satellite and global weather analysis was reinforced by these experiences.

Dr. Thomas J. Holt, Florida State Veterinarian, presented Rift Valley Fever – Plans for a Florida Training Exercise

Dr Holt outlined the planning and preparation for an out coming training exercise on RVF to be hosted by the Florida Department of Agriculture and Consumer Services/Division of Animal Industry and prepared by Dr. Paul Gibbs at the University of Florida/College of Veterinary Medicine. The purpose of this exercise will be to give participants an opportunity to plan, initiate, and evaluate current response concepts, and capabilities in a simulated introduction and outbreak of Rift Valley Fever in Florida. The exercise will focus on multiagency coordination and the critical decisions of key state regulatory and emergency response agencies in the first days of the simulated disease outbreak. This test will involve many state and several federal agencies. Given the ecological conditions of Florida, quite favorable for the development of an outbreak of vector-borne diseases, this exercise is expected to be very valuable to enhance Florida’s level of preparedness for an event of this type..

Dr. Luis Rodriguez, Plum Island Animal Disease Center, USDA-ARS presented Review of ARS Programs at PIADC

As it is customary in this FED Committee, Dr. Rodriguez provided an update on the research activities of ARS at the PIADC. The most recent research activities at PIADC include studies on the early events in bovine FMD pathogenesis; genetically engineered FMD virus for production of a safe inactivated vaccine; the use of cytokines as antivirals and immunomodulators; and the development of a novel Classical Swine Fever (CSF) live attenuated vaccine. Dr Rodriguez reported on the development of important strategic alliances with other government agencies, academia and the private industry to further develop research and the potential commercialization of the novel vaccine products. He finalized his presentation with a summary of the activities of the Global Foot-and-Mouth Disease Research Alliance (GFRA). The mission of GFRA is to establish and sustain global research partnerships to generate scientific knowledge and discover the tools to successfully prevent, control and eradicate FMD, with a broader vision of creating a coordinated global alliance of scientists producing evidence and innovation that enables the progressive control and eradication of FMD. Current members of this alliance include PIADC; the Institute of Animal Health Pirbright-UK; Canadian Food and Agriculture Institute, Winnipeg Canada; INTA-Argentina, the Department of Livestock Development – Thailand; and AAHL-CSIRO – Australia. A copy of the presentation is available at http://www.usaha.org/committees/fe/fe.shtml.

Research Update on Avian Influenza was provided by Dr. David L Suarez, Southeast Poultry Research Laboratory, USDA-ARS.

Dr. Suarez summarized the activity of H5N1 highly pathogenic avian influenza (HPAI) in the world during 2008. Research at the Southeast Poultry Research Laboratory (SEPRL) has concentrated in areas of pathogenesis of HPAI using reverse genetics and microarrays to further understand host specificity for these viruses. Research on the development and use of DIVA vaccines for he prevention and control of HPAI continue, as well as the further understanding of the molecular epidemiology of avian influenza viruses collected from poultry and wild birds during domestic and international outbreaks. Works continues in the development of new tests, and the evaluation and revision of existing tests A copy of the presentation is available at http://www.usaha.org/committees/fe/fe.shtml.

Dr. Kimberly Forde-Folle, USDA-APHIS-VS, presented The North American Animal Disease Spread Model

The North American Animal Disease Spread Model (NAADSM) is a stochastic, spatial, state-transition simulation model designed to simulate the spread and control of highly contagious diseases in a population of susceptible animals. The model can be used to prepare emergency responders for disease outbreaks, demonstrate to policy makers the potential scope and impact of an animal disease outbreak, compare disease control strategies, and estimate the resources needed in the event of an outbreak. User-established parameters define model behavior in terms of disease progression; disease spread by direct and indirect contact, and airborne dissemination; and the implementation of control measures such as movement restriction, mass depopulation, and vaccination. Resources available to implement mass depopulation and vaccination programs, as well as the calculation of estimates for direct costs associated with the control strategies implemented, are taken into consideration. The model calculates detailed and summary statistics which can be used to reconstruct and analyze the simulated outbreaks. Geographical information can be used to produce maps, which can serve as visual aids to understand the distribution characteristics of a simulated outbreak. Currently, the model is being used to evaluate outbreak scenarios and potential control strategies for several economically important highly contagious animal diseases in the United States, Canada, and elsewhere. The model has been developed by professionals from the U.S. Department of Agriculture, the Canadian Food Inspection Agency, the Ontario Ministry of Agriculture Food and Rural Affairs, Colorado State University, and the University of Guelph and is freely available via the Internet at http://www.*naadsm*.org. The various applications of *NAADSM* for selected foreign animal diseases were presented. A copy of the presentation is available at http://www.usaha.org/committees/fe/fe.shtml.

Foot and Mouth Disease in North American Wildlife: Susceptibility, Clinical Signs and Lesions was presented by Dr. Jack C. Rhyan, USDA-APHIS-VS

Dr. Rhyan presented a summary of the results on the experimental infections of native North American wildlife species to FMD virus (O1 Manisa) conducted at the Plum Island Animal Disease Center. These experiments were design to try to increase the general knowledge on susceptibility, clinical and pathological manifestations, intra- and interspecies transmission with cattle, as well as to determine if conventional laboratory methods detect infection, if species may be long term carriers, and to conduct vaccine studies when indicated. In summary these results demonstrated that for all practical purposes, Bison infections with FMD resemble those observed in cattle. Bison developed severe clinical FMD but as typical for wildlife animals, they were stoic to pain and distress. Cattle transmitted FMD to bison, but at least during the time frame of the study bison did not transmit to calves, and at least under the conditions of th experiments, there was no conclusive evidence of long term (>28 d) infection or shedding (RT-PCR + tissue 37 dpi.). In contrast, and unexpectedly, while inoculated elk (Wapiti) developed clinical signs of fever and mild lesions, contact exposed elk did *not* develop clinical signs. Cattle exposed to inoculated elk did *not* develop clinical disease, while inoculated steer and contact steer developed severe disease. Two inoculated elk and one contact elk had only laboratory evidence of FMD (Serology and/or virus isolation). Studies in hand raise pronghorn resulted in all pronghorn and cattle developing clinical FMD (high fever, lesions). Pronghorn foot lesions were severe, mouth lesions mild, and intra and interspecies transmission occurred. Decubital ulcers in all pronghorn were observed. In conclusion, pronghorn are very susceptible to and capable of transmitting FMD, and lesions can be severe and in the wild would likely result in death. The last study involved mule deer. All mule deer developed FMD oral and foot lesions, and intra and interspecies transmission occurred, with several deer died acutely during study due to severe myocarditis. While great advances in the knowledge of the effect of FMD in North American wildlife have been achieved, there is still the need to know about the effect of vaccination in the FMD susceptible species as well as their role as potential long term carriers and on the best practices to manage outbreaks of FMD affecting wildlife. A copy of the presentation is available at http://www.usaha.org/committees/fe/fe.shtml.

Foot and Mouth Disease in the United Kingdom was presented by Dr. Richard Drummond Food and Farming Group, Department of Environment, Food, and Rural Affairs, United Kingdom

Dr. Drummond summarized the events associated to the 2007 FMD outbreak in UK, highlighting some of the key features of the event, including a description of impact on industry and stakeholders, the outcome of several official reviews and the implications for the future. The outbreak occurred in the vicinity of the Pirbright FMD laboratories and included two phases. One from 3 August to 7 September with 2 cases, and a second phase from 12 September to 30 September with 6 cases. Protection and surveillance zones were established and a large amount of sero-surveillance was done. These outbreaks were identified and controlled much faster and efficiently than the large outbreaks in 2001, and clearly the lessons learned from the latter outbreaks resulted in rapid and efficient responses in 2007. While there was no loss of consumer confidence in meat and the media coverage was fair, the attention was focused more on virus handling laboratory facilities. Six official reviews were initiated regarding the events that lead to this outbreak. As a result the regulatory authority for high biosecurity laboratories was transferred from Defra to the Health & Safety Executive. The re-build of the Pirbright laboratory is likely to go ahead but the exact details have not been finalized. A copy of the presentation is available at http://www.usaha.org/committees/fe/fe.shtml.

Foot-and-Mouth Disease in Humans: A Literature Review, a Search for the Risk Factors was presented by Dr. Suzanne Burnham, Texas Department of State Health Services

Dr. Burnham reported on an extensive literature search on the potential of FMD infection and disease in humans. The authors reviewed 468 references from the 1800's to the present, including 5 bibliographies, 11 dissertations, and 119 clinical reports with 381 case descriptions, many of them from Germany in the 1830's. Some studies in the US were reported in the 1910's. Collectively, putative FMD cases in humans were associated with the consumption of high quantity of raw FMDV infected milk, direct contact with FMD with broken skin, and laboratory accidents, all in the context of a predisposing existing disease conditions or immune suppression. In conclusion the paper determined that while some may consider that FMD is potentially a zoonotic disease, there is no evidence of contagious among animals, symptoms were usually very mild, and the practice of drinking large amounts of unpasteurized infected milk is very unlikely today. Several Committee members recommended that the final publication of the paper carefully state their final findings as to not to create unnecessary concern or regulatory actions by misinterpreting this data. A copy of the presentation is available at http://www.usaha.org/committees/fe/fe.shtml.

Dr. Preben Willeberg, Center for Animal Disease Modeling and Surveillance, School of Veterinary Medicine, University of California-Davis shared his presentation FMD/AI BioPortal Update

The FMD/AI BioPortal has been developed as a system for global emerging animal disease surveillance, to provide real time management of multiple streams of information with international involvement (data providers and users). The portal offers spatial and temporal visualization of data as well as phylogenetic analysis, cluster analysis and anomaly detection in support of the decision making process and prediction models. Several excellent examples of the utility and power of this portal were presented by Dr. Willeberg. A copy of the presentation is available at http://www.usaha.org/committees/fe/fe.shtml.

Equine Influenza and Hendra in Australia: Lessons from the 2007 Outbreaks was presented jointly by Dr. Peter D. Kirkland, Virology Laboratory, Emergency Management Australia Institute (EMAI) and Dr. Hugh Millar, Chief Veterinary Officer, Victoria, Australia.

The presenters summarized the epidemiological aspects of the large Equine Influenza outbreak that occurred in Australia from August to December, 2007. This was the first occurrence of this disease in Australia. Ample description of several aspects of the outbreak including control measures, vaccination actions, regulatory controls and communication with the equine industry were presented. This outbreak was a good example of the devastating effects of a highly contagious disease in a large population of naïve susceptible animals in a large geographic area. The Presenters also summarized the latest activity of Hendra virus in Australia. A copy of the presentation is available at http://www.usaha.org/committees/fe/fe.shtml.

African Swine Fever in the Caucasus, 2007 – 2008 was presented by Dr. Linda L. Logan, USDA-APHIS, on behalf of Robert Tanaka, USDA-APHIS Attaché, Vienna.

These outbreaks were the first occurrence of ASF in Georgia. All the outbreaks reported were in domestic swine. The origin of the outbreaks is officially inconclusive. But it is suspected that imported pork products (from Africa to the shipping Port of Poti). Introduced from ship's waste, and spread by garbage feeding to pigs. These outbreaks have spilled into Armenia, Russia and Azerbaijan. Many lessons have been learned from this outbreak that has connections with geographic, cultural, and geopolitical situations in the Caucasus region. A copy of the presentation is available at http://www.usaha.org/committees/fe/fe.shtml.

The final set of papers was related to educational activities regarding foreign and/or emerging animal diseases. These presentations included the following titles and presenters, and all presentations were provided for posting on the web site:

- School for Global Health at Washington State University, presented by Dr. Terry McElwain, Washington State University
- Up-date on Animal Health Initiatives in Afghanistan, presented by Dr. Bob Smith, United States Agency for International Development, USDA, Kabul, Afghanistan
- Combating infectious animal diseases on a global scale: Capacity building of National Animal Health Programs in newly established countries, paper prepared by Dr. Mo Salman, Colorado State University and presented by Dr. Paula Cowen, USDA-APHIS.
- Gulf region animal health overview, presented by Dr. Alfonso Torres, Cornell University
- Foreign Animal Disease training, presented by Dr. Paula Cowen, USDA-APHIS-VS
- Harmonization of diagnostic tests in North America, presented by Dr. Paul Kitching, British Columbia, Canada

Committee Business:

Three resolutions were proposed from the floor and having an ample quorum, the Committee discussed them and approved the Resolutions, which were forwarded to the Committee on Nominations and Resolutions.

RIFT VALLEY FEVER OVERVIEW AND RECENT DEVELOPMENTS AT USDA

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Abstract

Rift Valley fever (RVF) is a mosquito-borne viral disease with significant health and economic impacts to domestic animals and humans in much of sub-Saharan Africa. Human infections are believed to occur mainly from mosquito bites and from infectious aerosols. The available strategies for protection of humans are limited to use of mosquito repellents and other mosquito vector control. Epidemic disease can probably be prevented by vaccination of domestic animals which serve as virus amplifiers for arthropod transmission; however, there are no licensed vaccines available for use in the United States. Epizootics and epidemics of RVF are closely linked to the occurrence of the warm phase of the *El Niño/Southern Oscillation* (ENSO) phenomenon. We have developed a monitoring and risk mapping system using normalized difference vegetation index (NDVI) times series data derived from the Advanced Very High Resolution Radiometer (AVHRR) instrument on polar orbiting National Oceanographic and Atmospheric Administration (NOAA) satellites to map areas with a potential for an RVF outbreak in sub-Saharan Africa. This system is an important tool for local, national and international organizations involved in the prevention and control of animal and human disease, permitting focused and timely implementation of disease control strategies several months before an outbreak. A Geographic Information System (GIS)-based remotely sensed early warning system for potential RVF vectors in the U.S. and elsewhere is being developed. Mosquito forecasting information will be disseminated throughout the U.S., granting several months warning before conditions are suitable for elevated mosquito populations, permitting targeted implementation of mosquito control, animal quarantine and vaccine strategies in time to lessen or prevent animal and human disease.

Introduction

Rift Valley fever (RVF) is a mosquito-borne viral disease with pronounced health and economic impacts to domestic animals and humans in much of sub-Saharan Africa (1). The disease causes high mortality and abortion in domestic animals, and significant morbidity and mortality in humans (Tables 1-3). The virus is endemic in sub-Saharan Africa, but a large epidemic/epizootic in Egypt in 1977 demonstrated the possibility that the disease could be exported into new ecological regions. Many mosquito species worldwide are capable of biological transmission of Rift Valley fever virus (RVFV). A list of mosquitoes which may be potential vectors in the United States is shown in Table 4.

The disease in humans begins with fever, chills, and myalgias and typically is self-limiting after 2-5 days (Table 3). However, in a small number of cases hemorrhagic fever, or encephalitis may occur. Human infections are believed to occur following bites from infected mosquitoes and from infectious aerosols. The available strategies for protection of humans are limited to use of mosquito repellents and other mosquito vector control. Epidemic disease can probably be prevented by vaccination of domestic animals which serve as virus amplifiers for arthropod transmission; however, there are no licensed vaccines available for use in the United States.

The most important animal species in RVF epidemics are sheep and cattle. (Tables 2 and 3). Both suffer significant mortality (20% in pregnant ewes, greater than 90% in newborn lambs) and virtually 100% abortion after infection; and their viremia is sufficient to infect many mosquito vector species. Most transmission to domestic animals is by-arthropod bite. It is likely that vaccination of domestic animals will curtail epidemic transmission of RVF virus and an effective vaccine would also protect the recipient animal from disease and, with more difficulty, abortion. Both inactivated and live attenuated vaccines are available within endemic areas of sub-Saharan Africa, but both have significant disadvantages.

RVF epidemics in West Africa, Madagascar and the Arabian Peninsula have emphasized the importance of irrigation in the continuing emergence of this virus as a major agricultural and human pathogen in Africa and the Arabia Peninsula. The emergence of intense transmission in new geographical areas in Africa and Arabia have increased the potential for exploitation of the virus to distant receptive areas such as may exist in the Middle East, the Mediterranean, and the Americas.

Risk Assessment and Linkage to ENSO phenomenon

RVF epizootics and epidemics are closely linked to the occurrence of the warm phase of the *El Niño/Southern Oscillation* (ENSO) phenomenon (2). We have developed a monitoring and risk mapping system using normalized difference vegetation index (NDVI) times series data derived from the Advanced Very High Resolution Radiometer (AVHRR) instrument on polar orbiting National Oceanographic and Atmospheric Administration (NOAA) satellites to map areas with a potential for an RVF outbreak (3). This surveillance system operates in near-real time to monitor RVF risk on a monthly basis and offers the opportunity to identify eco-climatic conditions associated with disease outbreaks over a large area (4). This system is an important tool for local, national and international organizations involved in the prevention and control of animal and human disease, permitting focused and timely implementation of disease control strategies several months before an outbreak. The RVF outbreak on the West coast of the Arabian Peninsula in 2000 demonstrated that other regions of the world can be at risk of the disease (5). The surveillance system developed for Africa has been modified to include the Arabian Peninsula, and can potentially be adapted to assess the risk of RVF and other arthropod-borne disease outbreaks in new ecological settings (6). We are currently developing a Geographic Information System (GIS) early warning system for RVF vectors in the U.S. using mosquito surveillance data collected by mosquito control and public health agencies, and climate data derived from satellite measurements and terrestrial weather stations. The GIS predicts disease transmission patterns based on the quantitative relationship between mosquito activity and patterns of local and global climate, and identifies early warning parameters associated with elevated populations of potential RVF vectors. Linkages between climate and mosquito densities are evaluated with spatial and temporal statistics, generating risk maps to inform vector control agencies. Mosquito prediction information will be disseminated throughout the U.S., granting several months warning before conditions are suitable for elevated mosquito populations, permitting targeted implementation of mosquito control, animal quarantine and vaccine strategies in time to lessen or prevent animal and human disease. The infrastructure and systems we develop in preparation for RVF can be laterally transferred to inform strategies against any other mosquito-borne disease threat.

Potential for RVF Risk Assessment in the U.S.

The documented expansion on RVF beyond sub-Saharan Africa into Egypt in 1977 (7) and more recently the emergence of the disease in Saudi Arabia and Yemen in 2000 (5) makes RVF a possible candidate for further globalization. Like the introduction of WNV into the U.S. in 1999 an introduction of RVF into the U.S. would pose a significant risk to the humans, domestic animals and wildlife. RVF would also present significant effects on the agricultural and public health community. The effect on the U.S. economy at large, including livestock feed suppliers, health care insurance, the food-service industry, and loss of confidence in the food supply, would be significant. The BSE outbreak in the United Kingdom in 1986 cost the European Union more than $100 billion. The U.S. had beef-related exports in 2003 of $5.7 billion. Additionally, the OIE imposes a 4 year trade ban on any country with confirmed RVF transmission and the ban is lifted only after a country is disease free for 6 months. It is important to now consider methods to adapt the RVF risk mapping methodologies developed for Africa for its application in other regions of the world, specifically the U.S.

There are two cases for predicting likelihood maps of RVF mosquito vectors, and thus the dispersal of RVF, in the U.S. The first depends upon the presence, vector competence, and vectorial capacity of mosquito vectors at the time and place of introduction of RVF in the U.S., which in turn depends on the historical climate patterns of vector abundances, and the climate in Africa and the magnitude of RVF activity there at that time. The second depends on the status of vectors after introduction takes place, which is driven by climate in the U.S. and historical patters of vector abundances. The second case leads to informed predictions of changes and movement of vector abundances across the landscape, and thus spatially-explicit patterns of risk for the appearance of RVF.

Each case highlights an important concept in handling the possibility of RVF in the U.S. By monitoring climate in the U.S. and in Africa, reports of RVF activity in Africa and worldwide, trade and movement of people between the U.S. and Africa, and the status of candidate vectors and reservoirs at nodes of potential arrival pathways of RVF, we can do a great deal to minimize the constellation of favorable conditions needed for RVF to arrive in the U.S. in the first place. On the other hand, by keeping a close eye on the status of candidate RVF vectors in the U.S., and developing predictive risk models of where vectors could be at any given time, we can more efficiently target, mobilize, and implement control and containment strategies (including vaccines, test kits, education, and vector control) should RVF actually be detected in the U.S.

Both cases hinge on the biogeographic links between organisms and climate. In Africa remotely sensed climate data are routinely and successfully used to flag areas at high risk of vector outbreaks and thus the earliest stages of a RVF epizootic (2,3). We are developing a companion approach in the U.S., but since RVF is not present in the U.S., and there is no historical climate precedent for RVF outbreaks there we are instead looking at the predictive power of climate to inform us of vector population dynamics.

Summary

In summary RVF is a mosquito-borne viral disease that causes significant periodic morbidity and mortality to domestic animals and humans in much of sub-Saharan Africa. Our current monitoring and risk mapping system, based upon NDVI and SST data from AVHRR instruments on polar orbiting NOAA satellites, is effective in assessing the potential spatial and temporal distribution of RVF transmission. RVF has demonstrated its ability to expand its distribution outside of the African continent. To prepare for the potential introduction into the U.S. we are developing a GIS/remotely sensed early warning system for RVF vectors in the U.S. using mosquito surveillance data collected by mosquito control and public health agencies, and climate data measured by satellites and terrestrial weather stations. The GIS predicts disease transmission patterns based on the quantitative relationship between mosquito activity and patterns of local and global climate, and identifies early warning parameters associated with elevated populations of potential RVF vectors. Linkages between climate and mosquito densities are evaluated with spatial and temporal statistics, generating risk maps to inform vector control agencies. Mosquito prediction information will be disseminated throughout the U.S., granting several months warning before conditions are suitable for elevated mosquito populations, permitting targeted implementation of mosquito control, animal quarantine and vaccine strategies in time to lessen or prevent animal and human disease. Many of the systems we develop in preparation for RVF can be laterally transferred to inform strategies against any mosquito-borne disease threat. Additionally the methodologies that we are developing could be used for RVF surveillance could be adapted for use in neighboring countries in North America, other continents such as South America, Europe, Eurasia, Asia, and Australia.

Acknowledgement. This study was supported in part by the Department of Defense Global Emerging Infections Surveillance & Response System

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Table 1. Clinical disease in Cattle.

Feature	Characteristics
Incubation period	1-6 days
Clinical signs	Calves: —Fever of 40°-42°C (104°-106°F) —Depression —Icterus —Anorexia and weakness —Listlessness —Evident abdominal pain Adults: —Fever of 40°-42°C (104°-106°F) —Excessive salivation —Anorexia —Weakness —near 100% abortion, Fetid diarrhea —Fall in milk yield —Nasal discharge
Case-fatality rate	—Calves: 10%-70% —Adults: <10% in indigenous breeds

Table 2. Clinical disease in Sheep and Goats

Feature	Characteristics
Incubation period	Lambs: 12-36 hr Adults: 1-6 days
Clinical signs	Lambs: —Fever of 40°-42°C (104°-107°F) —Anorexia and weakness —Listlessness —Evident abdominal pain Adults: —Fever of 40°-41°C (104°-106°F) —Mucopurulent nasal discharge —Vomiting —Anorexia —Listlessness —Diarrhea —Icterus
Complications	—Abortion rates can reach 100% (aborted fetus often autolysed) —Peracute hepatic disease in lambs and kids <1 wk of age —Hepatitis —Cerebral infections —Ocular infections
Case-fatality rate	Lambs —<1 wk of age: as high as 100% —>1 wk of age: as high as 20% Adults: 20%-30%

Table 3. Clinical disease in Humans.

Characteristic	Features
Incubation period	2-6 days
Prodrome	Fever, headache, photophobia, retro-orbital pain
Clinical signs/symptoms	—Subclinical infection common —Four clinical patterns: ~Undifferentiated fever lasting 2-7 days (>90% of cases; often associated with nausea, vomiting, and abdominal pain) ~Hemorrhagic fever with marked hepatitis and bleeding manifestations (<1% of cases; occurs 2-4 days after onset of fever) ~Encephalitis (<1% of cases; occurs 1-4 wk after onset of fever) ~Retinitis (up to 10% of cases; occurs 1-4 wk after onset of fever; often bilateral; hemorrhages, exudates, and cotton wool spots may be visible on macula; retinal detachment may occur) —Common bleeding manifestations include gastrointestinal bleeding and epistaxis —Neurologic symptoms include confusion, lethargy, tremors, ataxia, coma, seizures, meningismus, vertigo, choreiform movements —Hepatitis, hepatic failure, and renal failure may occur —A report of the 2000 outbreak in Saudi Arabia identified the following clinical features for 683 laboratory-confirmed cases: ~Fever: 92.6% ~Nausea: 59.4% ~Vomiting: 52.6% ~Abdominal pain: 38.0% ~Diarrhea: 22.1% ~Jaundice: 18.1% ~Neurologic manifestations: 17.1% ~Hemorrhagic manifestations: 7.1%

Table 4. A partial list of potential vectors of RVF in the United States

RVFV Control – Priority Vectors		
	RVFV Vector Competence	**Transovarial Transmission**
Aedes vexans	Yes	Unknown
Aedes taeniorhynchus	Yes	Unknown
Aedes sollicitans	Yes	Unknown
Aedes canadensis	Yes*	Unknown
Aedes excrucians	Yes*	Unknown
Aedes triseriatus	Yes*	Unknown
Aedes albopictus	Yes*	Unknown
Anopheles species	No	Unknown
Culex salinarius	Yes*	Unknown
Culex tarsalis	Yes	Unknown
Culex territans	Yes*	Unknown
Culex pipiens	Unknown**	Unknown
Culex quinquefasciatus	Unknown**	Unknown
Psorophora columbiae	Unknown	Unknown
*Probably of lower importance		
**Varies from inefficient to efficient for various African and European strains. Little to no data on North American strains.		