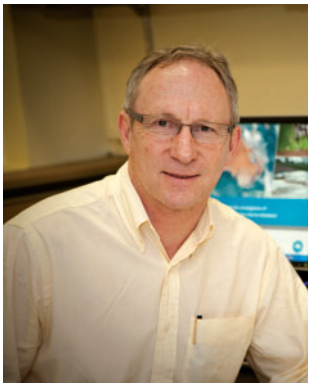
Bovine ephemeral fever: cyclic resurgence of a climate-sensitive vector-borne disease



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Bovine ephemeral fever is one of Australia's most important viral diseases of cattle. It is caused by a rhabdovirus that is transmitted by haematophagous insects, most likely mosquitoes, producing seasonal epizootics that can have serious impacts on beef and dairy production. Since 2008, extreme summer rainfall and extensive flooding have provided ideal conditions for the emergence of large mosquito populations, accompanied by successive extensive epizootics of bovine ephemeral fever. Climate change predictions of the increasing intensity and frequency of alternating droughts and severe La Niña events in Australia suggest there is a need to explore new intervention strategies to reduce or eliminate the future impacts of this costly disease.

Bovine ephemeral fever (BEF) is a debilitating, and sometimes fatal, viral disease of cattle and water buffalo. Also called three-day sickness (and various other local names), it is enzootic in tropical and sub-tropical regions of Africa, Asia and Australia, surging seasonally into temperate zones in sometimes extensive epizootics. It does not occur in most of Europe, the Pacific Islands or the Americas, where it is considered a significant exotic disease threat. The causative agent, bovine ephemeral fever virus (BEFV) is an arthropod-borne rhabdovirus (genus *Ephemerovirus*, family *Rhabdoviridae*)[1]. Although the disease is non-contagious and the epizootiology is consistent with insect-borne transmission, the vectors of BEF are not well defined. The virus has been isolated from both mosquitoes and biting midges (*Culicoides* spp) in Australia and Africa, but various factors suggest that mosquitoes are the principal vectors. Only one BEFV serotype exists worldwide and infection apparently leads to life-long immunity[2].

The clinical signs of BEF can be severe but are usually transient and can include anorexia, rumenal stasis, nasal and ocular discharge, excessive salivation, stiffness, joint swelling, rear limb paralysis and a biphasic fever. Typically, during extensive epizootics morbidity rates are very high (up to 80% in some herds) and, although mortality rates are usually quite low (less than 1%), deaths are more likely to occur in older, heavier, more valuable animals[3]. Due to the transient nature of the disease and low mortality rates, the economic impact of BEF is often underappreciated. Disease results in decreased milk production in dairy herds, delayed oestrus and mid-term abortions in cows, temporary infertility in bulls, and loss of condition in beef herds. The economic loss during a severe epizootic season in Australia can be as high as $100–200 million.

In recent years, major BEF epizootics have occurred in Taiwan and China, the Middle-East, and Australia, in some cases with unusually high mortality rates. Mortalities due to disease and culling of affected animals were reported to be as high as 11.3% and 21.9% in Taiwan in 1996 and 1999, respectively[4]. A mortality rate of 8.6% was reported in Jordan in 1999[5] and a severe epizootic with high mortalities (12% of clinical cases) was reported in NSW in 2001. In Henan Province in China, mortality rates have been reported to have increased significantly since 2000, estimated at 18% of cases in 2004 and 2005, and 5% in 2011[6]. It is not clear at this stage if the increased severity of the disease is associated with changes in virulence of the virus or environmental factors that have increased host susceptibility to infection.

In Australia, BEF has been known since 1936 when a sweeping epizootic surged out of the Top End of the Northern Territory (Fig. 1) spreading westward into the Kimberleys and eastward through NSW and Queensland, reaching Victoria in the late summer of 1937[3]. The prevalence of infection was very high, approaching 100% in northern areas. Similar wave-like epizootics occurred in 1955–56 and 1967–68, and then several occurred in succession during an intense La Niña period that persisted until 1976. The epizootiology of the disease in Australia then changed dramatically, with the virus becoming enzootic throughout a vast area of eastern Australia as far south as the Hunter Valley in NSW. Although the disease remained perennially active in the Top End, in Queensland and NSW the pattern was characterised by annual sporadic local outbreaks with occasional extensive epizootics during periods of heavy rainfall[3]. Surveillance data from sentinel herds indicated annual seroconversions in the eastern states and Western Australia, with very low levels of transmission during extended periods of drought, particularly during winter and spring.

In the summer of 2007–2008, after a period of prolonged drought, a return to La Niña conditions with record rains and extensive flooding

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Figure 1. Top End of the Northern Territory, Australia.

throughout much of eastern Australia caused a surge in mosquito populations and another extensive BEF epizootic. Large numbers of diseased animals were reported throughout the Northern Territory and Queensland with high morbidity and mortality rates, particularly in the severely flooded Belyando District in Central Queensland. In New South Wales, a widespread epizootic commenced near Bourke in the north-west of the state in the first week of January 2008 and progressed rapidly to the Victorian border over a period of 2–3 weeks. As in the epizootic of 1970–71, the southerly sweep of the 2008 epizootic in NSW was initially west of the Great Dividing Range with transmission subsequently occurring on the coast. This appears to have been due to the deposition of insects carried from Queensland in an intense low pressure system that moved through the region at that time[7]. BEF remained very active in Queensland during the summer and autumn of 2009 and then, in early 2010, widespread flooding across much of eastern Australia resulted in another extensive epizootic, with the virus entering northern Victoria for the first time since 1996.

With the imminent return to El Niño conditions to Australia in coming years, we will undoubtedly see a decline in the BEFV transmission throughout much of eastern Australia and, as in the past, the disease will again assume less importance to farmers. However, as rainfall declines and leads inevitably to drought, and as vector activity declines and leads inevitably to low herd immunity, the large susceptible cattle population will inevitably host future extensive epizootics. An effective BEF vaccine is available in Australia but its adoption rate in northern beef herds is low primarily because of the need to muster for multiple vaccinations to get effective protection and its use in dairy herds declines as epizootics subside. Nevertheless, the availability of the vaccine presents the opportunity for more effective intervention and the seasonal characteristics of the disease raise the interesting question of the potential for future eradication.

Phylogenetic analyses conducted using the complete ectodomain region of the BEFV G gene (encoding the surface transmembrane glycoprotein) indicate that the Australian clade is a single lineage, which is evolving at a relatively constant rate, and that all Australian isolates are derived from a single ancestral virus that was introduced approximately 60 years ago. Although West Australian isolates have not been analysed to date, the absence of regional sub-lineages amongst 100 or more isolates analysed from Queensland, NSW and the NT indicates that the virus is continually extinguished in the eastern states due to transmission failure, and replenished regularly by strains from the tropical endemic focus in the Top End. Could we therefore, through targeted vaccination, halt completely the low level of transmission that occurs during winter months, particularly in periods of severe drought? As infection leads to lifelong immunity and a durable vaccine is available, this appears to be feasible in the eastern states where winter seroconversions are sometimes not detected. However, the Top End presents a more significant challenge as beef herds are large and remote and feral water buffalo are likely to be involved in the epizootiology. The molecular epizootiology clearly shows that eradication in eastern states would be temporary if there remained an endemic focus in the North. Nevertheless, it is clear that the impacts of BEF in Australia are substantial during periods of cyclic resurgence such as we have seen recently, and more effective intervention strategies are badly needed.

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Biography

Dr Peter Walker is a Chief Research Scientist at the CSIRO Australian Animal Health Laboratory (AAHL) in Geelong. He is a virologist with expertise in a wide range of diseases in humans, livestock and aquatic animals. He leads a research program that aims to reduce the risks of emergence and spread of climate-sensitive viral diseases that are transmitted by biting insects. His current research includes arbovirus discovery and population genomics, insect vector biology and insect innate immunity. He also has an interest in aquatic animal health and viruses infecting aquatic invertebrates.