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Review Article

Review on Epidemiological Interface of Foot and Mouth Diseases between Wild Animals, Domestic Animals and Human

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Abstract

Diseases transmission at wild-domestic interfaces is an important epidemiological issue on most continents. Humans live increasingly in the proximity of natural areas, leading to increased interactions between people, their livestock and wildlife. Wildlife is a maintenance host for several significant livestock diseases. The raised strategy for cattle herders at the wildlife/livestock interface might be to decrease the likelihood of livestock depredation by avoiding the use of protected areas when the constraints in communal lands are adequate. Interspecific pathogen transmission may occur in complex socio-ecological systems at wild-domestic interfaces that have so far been seldom studied. The potential spillover of Foot and Mouth Disease (FMD) virus at the wildlife-livestock interface and interventions to control disease transmission at the wildlife-livestock interface is the present-day challenging due to different reasons. The risk of pathogen spillover between sympatric host populations is restricted to limited areas at specific seasons and predators could mitigate interspecific disease transmission. There is also limited studies considering humans, livestock and wildlife concurrently. This review outlines epidemiological interfaces for the spread of Foot-and-Mouth Disease.

Keywords: Foot-and-Mouth Disease; Epidemiology; Livestock-Wildlife-Human Coexistence; Interspecific contacts

Introduction

FMD mainly affects members of the order Artiodactyla (all cloven-hooved mammals) and is endemic in Africa, Asia, South America and parts of Europe. Many diseases including FMD have been reported from around the world that is shared between wildlife and livestock. Important livestock hosts include cattle, pigs, sheep, goats, water buffalo and yaks. Other susceptible species include reindeer (Rangifer tarandus), deer and elk (Cervus elaphus nelsoni). The FMD virus is a small non-enveloped RNA virus. It is a member of the genus Aphthovirus in the family Picornaviridae. There are seven major viral serotypes: O, A, C, SAT1, SAT2, SAT3 and Asia 1. RNA viruses show frequent spontaneous mutation and serotypes are more variable which contain more than 60 strains. Most strains affect all susceptible host species, some have a more restricted host range (e.g., the serotype O Cathay strain, which only affects pigs). Serotype O is the most common serotype worldwide. Immunity to one FMDV serotype does not protect an animal from other serotypes. Protection from other strains with in a serotype varies with their antigenic similarity. The onset of FMD in affected animals is manifested by a precipitate fall in milk yield and a high fever (40-41"C; 104-106°F), accompanied by severe dejection and anorexia, followed by the appearance of an acute painful stomatitis, profuse salivation, vesicles in mouth and feet. The incubation period can range from 1-14 days. However, the extent to whichs patial and seasonal variation in contact rates between buffalo and cattle drive FMD incidence patterns is still unknown, and so is the impact of vaccination campaigns on the circulation of the virus. Therefore, the objectives of this review paper is:

- To highlight foot and mouth diseases at wildlife-livestock interface, their spread and impact, wild life and domestic animal health and other attributes of this disease transmission.
- To highlights the complex dynamics that operates at human-livestock-wild life interfaces.

Geographic Distribution

There are no reliable figures for the prevalence of FMD in different countries. The disease generally occurs in the form of an outbreak that rapidly spreads from herd to herd before it is controlled. Foot and mouth disease is endemic in parts of Asia,

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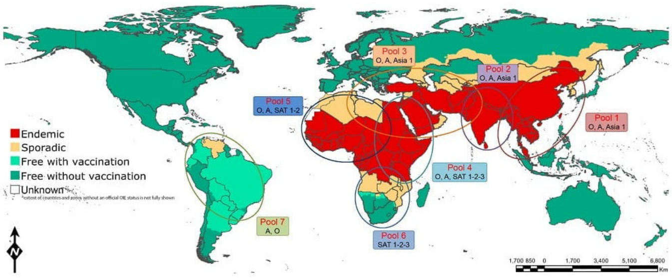

Figure 1: World map showing the distribution of Foot-and-Mouth Disease (FMD) virus pools by serotype (source:) (reprinted and adapted from [5]).

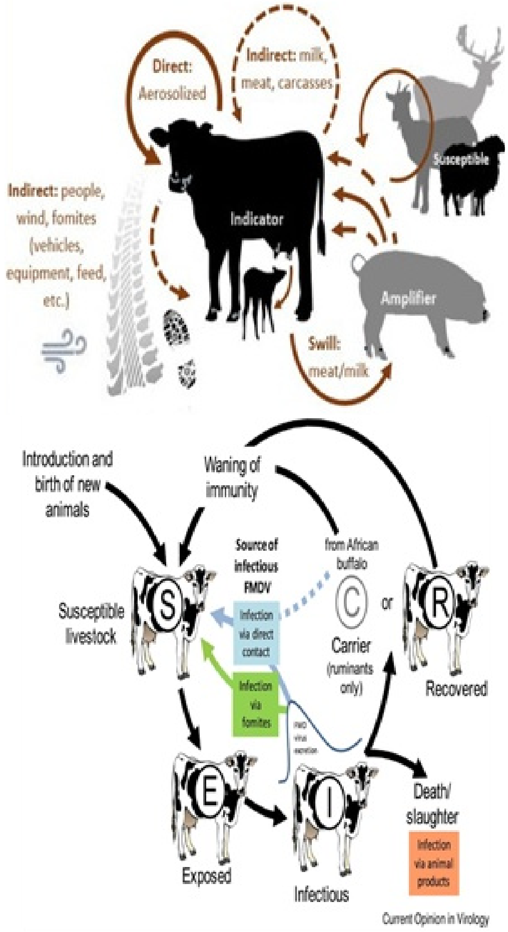

Figure 2: Foot and Mouth Diseases transmission (FMDF act sheet OIE-WAHIS Interface: https://wahis.oie.int/#/home,2021).

Africa, the Middle East and South America. While serotypes O and A are widely distributed, SAT viruses occur mainly in Africa (with periodic incursions into the Middle East) and Asia 1 is currently found only in Asia.

FMD Route of Transmission

Highly contagious and transmission is by inhalation/ingestion. Virus is present in fluid from ruptured vesicles and in almost all secretions and excretions including serum, oral and pharyngeal fluid, urine, faces, semen, milk, bone marrow and lymph nodes of carcass meat. Large quantities of virus are released in expired air, particularly in pigs; this is why pigs are seen as important amplifiers of FMD. The major route of virus entry in ruminants is via the respiratory system; very low doses of virus can initiate infection. Higher doses of virus are required to infect animals by the oral route in comparison to the respiratory route. Pigs are frequently infected by the oral route while in ruminants' oral infection is uncommon. Fomites, including bedding, mangers, clothing, motor tires, harness, feed stuffs and hides, may also remain a source of infection for long periods. People can act as mechanical vectors for FMDV, by carrying the virus on clothing or skin. The virus might also be carried for a time in the nasal passages, although several studies suggest prolonged carriage is unlikely (Figure 2).

FMD Transmission between Domestic Animals and Wild Animals

FMD have been transmitted from livestock to wildlife. Movement of livestock provide a route for the transmission of pathogens between populations. Land use, human and animal movements and grazing by livestock have been considered as a major force in the spread of diseases from domestic animals to wild populations and vice-versa. Some of the diseases in livestock have spilled-over to wild populations and have spilled back to livestock. In most of the cases, the economic, geographical and ecological situations which permit reciprocal transmission are extremely variable [17]. Increasing human populations and the associated resource consumption and habitat fragmentation force humans and their domestic animals to live in increasing proximity to protected areas and wild life [21]. Protected areas are often delimited by soft and porous frontiers such as rivers or roads, and consequently, animal movements between protected areas and their periphery occur in both directions [4]. The interfaces between protected areas and surrounding communal lands are thus hotspots of potential interactions between people, their live stock and wild life, often typified by human–wildlife conflicts including threat to human life [16], livestock depredation by carnivores [12], crop destruction by wild herbivores [8], competition for shared resources [14], hunting or illegal poaching and disease transmission [9]. World-wide, increasing human populations and the associated resource consumption and habitat fragmentation force humans and their domestic animals to live in increasing proximity to protected areas and wildlife. In Africa, where population growth is the highest and the populations living at the edge of protected areas have increased dramatically in the recent [2]. The use of space by cattle in African range lands is likely to reflect a trade-off for cattle herd and disease transmission from wild reservoirs (Figure 3).

Risk Factors for FMD

Host Risk Factors: The disease is most important in cattle and pigs but goats, sheep, buffaloes are also affected. Some strains of the virus are limited in their infectivity to particular species. Immature animals and those in good condition are relatively more susceptible and here dietary differences in susceptibility. A variety of wild life species such as the deer in England, the water buffalo (Bubalusbubalis) in Brazil and wild ungulates in Africa become infected periodically. A notable exception is the African buffalo (Syncerus caffer), probably the natural host of the SAT types of the virus and the major source of infection for cattle in southern Africa. Small rodents and hedgehogs in Europe and capybaras in South America may also Acta reservoirs.

Environmental and Pathogen Factors: The virus is resistant to external influences including common disinfectants and the usual storage practices of the meat trade. It may persist for over 1 year in infected premises, for 10-12 weeks on clothing and feed, and up to a month on hair. It is susceptible to changes info away from neutral, sunlight destroys the virus quickly but it may persist on pasture for long period sat low temperatures. The virus can survive for more than 60 days in bull semen frozen to-79°C.

Immune Mechanism: In endemic areas, periodic outbreaks

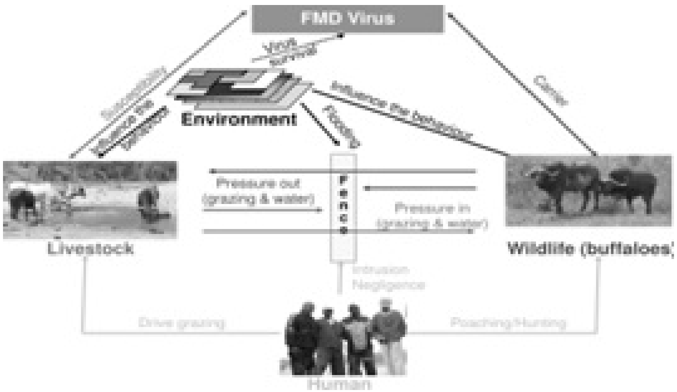

Figure 3: FMD Transmission at wildlife-livestock-human interactions.

occur which sweep through the animal populations and then subside. A long year epidemic cycle has been causes the disappearance of immunity which develops during an epidemic and the sudden flaring up from small foci of infection when the population becomes susceptible again. Immunity after natural infection lasts for 1-4 years in cattle and for a shorter time in pigs.

Factors Attributed to Disease Transmission at Wildlife-Livestock Interface

Land use Patterns: The rapid growth in global human population has resulted in the expansion of human -dominated landscape and use of more land for agriculture and irrigation and developmental activities. There by extensive livestock farming has taken place over the years, which led to the emergence and re-emergence of many diseases both shared by wild life and livestock. The altered agricultural practices result in the change in habitat. This forces the wildlife to come into close proximity with human habitation, there by jumping of pathogens to new host takes place. cohabitation between domestic and wild species may also have some beneficial effects. This pattern of land use has more chance of contact between livestock and wild animals, thus there is every possibility of bi-directional transmission of disease [17]. Cohabitation between domestic and wild species have beneficial effects.

Grazing/Pastoralism: A large proportion of human population depends on livestock for their sustenance. The increase in land use pressure and grazing of these livestock has led to a conflict between pastoralists and wildlife resulting in a growing risk of disease transmission between livestock and wildlife and increasing competition for grazing and water resources [11]. In East Africa there are large numbers of small-scale farmers, traditional pastoralists, and wilderness areas with wild life and livestock often mixing on a continuous or seasonal basis. Disease control measures usually rely on ethno-veterinary practices, based on traditional knowledge of livestock diseases [20]. The dynamics of both wildlife and domestic diseases and the changes in livestock and wildlife management make it increasingly difficult to overview the current situation of wildlife diseases in continents like Europe [7]. The expansion in grazing land of livestock has resulted in the sharing of habitats with the wild animals. In tropical countries, due to the high ambient temperature, animals tend to concentrate under trees or other shaded areas for parts of the day like wallowing sites, preferring to graze early in the morning and late in the afternoon [1]. These areas serve as interface for transmission of disease to both wildlife and livestock.

Movement of Animals/Global Trade: The increased human and animal mobility as well as a constantly evolving animal trade across the globe. The translocation of wild or domestic animals is one of the major factors responsible for the introduction of diseases. Transports are often carried out under very poor conditions because animals are piled up and stressed and their susceptibility to infections increases [13]. Wildlife trade is one of the main problems in a potential cross-species transmission of infectious agents [7]. In East and Southeast Asia, millions of wild animals are shipped each year regionally and from around the world for food or use in traditional medicine.

Role of Vectors/Carriers: Arthropods like ticks and flies play an important role in the bidirectional transmission of infectious agents in wildlife-livestock interface [10]. The prevalence and distribution of diseases have increased due to a result of carriers [19].

Effect on livestock production/Economic Importance of FMD

FMD is the most feared animal disease in the developed world, even though the mortality rate is low. Morbidity from FMD varies with the animal's species, breed and pre-existing immunity, as well as the dose of virus and other factors. The morbidity rate can approach 100% in naïve cattle or swine herds, but some FMD viruses can disappear from a sheep flock after infecting a relatively low percentage of the animals. Adult livestock do not usually die from FMD (the case fatality rate is approximately1-5% for most strains), but deaths can occur in young animals. Most infections in wild life species appear to be similar to those in domesticated animals. It is the most contagious disease of livestock and has a great potential for causing severe economic loss in high producing animals. Losses occur in many ways although loss of production, the expense of eradication and the interference with movement of livestock and meat between countries are the most important economic effects. There are also significant losses in agriculture and tourism due to restriction on human movement. The outbreak of disease in the livestock farms directly affects their venue generated from them. Outbreaks of the diseases in the livestock has increased market instabilities in many countries.

Zoonotic Importance

Humans are believed to be slightly susceptible to infection with the virus and vesicles may develop in the mouth or hands. Very few cases have been reported even among people working with infected carcasses and laboratories.

Managing or Control and prevention of FMD at Wildlife-Livestock Interface

Surveillance and Monitoring Programs: Understanding the dynamics of disease transmission at the wildlife-domestic interface is a critical step to prevent disease transmission and to work towards the overall goal of improving health, livelihoods, and conservation outcomes. Most attempts to manage or control diseases at the wildlife-livestock interface are done because they are a threat to public health and the livestock production industry. Recent disease epidemics and their spread around the world have illustrated the weaknesses of disease surveillance and early warning systems, both at national and international levels. The existence of interface continuously threatens wildlife, livestock and public health.

The implementation of epidemiological surveillance should be based on both epidemiological (regular collection and analysis of epidemiological information and early warning systems for animal diseases) and ecological monitoring (surveillance of vectors and wild reservoirs) [3]. The OIE List A diseases should be reported immediately while others must be turned in annually when diagnosed. Information gathered should be displayed graphically. It should be correlated with human disease reports to allow epidemiologist to conduct case investigations that include all information. As public health implements programs to address the animal disease, the surveillance system should allow the ongoing monitoring and evaluation of the various programs [23].

Vaccination Programs: Immunizations are an integral part of an effective herd health program. Vaccinations help to curtail the emergence of disease and limit its spread from animal to animal. A mass vaccination and disease screening program should be conducted in these human populations for the presence of any endemic pathogen to prevent cross-infection. In countries where the disease is endemic, or where there are wildlife reservoirs, eradication is seldom practicable. In areas with only occasional epidemics, slaughter of all infected and in-contact animals is usually carried out.

Restricted Animal Movements: This is accomplished by prohibition or strict controls of the importation of animals and animal products from endemic areas. The exact initial mode of FMD contamination has not always been identified, but vehicles, markets, and other places where animals are collected have played a major role in the spread of the disease [15]. Livestock movement control should ensure stock inspection at markets, auction yards, stock routes, and entry points. Proper disease screening of the herd should be conducted which are subjected to movement. Grazing and movement of livestock in protected areas are checked to prevent disease interface. Stall feeding of livestock should be practiced in places where there is high risk of disease interface with wildlife.

Trade Policies and Restrictions: The World Trade Organization has a series of agreements on agriculture and agreements on Sanitary and Phyto-sanitary measures which apply to certifying animals and animal products for international trade. This restricts the spread of any disease or infectious agent across states through animals or their products. Even though the World Trade Organization agreements call for scientific bases of trade barriers, the disputes over proper trade actions demonstrate that imposing trade bans are controversial and that re-establishing trade which is a necessary first-step to recovering market share is relatively difficult to achieve and notal ways transparent in nature. The increase in international travel and trade brings an increased risk of unmonitored pathogens via the illegal wild life trade. Through better surveillance of illegal wildlife product shipments entering ports around a country, authorities will have a better chance at preventing new disease emergence before it occurs [18].

Intensive Management: Both wildlife population and livestock need to be intensively managed so as to ensure minimal interaction between the populations. This can be facilitated by ensuring proper selection of productive herd in livestock and stall-feeding of livestock can be an effective tool to prevent the spread of diseases form wildlife.

Productive cattle should be maintained in farms, whereas unproductive ones should be culled. Proper land-use policy should be ensured to mitigate interface related problems. In case of wildlife, habitat improvement like construction of water bodies, should be integrated in protected areas so that the chances of wild life going out of their habitat is minimized. Habitat modification may also be used to reduce exposure to disease agents, or to alter host distribution or density [22].

Biosecurity Concerns: The virus is very resistant and able to survive well in the environment. Measures taken to control an FMD outbreak include quarantines, euthanasia of affected and exposed animals, and cleaning and disinfection of affected premises, equipment and vehicles. It is susceptible to in activation at low or high pH, so acid or alkali disinfectants can be effective. Various disinfectants including sodium hydroxide, sodium carbonate, citric acid and Virkon are effective against FMDV. Survival in the environment is dependent on pH, temperature, humidity and initial concentration.

FMD is highly contagious, there are biosecurity concerns regarding intentional or accidental introduction of the virus into nonendemic countries. Intentional introduction would be a form of agroterrorism and this would be devastating in any country that is FMD free, since it would probably take somedays before the disease would be recognized and much longer before it could be stamped out. Laboratories working with FMD virus or producing FMD vaccines and reagents must comply with OIE requirements for to ensure that there is no escape of the virus. There are also strict regulations for shipping diagnostic samples to national or international laboratories.

Awareness Programme: The general public as well as the professionals should be made aware of the growing risks of wildlife-livestock interface diseases and the steps to be taken to prevent such transmission. People residing in the periphery of protected areas should be provided with alternatives to restrict their livestock grazing with wildlife in these areas. A standard disease prevention program should be developed for management of herd in farms which should include strict hygiene and sanitary measures. In regions normally free of certain disease, the first line of defense is to prevent introduction of the pathogen into susceptible populations.

Conclusion and Recommendations

FMD is highly contagious diseases transmitted from livestock to wildlife and vice-versa. The importance of wildlife-livestock interface cannot be undermined and there is an urgent need for innovative animal disease control policies that do not limit land use options and proactive planning and management strategies is necessary to prevent the epidemics or development of serious FMD. Generate ways to decrease contact of wildlife and livestock.

To control transboundary spread of FMD, capacities for emergency preparedness and response to disease outbreaks need to be developed throughout the globe by building up Early Warning Systems (EWS) and strict epidemiological surveillance and monitoring. The proactive planning and management strategies is necessary to prevent the emergence or development of serious FMD. Integrated approaches that in corporate inter-disciplinary expertise from wildlife managers, ecologists, conservation biologists, and environmental scientists. Focusing efforts at markets and movements of livestock to regulate, reduce, or eliminate the risks for disease for domestic animals and wildlife.

Author Statements

Conflicts of Interest

The authors declare they do not have conflicts of interest.

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