Lessons to be learned from foot-and-mouth outbreaks

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Categories : Farm animal, General, Vets

Date : March 21, 2016

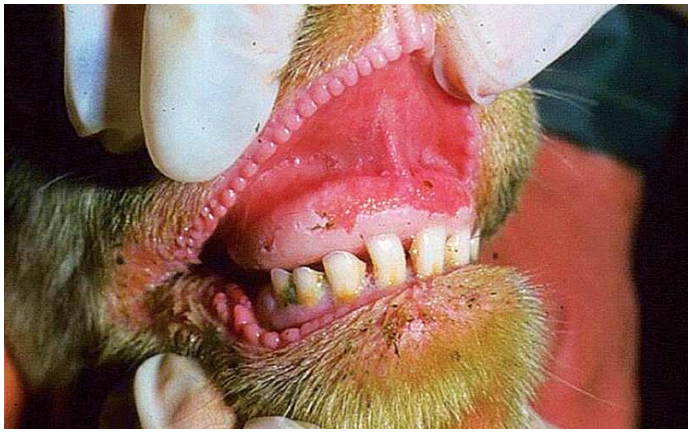
ABSTRACT

Foot-and-mouth disease (FMD) is the major disease constraint to international trade in livestock and animal products. Countries free of FMD enjoy access to world markets, but endemically or sporadically-affected countries suffer productivity losses in their territory and have greatly reduced opportunities for trade.

Consequently, FMD-free countries, such as the UK, take strong measures to avoid the introduction of the disease and generally have well-established contingency plans to mount a rapid and effective response, should the virus gain entry and cause an outbreak.

The participation of the author in the BBC Radio 4 programme *The Reunion*, which featured the UK 2001 FMD outbreak, rekindled his memory of that devastating episode. His involvement in that FMD event and the Pirbright Laboratory, for which he was responsible, is reviewed. He retired in 2002, but has maintained a keen interest in FMD. In this article, he recollects on FMD events that have occurred in the UK from 2001 to 2011.

“Essex samples positive for type O FMDV by ELISA”. This was the note passed to me by a staff member at the Pirbright Laboratory on 20 February 2001 and one of the events I recalled when participating on BBC Radio 4 programme *The Reunion*, which featured the UK 2001 foot-and-mouth disease (FMD) outbreak.



A sheep with foot-and-mouth disease showing erosion of the dental palate.

This prompted me to reflect on the 2001 UK FMD outbreaks and other FMD events during the decade of 2001 to 2011.

Pirbright was at the fore at the start of the UK 2001 FMD outbreak, making the confirmatory diagnosis and, at the first five reported outbreaks, performing clinical examinations, determining the age of lesions, taking samples, collecting and analysing epidemiological data.

Meanwhile, vaccine matching tests and nucleotide sequencing analysis was being performed to characterise the causal virus – all during the first six days.

It was apparent assistance was needed in the lab with diagnostic, serological and veterinary advisory activities. The speed and magnitude of the response was magnificent and heart-warming.

Many people volunteered, including former veterinary staff and PhD students; veterinarians from the UK, Australia, Ireland and Italy; staff from the Veterinary Laboratories Agency; staff at Pirbright who transferred from other departments; and wives of staff members.

Thanks to those 200 or so volunteers and staff working for several months, more than 15,500 diagnostic and one million serological samples were processed. Everyone worked long hours with total commitment, engendering great camaraderie.

Despite this, the lab was criticised for delays in diagnosis. In our defence, I can explain we were obliged, under contract with the Ministry of Agriculture, Fisheries and Food (MAFF), to use tests prescribed by the World Organisation for Animal Health.

In many instances, samples had to be passed once or twice in cell culture to determine whether the virus was present. This could take two to four days. Faster tests, such as reverse transcription PCR (RT-PCR) and chromatographic strips, were available[1,2], but they weren't prescribed. RT-PCR was used in many instances for the initial screening of samples, with positive results being confirmed by

prescribed tests.

Government’s FMD Science Group

I was requested to join Government chief scientific advisor Sir David King’s FMD Science Group, which brings back mixed memories.

The committee met regularly from 26 March to 1 November 2001 (a total of 31 meetings). I attended most of them, but occasionally colleagues from Pirbright stood in for me. For the first three weeks the meetings were held daily in London.

A topic discussed early on was whether to vaccinate 200,000 housed cattle in Cumbria before their release on to potentially contaminated spring pasture. The FMD Science Group was unanimously in favour of a “vaccinate-to-live” policy, not the “vaccinate-to-kill” strategy announced later and as promulgated in the Netherlands during the spill of the outbreak there.

In any event, due to resistance from the NFU and the food industry, vaccination wasn’t employed.

The Science Group was dominated by four teams of modellers. The description of it being like a modelling sub-committee was accurate, especially at the beginning. “A formally constituted scientific advisory committee would have looked very different,” said David Shannon, MAFF’s chief scientific officer[3].

Paul Kitching and I were the two FMD experts from Pirbright, but for lengthy periods we were spectators to discussions between the modellers. What concerned us most was the model from Imperial College London, which drove the 24hr/48hr cull policy and dictated all FMD-susceptible species on infected premises (IP) were to be slaughtered within 24 hours of disease confirmation and all susceptible animals on premises contiguous to an IP were to be slaughtered within 48 hours.

We could accept the 24hr cull because good evidence existed from previous outbreaks (UK, 1967 to 1968; Denmark, 1982) that killing animals quickly on an IP is an effective control strategy. We were, however, vehemently opposed to the 48hr contiguous cull because its basis ignored the species composition of farms. This was a serious error since considerable differences exist between FMD-susceptible livestock in the amount of virus they excrete and the doses causing infection.

The model also assumed the virus would infect whole herds or flocks at once and be excreted maximally and indefinitely, unless the animals were killed. Clearly, this was a gross exaggeration of the predicted risk of spread[4].

A mathematical modeller later remarked: “The initial [Imperial] model was formulated during the

first few weeks of the epidemic and was necessarily a crude approximation[5].” More importantly, it was wrong.

The 24hr/48hr cull, announced by Sir David on 23 March and implemented on 29 March, was based on a model that was crude and wrong, and led to the slaughter of hundreds of thousands of animals, created severe disposal problems, and diverted scarce veterinary resources and support staff from activities of greater priority.

Wendy Vere, a West Country veterinarian, commented in the Devon Independent Inquiry: “It was carnage by computer.” Retrospective analysis showed the Imperial model was flawed[3,4].

It is noteworthy the report of The Royal Society’s inquiry, published after the outbreak, stated: “It is not satisfactory to rely on the development of models during an outbreak, or even to make other than minor modifications to existing research tools[6].”

Outbreak control methods

Three novel methods were introduced during the outbreak: the contiguous cull (implemented on 29 March)[7]; the 3km cull (implemented on 22 March); and slaughter-on-suspicion (SOS; implemented on 24 March)[8].

The contiguous cull was the only method based on mathematical modelling. The aim of the 3km cull was to create “fire-breaks” in areas of high-density sheep population and prevent perceived potential spread to cattle. SOS was introduced to accelerate disease control procedures.

It is interesting to reflect on the events that took place on 21 March 2001, as the modellers who attended a meeting at the Food Standards Agency believed the outbreak was “out of control”.

That evening, Roy Anderson, of Imperial College London, stated on BBC’s Newsnight “this epidemic is not under control,” and “the infection is not going to peak for many weeks to come”.

Analysis performed after the epidemic showed the spread of infection had peaked on 16 March in Dumfries and Galloway, and nationally by 21 March4. The traditional methods were working and had brought the epidemic under control before the 24hr/48hr policy was implemented on 29 March.

The last reported outbreak in Scotland was on 30 May and in the rest of Great Britain on 30 September, but to demonstrate the UK’s freedom from the FMD virus, a massive serological campaign was undertaken by Pirbright and five other laboratories. Six million tests were performed by the time the survey was completed in mid-January 2002.

On 22 January 2002, the UK regained its international FMD-free status. However, this wasn’t the end of FMD in 2001, since we were kept busy for the following four to five months responding to

many enquiries from the committees of inquiry[6,8,9].

Further outbreaks

Two FMD events attracted my attention after I retired from Pirbright in June 2002: a series of outbreaks in Surrey and proposals for a radical change in FMD control policy.

The outbreaks in Surrey occurred in August and September 2007, in two clusters. The first in Normandy, about 5km from the Pirbright site, and the second around Egham, about 18km from Normandy.

Investigations discovered the primary outbreak in Normandy was initiated by the escape of the O1 1860 vaccine strain from a pharmaceutical firm on the Pirbright site.

Drainpipes were damaged by the ingress of roots and it was concluded this allowed the virus to escape and contaminate nearby soil, which was then carried on the wheels of lorries moving off the site. The lorries then travelled along a lane in Normandy and, from there, the virus was transported by unknown means to cattle grazing at the first IP[10].

Robert Sellers (director of Pirbright from 1980 to 1984) and I were not convinced, since:

- The days when there was vehicle movement from the Pirbright site did not coincide with when the high titre virus was in the drains.
- The drainpipes, damaged by roots, were beneath a concrete path, so the probability of contamination of vehicles from that potential source was low.
- FMD is not an enteric disease and, although infection of cattle can occur via the oral (alimentary) route, the dose required is relatively high (10^5 to 10^6).
- Natural infection of cattle is much more likely via the respiratory route, where a dose of 10^1 is sufficient.
- The cattle at the primary outbreak were in a field about 400 metres from the lane in Normandy, so the mechanical transfer of a dose sufficient to infect them seemed highly improbable.

Our hypothesis was the virus escaped into the drains via a faulty valve on a vaccine vessel. The valve, fitted during February 2007, failed totally on 19 November 2007[11] and was found to be wrongly installed.

We proposed the faulty valve allowed the high titre virus to escape during the propagation of the vaccine virus and when the routine pumping of effluent took place, the partially blocked drains caused a build-up of back pressure. This resulted in sufficient energy to generate a plume of contaminated particles, which travelled downwind and infected cattle in Normandy by the airborne route.

We believed 23 July was the probable day for the spread as vaccine production was in progress, the meteorological conditions were favourable and there was a good fit with the age of lesions in the cattle at the primary outbreak.

Unfortunately, our investigations were hampered by the pharmaceutical firm's impenetrability. Consequently, the mechanism of escape remains an open question.

The second event relates to a paper in *Science* in 2011, which proposed, on the basis of modelling of data from experimental studies, cattle infected with FMD could be safely removed from an IP if this was done before they developed clinical signs, thereby greatly reducing the number of animals slaughtered[12].

Unsurprisingly, these findings generated great interest and the paper was given considerable publicity[13]. Close scrutiny revealed, however, the data was based on flawed experimental methods which included, for example, the omission of critical time points, taking fever as a specific diagnostic sign of FMD and the removal of the environmental virus between experiments by washing and cleansing.

Furthermore, previous findings of pre-clinical and post-clinical excretion of the FMD virus were overlooked[14,15], while the proposals for separating infected from non-infected animals on an IP ignored the role of environmental virus in spread[16].

A series of veterinary virologists said: "We strongly suggest it would be inadvisable to base decisions on control policy for FMD on the results of this paper[17]."

Since data from the 2011 *Science* paper was used as a basis for two spin-off articles[18,19], their validity is also doubtful. This event illustrates clearly the need for novel proposals for FMD control to be based on sound scientific evidence. This goal can be achieved only with input from veterinarians with expertise of the biology and epidemiology of the disease.

The UK 2001 FMD outbreak resulted in the slaughter of around 6.5 million animals and cost an estimated £10 billion[3]. It was undoubtedly the outstanding FMD event of the decade. While a public inquiry would have revealed more than the official inquiries, those reports[6,8], and that of The Royal Society of Edinburgh[9], contain useful information.

People concerned about FMD, in particular policy makers and research leaders, would be well advised to study their recommendations, so the mistakes of 2001 will not be repeated during future incursions of FMD in the UK.

Acknowledgement

Mike Thrusfield is thanked for his helpful comments on the manuscript.

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