Foot-and-mouth disease – a case study in microbiology education

Tracey Duncombe & Janet Hurst

Table 1. Chronology of the foot-and-mouth disease epidemic in the UK, 2001

20/2	First case is discovered at an abattoir in Essex and a five-mile exclusion zone is set up.
21/2	European Commission (EC) halts all UK food exports and imposes a worldwide ban on shipments of all cattle and meat.
23/2	A case on a pig farm in Northumberland is suspected of being the source of the outbreak. UK Government bans livestock movements throughout the country.
1/3	First suspected case in Northern Ireland. EC announces that vaccination will only be reintroduced in Europe as a last resort.
2/3	First confirmed case in Scotland. Farmers' leaders say that the outbreak is on the verge of an epidemic. Licensed movement of livestock to selected abattoirs.
4/3	France discovers infected sheep imported from Britain.
6/3	EC suspends all livestock markets in the European Union (EU).
12/3	Germany announces the slaughter of livestock imported from UK.
13/3	Confirmed case in Northern France.
15/3	Agriculture Minister Nick Brown announces cull of up to 1 million healthy livestock to prevent further spread of the disease.
22/3	Dutch authorities vaccinate animals within 3km of infected areas. First case in the Republic of Ireland. Government announces £150 million scheme to compensate for culled healthy livestock.
25/3	UK army prepares to bury up to 500,000 animals at a disused airfield near Carlisle. EC grants permission to vaccinate up to 180,000 dairy cattle in disease hotspots Devon and Cumbria.
29/3	Government delays vaccination after signs that the cull is working.
2/4	The general election, which was forecast to take place on 3 May, is postponed.
3/4	Total number of animals slaughtered exceeds 1 million as number of reported cases rises above 1000.
4/4	900 sheep and cattle buried in Co Durham face being exhumed because they threaten to contaminate a freshwater spring.
12/4	Chief Scientific Advisor David King announces that the epidemic has 'plateaued' as the number of reported daily cases remains between 20 and 30.
14/4	Nick Brown is under pressure to reconsider vaccinating livestock after admitting that deadlines to slaughter infected livestock are not being met.
15/4	Government takes emergency powers to bury slaughtered healthy livestock in landfill sites. Government orders a change in policy on vaccination as the number of animals waiting slaughter or disposal approaches one million. Government scientists admit there is no evidence that it is safe to burn infected animals in the open. Britain's largest pyre in Cumbria is halted after protests from local residents about potential health risks.
16/4	Mass burial of thousands of slaughtered animals in mid-Wales is suspended due to pollution fears.
17/4	Supermarkets give support to the vaccination lobby.
18/4	Government fails to get farmers' leaders' backing for vaccination.
19/4	Confidential report from Chief Scientist's own laboratory says that vaccination could do more harm than good.
20/4	Institute of Directors say that the outbreak has cost the UK £20 billion in lost business so far. Restrictions lifted in parts of Northamptonshire and Leicestershire.
21/4	Ireland lifts restrictions.
22/4	Vets fear the disease has spread to deer.
23/4	Department of Health launches investigation as concern grows over release of poisonous dioxin from massive pyres.
24/4	Human case of FMD suspected. Government abandons vaccination as outbreak is 'under control'.
25/4	Government drops its policy to cull healthy animals living near infected farms.
28/4	First suspected human case given all clear.
30/4	Total number of cases to date 1,515; total number of animals slaughtered 2,338,000.

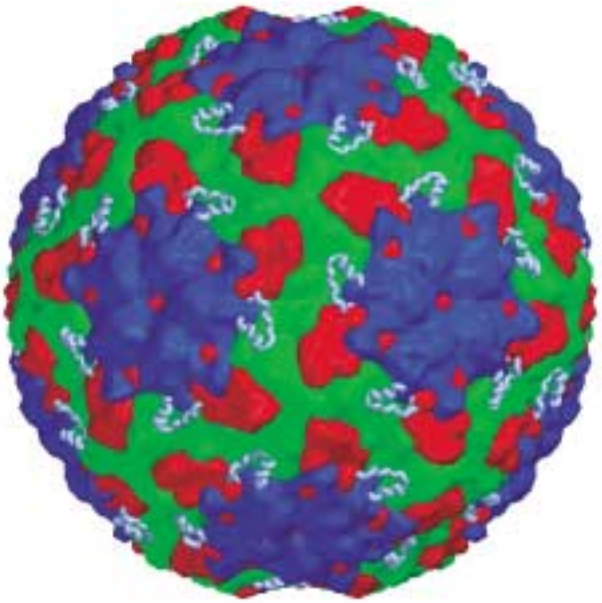
Information taken from reports in The Times, Daily Telegraph, Independent and The Guardian. See www.sgm.ac.uk/PA/mic_news/micro.htm for further updates

Readers worldwide cannot fail to be aware that the UK has been thrown into turmoil due to an outbreak of foot-and-mouth disease in cattle, sheep and pigs. A summary of the events associated with the outbreak is given in Table 1.

A policy of wholesale slaughter around farms with a confirmed infection was introduced by the Government, which itself postponed the general election in response to the situation. Footpaths were closed throughout the country in an attempt to halt the spread of the disease, with the knock-on effect that hotels and tourist attractions lost all their business. People were amazed by the revelations of the complexity and extent of animal movements around the UK, and indeed in Europe, which had contributed to the spread of the virus. The scale of past governments' earlier culls – of the national veterinary service and Ministry of Agriculture (MAFF) staff – was exposed, which meant vets had to be brought in from overseas and veterinary students learnt techniques that they would not use in the small animal practices most aspired to. The public were sickened by the sheer scale of carnage which appeared on television screens daily.

Many heated debates took place. Should we vaccinate? Should we have a general election in the midst of the crisis? Is the countryside 'open for business' or not? The arguments, like the epidemic itself, are on-going, but will hopefully be resolved soon so that Britain can regain its all-important 'disease-free' status. But what lessons have been learnt? There have been public demands to change farming and food production methods in the hope that this may reduce the risk of future epidemics. Some have called for MAFF to be scrapped. Agriculture Minister Nick Brown is keen for reform and has said that a far-reaching government review of UK agriculture would radically change the lives and incomes of farming communities.

Whatever the rights and wrongs and politics of the affair, as we go to press (early May) the measures imposed by scientists and the Government appear to be working – the incidence of confirmed cases is on the wane. Official sources are now predicting that the worst will be over by June. It was decided not to vaccinate. Culling has been scaled down. Media attention has switched to the disposal of carcasses and the possible dangers to health posed by carcinogens from burning pyres and the contamination of water supplies from burial pits. The effects of this disease



have been far-reaching, not only on animal health and the rural economy, but on British tourism, the country's political situation and our international relationships.

A virus has caused this state of affairs. When the editorial board planned this issue of *Microbiology Today*, which emphasizes again and again the need for education in our subject in its broadest sense, we did not know how timely it would be, nor how foot-and-mouth disease would serve to reinforce our message.

● ***Tracey Duncombe, Janet Hurst, SGM HQ***

ABOVE:
A surface representation of the FMDV capsid viewed along the two-fold symmetry axis. The colour scheme is defined in the legend to the image on p. 96. The ordered antigenic receptor-binding loop is shown in pale blue as a thick worm.
COURTESY DAVID STUART, LIZ FRY AND ROBERT ESNOUF, OXFORD UNIVERSITY

BELOW:
A familiar rural scene across the UK.
PHOTO IAN ATHERTON

FMDV update

Delegates at the Heriot-Watt meeting in March were updated on the foot-and-mouth disease outbreak. In a jam-packed auditorium Dr Nick Knowles from the Institute of Animal Health, Pirbright presented data on the virus and plotted the suspected transmission route to the UK. He reported that the sequencing of UK samples carried out at Pirbright had revealed that a type-O virus was involved, the so-called 'Pan-Asia' strain. This particular strain was identified in India in the early 1990s and subsequently spread through Turkey, Nepal and Malaysia. During the late 1990s there were contained outbreaks of type O in Eastern Europe. But this was followed by re-emergence from India and a more dramatic spread through South East Asia, Eastern Russia and South Africa. Sequence comparisons of UK samples with samples from South Africa were almost identical: only two nucleotides different in the most variable gene. Dr Knowles said, '*This implies that the virus could have spread from South Africa or that they had a common ancestor*'. A more detailed presentation of this data can be found in *Journal of General Virology* (2001), **82**, pp. 609–621. See also *Hot off the Press* on p. 96.

● ***Tracey Duncombe, SGM HQ***

Letters received from members

New vaccines for FMDV?

To what extent is the current disastrous outbreak of foot-and-mouth disease a result of complacency? Europe now has a huge susceptible population of farm livestock since the cessation of vaccination in the early 1990s and can only hope to maintain a disease-free status by controlled animal management and continuous high-level surveillance. We in Britain have traditionally managed to ward off the virus by control of animal movement and slaughter when it has appeared. This policy has worked effectively in the past, although we only just made it in 1968.

What have we learned from the current situation? First, swill feeding adds a level of risk that must now be considered unacceptable. Second, the extent of animal movement, registered or otherwise, that has become a feature of modern farming practice seems to have taken even the authorities by surprise. As we have seen, this provides the ideal scenario for the wide dissemination of infection. The situation was made worse, of course, because of the difficulty in diagnosing the infection in sheep compared with other species. During the 30 years since we last had a meaningful outbreak of the disease it is perhaps inevitable that our 'guard will drop' a little – it is hard to justify the maintenance of a large infrastructure to deal with a rare occurrence. On the other hand, the pandemic spread of the particular strain of virus from which we are now suffering has been monitored by the epidemiologists in Pirbright. Should we have been expecting it?

A lot has been said in the media about vaccines. They were, after all, responsible for the elimination of endemic disease in Europe, so why are they not used now? There are a number of problems associated with the current killed vaccines, such as the antigenic diversity of the virus, the security risks associated with growing huge volumes of virulent virus, the difficulty of distinguishing vaccinated from infected animals, the short duration of effective immunity and the absence of secretory immunity. For these reasons the policy in Europe has been to stop vaccination as soon as possible. One result of this decision is that research into the development of superior new vaccines has been of low priority. However, given the current enormous burden to the country, do we need to re-evaluate the question of new vaccines? I feel sure that with the investment of a tiny fraction of the overall cost of this outbreak it would have been possible to develop new and better products.

● ***Professor David J. Rowlands***

A disaster waiting to happen

The two books I recall most vividly from my student days are Macfarlane Burnet's *Biological Aspects of Infectious Disease* and René Dubos's *Mirage of Health*. Both taught me the importance of seeing communicable disease not from a narrow medical or veterinary viewpoint but from a broad ecological perspective. Four decades later, I wonder what Burnet and Dubos would have made of the 2001 outbreak of foot-and-mouth disease in Britain.

They might have reasoned as follows. If we were to design a perfect scenario for a highly infectious (and possibly highly virulent) virus to wreak havoc in a population of animals in Britain, we would need to take two steps.

First, we would resolve not to protect our national herd(s) by immunization and would indeed ban farmers from doing so. This would leave the animals totally vulnerable to the infection.

Second, we would arrange our farming and food practices so that, in contrast to the past, animals are moved frequently and widely between farms, holding farms, markets and abattoirs. This would ensure that, if the virus were to enter the country, it would be disseminated widely and efficiently to other unprotected animals.

These two conditions would create the ideal setting for 'a disaster waiting to happen'. However effective our other precautions to exclude the virus, its eventual accidental (or deliberate) introduction from outside would be inevitable. The danger would be all the greater in the case of a virus that circulates freely in other parts of the world.

This is precisely the scenario we have allowed to develop in the case of foot-and-mouth disease. Of course, existing FMD vaccines, though effective, are imperfect in several ways. Yet we have controlled many other communicable diseases with imperfect vaccines. And eight European countries did precisely that in the case of FMD until about a decade ago (since when vaccine technology has advanced considerably).

I believe that Macfarlane Burnet and René Dubos would have agreed with this analysis.

● ***Bernard Dixon OBE DSc***