Papers

Establishing a pilot bovine viral diarrhoea virus eradication scheme in Somerset

R. E. Booth, J. Brownlie

Beginning in April 2006, 41 farms were recruited onto a pilot Bovine viral diarrhoea virus (BVDV) eradication programme across the south of England with the majority of study herds concentrated in Somerset. Each herd was assessed and where relevant cleared of persistently infected (PI) animals. Seven farms dropped out before whole herd screening could be performed. Of the remaining 34 farms, 20 (59 per cent) were classified as infected although two of these were initially misclassified as BVDV-free. Over the course of three years, 61 PIs were identified across 16 of the 20 infected farms. 72 per cent of PIs indentified on the first herd test were below two years of age. PI prevalence ranged from 0.2 to 3.1 per cent of infected herds and was highest in herds that did not vaccinate. By the end of 2009, 24/34 (71 per cent) of study farms were BVDV-free while 10 (29 per cent) remained infected.

BOVINE viral diarrhoea virus (BVDV) is an economically important pestivirus affecting cattle worldwide. In infected herds, losses are due to decreased fertility, secondary infections following immunosuppression and decreased milk production in acutely infected animals (Edwards and others 1986, Wray and Roeder 1987, Ellis and others 1988, Virakul and others 1988, McGowan and others 1993, Moerman and others 1993, Potgieter 1995). In 1998, it was estimated that 65 per cent of UK herds had experienced recent BVDV infection and 95 per cent of the national herd had been exposed to the virus (Paton and others 1998). In 2003, BVDV was calculated to cost the UK cattle industry £40 million per year placing the disease as the third largest loss after mastitis and lameness (£180 & £54 million per year, respectively) (Bennett and Ijpelaar 2003).

Herd infections most commonly occur due to the purchase of stock of unknown status combined with a failure to implement test and quarantine procedures (Houe and others 1997, Houe 1999). If fetal infection occurs in the first 110 days of gestation and pregnancy results in a live calf, the calf is born immunotolerant to the infecting strain and remains persistently infected (PI) for life (Brownlie and others 1989, Peterhans and others 2003). PI animals play a significant role in the epidemiology of the BVDV shedding virus in large quantities in most body secretions (Barlow and others 1986, Mars and others 1999). Previous surveys in varying cattle populations indicate that the range of PI animals present is normally in the order of 0.5 to 2 per cent of those tested (Houe 1999, Rüfenacht and others 2000). This may be an underestimate of the true level seen in late fetuses and early neonates; studies have suggested that this may be as high as 13 per cent (Nettleton and Entrican 1995).

Across Europe, there is an increasing drive to address the issue of BVDV. In part, this has been a consequence of the success of the Scandinavian BVDV eradication programmes and a growing awareness of the losses caused by the disease (Sandvik 2004, Houe and others 2006). Schemes across Norway, Sweden and Denmark all began in the early 1990s with the primary drive for BVDV control arising from the dairy sector (Sandvik 2004, Houe and others 2006). Austria and Switzerland launched national BVDV eradication programmes in 2004 and 2008, respectively, while France and Germany currently have regional schemes in place (Houe and others 2006, Presi and others 2011). Vaccination was not used in the Scandinavian schemes but it is generally accepted that it could be required elsewhere due to higher cattle densities and differing industry structures (Houe and others 2006).

At the time of writing, the most recent country to announce national BVDV eradication was Scotland. This announcement brings the UK another step closer to national eradication as trade from England and Wales into Scotland will likely become restricted to herds that have proven/certified BVDV freedom. Within the UK, CHeCS (Cattle Health Certification Standards) exists to provide comprehensive testing regimens and guidance to attain BVDV freedom and subsequent certification. In 2007, it was estimated that only 4.4 per cent of UK farms were members of CHeCS accredited schemes (T. Brigstocke, personal communication) and while isolated groups and individual farms are undertaking BVDV control, a lack of national coordination is apparent. There is, however, some encouraging evidence that eradication within the UK is possible albeit on the Shetland Islands (Synge and others 1999), and more recently, the Orkneys although some recent difficulties have been reported (Truyers and others 2010).

This paper describes the setup and preliminary results of an English eradication scheme, primarily based in Somerset. This longitudinal study is continuing and further 'on-farm' data quantitating the risk factors, relevant control strategies and cost benefit of BVDV eradication are being collected for subsequent analysis. The data presented here introduce the study population and report the initial epidemiological findings, and the lessons learned from farms in one of the most cattle-dense areas of the UK (see Fig 1) to further inform practitioners and policy makers undertaking BVDV control.

Materials and methods

Several farm meetings were held in Somerset, beginning in spring 2006, to develop interest in a BVDV eradication scheme involving the local farming community. Initially, farm clients of Shepton Veterinary Group (SVG) were targeted as potential study members and (110)

Veterinary Record doi: 10.1136/vr.100191

R. E. Booth, BVSc, PhD, BSc (Hons), MRCVS,
J. Brownlie, CBE, BVSc, PhD, DSc, DipECVP, FRCPath, FRAgS, FRASE, FRCVS,
Department of Pathology and Infectious Disease, Royal Veterinary College, Hawkshead Lane, North Mymms, Hertfordshire, AL9 7TA, UK

E-mail for correspondence: rbooth@rvc.ac.uk

Provenance: not commissioned; externally peer reviewed

Accepted September 20, 2011

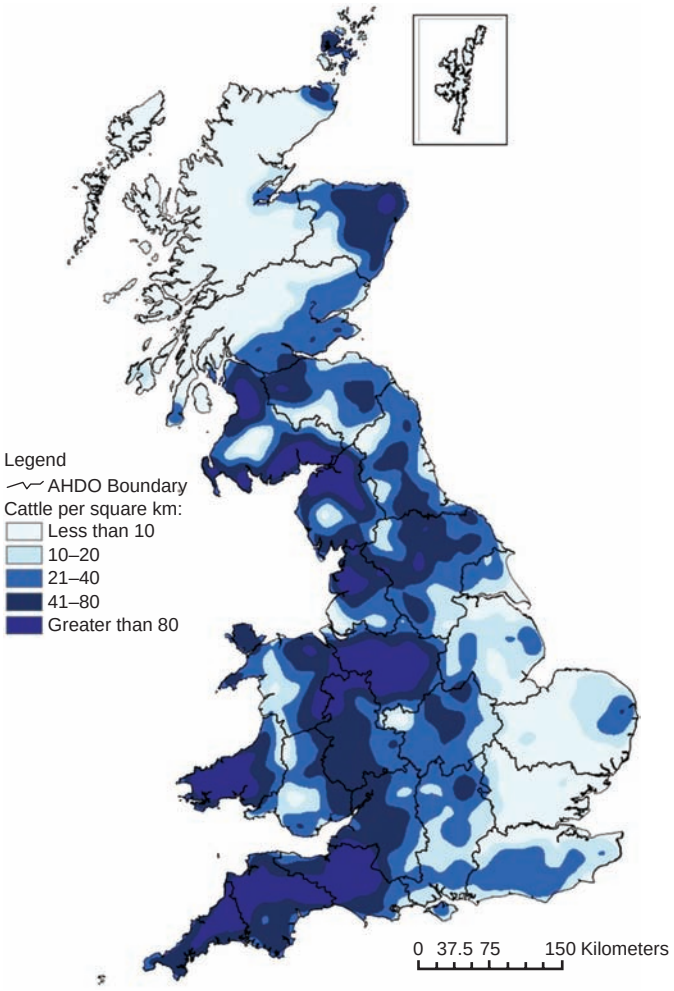

FIG 1: Cattle population density on June 1, 2008 ('The Cattle Book 2008' © Crown copyright. Reproduced with kind permission of Ordnance Survey)

farm clients were invited by the practice to attend a meeting held at the Bath and West showground on April 25, 2006 at 19.00 pm. The meeting lasted for two hours and, at the end, interested parties were asked to complete a form so they could be contacted to discuss the scheme further. Following this, the veterinarians at SVG spoke to the farmers to encourage their interest and newsletters were circulated detailing the scheme. Due to interest from clients of a neighbouring practice, Kingfisher Veterinary Practice (KVP, now Synergy Farm Health), a second, smaller, meeting was held in Crewkerne, Somerset on August 8, 2006 at 11 am to which selected farmers were invited. A small number of additional farms were recruited in the south-east of England via the Royal Veterinary College (RVC) Farm Practice. No preference was given to dairy or beef units and farms were not excluded from the study if they were already vaccinating against BVDV. Selection criteria for inclusion in the study were based on the suitability of the enterprise for a BVDV eradication scheme. The farmer had to be willing to consider simple biosecurity enhancements and had to agree that if PIs were found they were to be culled or kept on the farm of origin until slaughter; there had to be a commitment that PIs would not be sold undeclared on the open market. The farms involved were always advised to cull PIs when identified. Biosecurity recommendations given to study members were in line with the biosecurity rules detailed by CHeCS (Anon 2010). Most emphasis was placed upon quarantine and testing of incoming stock. Farms were also advised to control boundary contacts with neighbouring cattle. Vaccination was encouraged on all farms involved.

All laboratory tests and veterinary time for BVDV testing were free to study members. No compensation was offered for PI animals.

The vaccine used by farmers in the study was either Pregsure (Pfizer Animal Health) or Bovilis BVD (Intervet/Schering-Plough Animal Health); choice was dependent on the prescribing veterinary practice. Farms using vaccine were advised to follow the product data sheets exactly and to vaccinate all breeding stock.

When first recruited, each farm was visited and both the disease and an appropriate course of action were discussed. Each herd was assessed in accordance with the CHeCS biosecurity recommendations and given appropriate advice. The herd was then screened to determine the likelihood of PI presence and initial BVDV status. All laboratory testing for this work was performed by the Veterinary Laboratories Agency (VLA, now Animal Health and Veterinary Laboratories Agency). Milk samples were submitted in sampling pots containing Bronopol preservative (VLA) and blood samples in 6 ml lithium-heparinised vacutainers (National Veterinary Services). The initial screens performed on each consisted of, 10 youngstock (YS) from each separate management group aged 6-18 months, blood sampled and tested by antibody (Ab) ELISA and, on dairy farms, a bulk milk (BM) sample taken on the same day as YS sampling which was tested by both antibody ELISA and PCR..

Where the initial screen of a herd indicated no active infection or a historical infection, the herd was monitored with a combination of monthly BM Ab and YS tests repeated at a maximum interval of one year. Farmers with herds appearing BVDV-free were also given the option to perform whole herd testing to confirm herd status. In a herd where initial screening indicated active BVDV infection, every animal in the herd was blood sampled. The tests performed were selected according to the age of the subject animal as described in Fig 2. Note that the Ab ELISA used by the VLA changed at the end of 2008, subsequently the cut-off levels to determine negative and low Ab titres were also altered. Specifications and interpretation of the laboratory tests are detailed in Table 1.

All maps presented were created using ArcGIS 10 (ESRI; Redlands). Graphs and tables were created using Microsoft Office Excel 2007 (Microsoft Corporation).

Results

Seventy farmers, 64 per cent of those invited, attended the initial meeting in April 2006 and at the end of the meeting, 36 written responses were collected from attendees wishing to discuss the scheme further. Of the 110 SVG clients, there were a number of 'flying herds' meaning that only 80 were eligible for this BVDV eradication programme. Farm recruitment began in May 2006 and is illustrated in Figures 3a-d.

From SVG, 27 farms out of a potential 80 (34 per cent) signed up to the scheme, 10 farms (11 premises) were then recruited via KVP and four via the RVC Farm Practice. None of the KVP or RVC herds were flying herds and all were receptive to recommendations to improve biosecurity. In total, 41 farms signed up to the study; farms 35 and 32 (Table 2) should be considered as one since, although under different management, farm 35 was a heifer-rearing unit for farm 32.

The geographic location and changing status of each study member is illustrated in Fig 3a, b, c, d. Table 2 provides basic information on the size and structure of each farm involved. In total, 41 farms signed up to this study, however, seven (17 per cent) dropped out having only completed enough testing to establish their status leaving 34 farms that remained active for the period reported. Of the 34 active herds, 30 (88 per cent) were dairy enterprises and four (12 per cent) were beef. Average herd sizes of the active study farms were 344 (interquartile range: 231 to 437) and 98 (interquartile range: 59 to 117) animals for dairy and beef herds, respectively. The average herd size for the Taunton area in June 2008 was 126 animals (Defra 2008).

Initial herd screens were interpreted cautiously; any herd with more than one out of 10 YS positive for BVDV Ab and/or a positive BM PCR result in dairy herds (generally associated with a high positive, OD ratio >0.7, BM Ab level) was classed as infected on the initial herd screen. BM Ab alone was not used to classify herd infection status, but a high positive result initiated more frequent YS (at least twice yearly) surveillance in order to determine whether the titre was due to current or historic infection. Of the 34 farms remaining active throughout the study, 18 (53 per cent) began as infected based on their initial screens. Two farms (farms 15 and 27) appeared BVDV-free on the initial screen (no Ab-positive YS, BM PCR negative and high positive BM Ab), yet, PIs were found in the whole herd test (WHT).

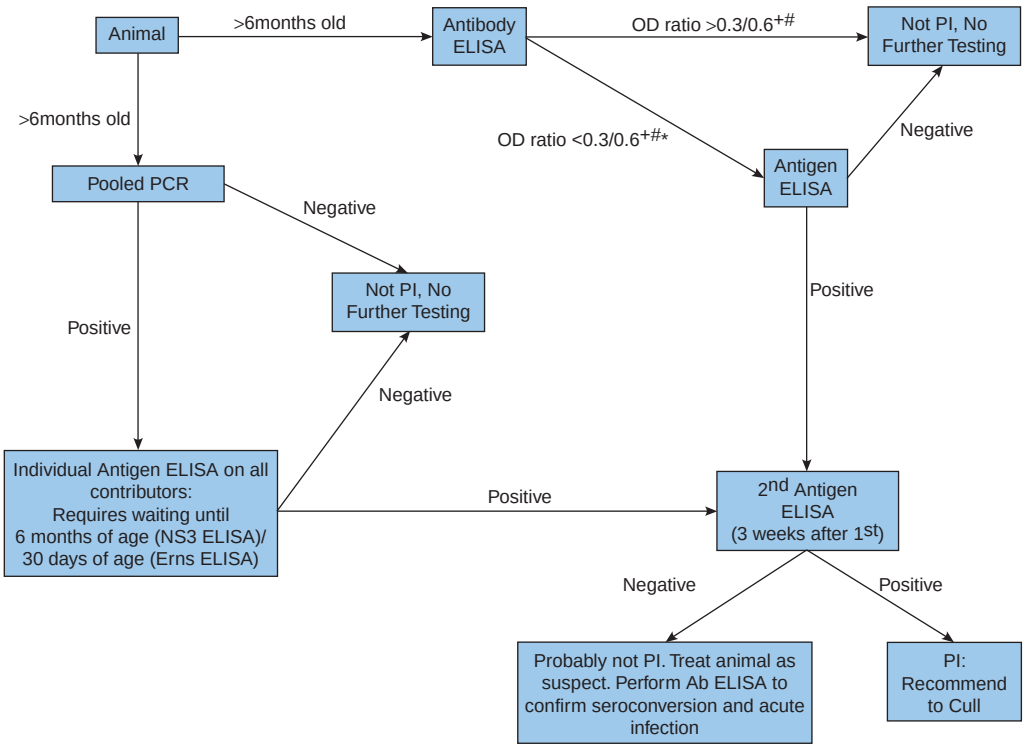

FIG 2: Testing regimens for whole herd testing. *>50% of animal test results were <0.3 OD units or <0.6 OD units for original and late Ab ELISA tests, respectively; blood samples for the whole herd were screened by pooled blood PCR. +Samples with negative or low levels of Ab (OD ratios <0.3 units or <0.6 units for original and late Ab ELISA, respectively) were screened for PI. Cut-off levels for negative samples are 0.2 and 0.3 OD units for original and late Ab ELISA, respectively. #OD ratios are specific to the ELISA used by the VLA. Cut-off values and reporting units may differ from other laboratories.

Including farms 15 and 27, the number of infected farms at the outset was 20 (59 per cent). Farm 36 began the study as infected, went clear, but in the third year became re-infected. At the end of 2009, the study group consisted of 24 (71 per cent) BVDV-free farms and 10 (29 per cent) infected. Five of the farms remaining infected at the end of 2009 were close to BVDV freedom, which would bring the number of infected farms down to 5/34 (15 per cent).

On the initial screens of the seven farms that elected to leave the study, three appeared infected and four appeared BVDV-free. No further work was performed on these farms beyond establishing their initial status.

The vaccination policies of active study farms are shown in Table 2. Twenty-two out of 34 farms were vaccinating before the start of the study and continued to do so. Six out of 34 began vaccinating when they joined and 6/34 were not vaccinating before the study and did not begin despite recommendations to do so. Of the infected farms, 2 and 19 chose not to vaccinate. Of the BVDV-free farms, 13, 21, 24 and 39 chose not to vaccinate even though it was explained that a high proportion of their stock were likely to be seronegative to BVDV and therefore at risk.

The farm policies towards purchase of cattle and biosecurity are summarised in Table 2. In total, 25/34 (74 per cent) active study farms purchased cattle occasionally. The maximum number of animals purchased by any study farm in one year was 20 cattle. Of the 25 farms that bought in cattle, 21 (84 per cent) tested them for BVDV after purchase, however, only 13 (52 per cent) combined this with quarantine procedures. Sixteen out of 34 (47 per cent) study farms had boundary fencing that restricted contact with other cattle, 5/34 (15 per cent) did not allow cattle to graze fields bordering other premises and 13/34 (38 per cent) did nothing to restrict contact with neighbouring cattle.

By the end of 2009, 61 PI animals had been confirmed on 16/34 (47 per cent) farms (Table 2). Thirty-nine (64 per cent) of these PIs were identified on study farms in the first year of investigation. The percentage of each herd that was PI at the WHT ranged from 0.2 to 3.1 per cent (Table 2). Nine infected herds were vaccinating before the start of the study and 0.2 to 1.2 per cent of these herds were PI at the WHT. Seven infected herds either began vaccinating at the start of the study or chose not to vaccinate throughout and, in these, PI proportions ranged from 0.4 to 3.1 per cent. Of the 39 PIs initially identified, 21 (54 per cent) were younger than one year, seven (18 per cent) were one to two years old and 11 (28 per cent) were older than two years (Fig 4). Of the remaining 22 PIs, 10 were identified via follow-up testing on infected farms and 12 were identified on farm 2 in the second year of the study. At the time of writing, farm 2 had 12 PI animals confirmed and, in addition to this, nine suspect PIs that had been culled without confirmation tests. In the first year in which PIs were identified, farm 2 reached a peak of 2.6 per cent of the herd PI (data not shown). All infected farms, with the exception of farm

TABLE 1: Specifications of the laboratory tests used by the VLA

Test	Sensitivity	Specificity	Details
BVDV antibody ELISA 1 (TC0390)† (in use until the end of 2008)	Estimated at >90%	Estimated at >90%	OD ratios <0.2=negative; >0.2=positive
BVDV antibody ELISA 2 (TC0390)* (in use from 2009 onwards)	93%	90.36%	OD ratios <0.2=negative; 0.3-0.3=inconclusive; >0.3=positive
BVDV bulk milk antibody ELISA (TC0123)	97.3%	93.2%	OD ratios <0.1=negative; 0.1-0.35=low positive; 0.35-0.7=mid-positive; >0.7=high positive
BVDV (NS3) antigen ELISA (TC0522)†	Not determined	Estimated at 99.5%	Only recommended for animals older than 6 months of age
BVDV (Erns) antigen ELISA (TC0772)	100% (98.1-100%)	100% (97.6-100%)	Recommended for animals from 30 days of age. This test was only available in the last year of the study. Before the release of this test, accurate antigen ELISAs could only be performed from 6 months of age
BVDV bulk milk PCR (TC0709)	Estimated to be 'high'	Not determined	Recommended to test pools of up to 300 contributors for the presence of one or more PI animals
BVDV pooled blood PCR (TC0758)	Estimated to be 'high'	Not determined	Recommended to test pools of up to 10 contributors for the presence of one or more PI animals. Test can be used on animals of any age and is unaffected by the presence of MDA

* Supersedes previous antibody ELISA 1
† Test no longer offered by VLA
MDA Maternally Derived Antibody

FIG 3: (a to d) Geographical distribution, recruitment and status of Somerset Study farms at the end of 2006, 2007, 2008 and 2009, respectively. Infected farm (●), farm in an intermediate state (infected and going through eradication) (●), BVDV-free farm (●), farms that has dropped out of the study (●), farm of unknown status as further testing is required (●)

2, elected to promptly cull confirmed PI animals. Despite veterinary advice, farm 2 elected to keep PI animals for the duration of the project and not to vaccinate thus remaining infected for the entire study. To the authors' knowledge, all PI animals identified via this project were either culled or kept on the farm of origin as required as a condition of entering the study.

Discussion

When setting up this study, the initial intention was to recruit 40 SVG clients within one year providing a population falling within a 20 mile radius of Shepton Mallet. Flying herds were regarded as ineligible due to difficulties isolating and testing incoming animals thus excluding 30 SVG clients. Herds that were unlikely to comply with any basic biosecurity recommendations were not put forward as suitable study members by the practice veterinarians. The biases introduced excluding flying herds and only recruiting farms considering/already undertaking biosecurity improvements mean that the population surveyed in this work was potentially less likely, than ineligible farms, to have imported BVDV in recent years. In efforts to avoid simply recruiting infected farms, members were recruited without prior knowledge of their status. At the end of 2006, it appeared unlikely that study numbers would reach the required 40 farms and other interested parties from KVP and RVC were invited to join. The total number of beef farms involved in this study is low and so little can be drawn from the results obtained on these farms alone. The region from which the majority of the farms were recruited is predominantly dairy. All, but one (farm 4), of the dairy farms involved in this study were larger than the stated average for the Taunton area, however, the average for the area given by Defra (2008) will include smallholdings and so may be falsely low.

Upon advising farms on biosecurity, it became evident that it would prove difficult for many (especially dairy) to comply fully with the rules set out by CHeCS regarding double fencing and quarantine of incoming stock. It became apparent that many farmers would be unable to enter the scheme if these factors were made obligatory, however, considering the significant role that biosecurity plays in BVDV control it was impossible to ignore (Lindberg and Alenius 1999). Rather than insisting that study farms follow strict biosecurity rules in order to join the scheme, they were encouraged to limit the purchase of cattle where possible and to test any incoming stock for PI. Nearly three-quarters of active members continued purchasing animals throughout this study and this is not a practice that is likely to cease. For most members, cattle purchases were breeding bulls and occasionally replacement stock when home reared animals were not of adequate numbers. Despite free testing and frequent reminders, four farms purchasing additional stock still failed to test all added animals at the point of purchase and this represents a real risk for re-infection of a herd. Only 48 per cent (12/25) farms purchasing stock had a policy to quarantine added animals and this was an area of low compliance among the dairy farms involved. This is perhaps partly explained through the difficulty of effectively quarantining milking animals. Almost half of the study farms had boundary fencing in place to prevent contact with neighbouring stock. A small number of additional farms chose not to alter boundary fencing and instead to only graze cattle on boundaries when neighbouring animals were elsewhere. Farms 3 and 24 currently have grazing arrangements in place to prevent cattle contacts between the farms. This could represent a practical way of managing farm border contacts without the expense of double fencing and it is encouraging that 62 per cent of study members took a proactive attitude towards border contacts.

In order to balance some of the risks associated with poor biosecurity, BVDV vaccination was recommended to every farm in the study. The reasons why farms 2 and 19 chose not to vaccinate in the face of proven infection are unclear. Of the four BVDV-free farms that chose not to vaccinate, three had a proactive attitude towards biosecurity considering vaccination an unnecessary additional cost to that

TABLE 2: Introduction to the study farms, structure and overview of PIs

Farm number†	Size of herd upon joining‡	Vaccine	Purchase policy	Biosecurity	Total number of PIs identified	PIs present at WHT	Herd PI on day of WHT (%)
1	349	V	N		3	2	0.6
2	542	N	N		12#	0	0
3	450	V	N	C	0	-	0
4	47	V	Y	T, CD	0	-	0
5	527	V1	Y	T	2	2	0.4
6 (Beef)	61	V	N	Q, T, CD	0	-	0
7	381	V1	N	CD	0	-	0
8	381	V	Y	T	0	-	0
9	429	V	Y	T	0	-	0
10*	283	-	-	-	-	-	-
11	217	V	Y	Q, T, CD	0	-	0
12* (Beef)	25	-	-	-	-	-	-
13	201	N	Y	C	0	-	0
14*	672	-	-	-	-	-	0
15	633	V	Y	T	1	1	0.4
16*	211	-	-	-	-	-	-
17 (Beef)	180	V	Y	Q, T, C	-	-	-
18	307	V1	N	CD	6	4	1.3
19	214	N	Y	CD	1	1	0.4
20	309	V1	Y		3	3	0.9
21 (Beef)	54	N	Y	Q, T, CD	0	-	0
22*	287	-	-	-	-	-	-
23*	264	-	-	-	-	-	-
24	286	N	N	CD	0	-	0
25	300	V	Y	Q, T, CD	0	-	0
26	170	V	Y	CD	3	2	1.2
27	192	V	Y	T	1	1	0.5
28	335	V	Y	T, CD	0	-	0
29	412	V	Y	Q, T, C	0	-	0
30	360	V	Y	Q, T, CD	0	-	0
31*	201	-	-	-	-	-	-
32	473	V	N	Q, T, CD	0	-	0
33	479	V	N		3	3	0.5
34	223	V	Y	Q, T, CD	1	1	0.2
35 (Heifer unit for 32)	See 32	See 32	See 32	See 32	See 32	-	See 32
36	336	V	Y	Q, T	0	-	0
37	402	V	Y	T	5	3	0.9
38	542	V	Y	Q, T	2	2	0.4
39	143	N	Y	Q, T, CD	0	-	0
40	230	V1	Y	Q, T	9	5	2.1
41 (Beef)	96	V1	Y	Q, T, CD	4	3	3.1
42	440	V	Y	Q, T, C	5	5	1.1

* Farms 10, 12, 14, 16, 22, 23 and 31 are no longer active study farms
† Farm numbers enable cross referencing between the results presented and the discussion (unless otherwise indicated alongside farm number, each farm is a dairy unit)
‡ Numbers supplied by BCMS. This will differ with the total number tested due to the sale of youngstock and store cattle
# Confirmed PIs; 9 suspect PIs had been culled without confirmation tests
For vaccine use: V Vaccinating before study, V1 Began vaccinating at start of study, N No vaccination
For purchase Policy: Y Occasional purchase (eg, bull, replacements), N No cattle purchased
For biosecurity: Q Quarantine incoming stock, T Test incoming stock, C Aware of boundary biosecurity, C[D] Boundary fences prevent nose:nose contact with neighbouring stock, WHT Whole herd test, BCMS British Cattle Movement Service

of maintaining good biosecurity. The fourth, farm 13, occasionally purchases animals, but frequently fails to test or quarantine them and this represents a real risk to this herd. Nine farms had been vaccinating before the start of the study yet had PIs identified indicating that vaccination alone is unlikely to result in BVDV freedom without also identifying and culling PIs. However, infected farms that were either not vaccinating before the start of the study or chose not to vaccinate throughout generally had a higher proportion of PIs than infected herds that had been utilising vaccine for some time. The data indicate that while BVDV vaccination alone may not result in eradication from an infected herd, it can be beneficial in reducing the overall number of PIs.

For the current study, it was deemed difficult to use isolated BM Ab results to accurately assess the BVDV status of each herd. BM Ab screening has traditionally been used as a starting point (Lindberg and Alenius 1999) providing an historical perspective of the disease but often offering insufficient information regarding the likelihood of the presence of PI animals to drive forward eradication programmes. The immune response to natural infection can persist in individual animals for more than three years (Fredriksen and others 1999) and if a milking herd is populated by a moderate number of animals that have been infected historically, a BM sample may falsely indicate current infection. The effect of vaccination on the results of the BM Ab test is not well documented and could further confound interpretation. In many European BVDV control programmes, vaccination has not been used due to the confusion it may cause in diagnostic test interpretation (Houe and others 2006). BM Ab tests are highly sensitive in naïve herds; however, at the outset of this study, none of the herds involved were naïve, hence the value of this test alone was considered limited. In areas of high BVDV prevalence, it is preferable to undertake YS blood tests as a primary screen to assess herd status (Valle and others 2001). Ab-positive YS are closely associated with the presence of a PI (Houe 1992) and, as the life of a PI is often shorter than a clinically normal animal, it is common to find PI animals among YS (Houe 1993). For this reason, herds in this study were assessed as infected or not based predominantly on a cautious analysis of their YS Ab levels. The fact that farms 15 and 27 were classified as BVDV-free on the initial screens was due to the purchase of PI animals just before the initial tests, which did not allow sufficient time for transmission and seroconversion to occur in the sentinel animals highlighting the need for continuous on-farm disease surveillance. Four farms had enough evidence from initial screens to support the WHT, yet no PIs were discovered; it is likely that these farms had been recently infected and that any PI animals had left the farm before WHTs were performed. The number of infected farms (59 per cent) involved in this study was marginally lower than expected. Previous studies have estimated that, in the UK, 65 per cent of herds have experienced recent infection (Paton and others 1998).

Where WHTs were performed to identify PIs, a day was generally required to blood sample 300 to 600 animals depending on the organisation and facilities available. Testing was undertaken alongside bovine tuberculosis testing, vaccination or other routine procedures on the farm. The key was good organisation, not rushing and ensuring that animal numbers were recorded accurately on the sample tubes.

Of the active study farms, PIs were identified on 16 farms and 14 of these had been correctly classified as infected at their initial screen. The two misclassified farms (15 and 27) have been discussed. In total, 61 PI animals have been confirmed during this study and Fig 4 illustrates the ages of the PI animals identified in infected herds on the day of the first WHT. While the authors do not know how long each of these animals would have survived if they were not culled early, this snapshot of PI ages provides an indication of the likely proportions of PIs that fall into each age category. The results demonstrate that the more than half of the PIs in infected herds are likely to be identified among animals less than two years of age. However, 28 per cent of PIs

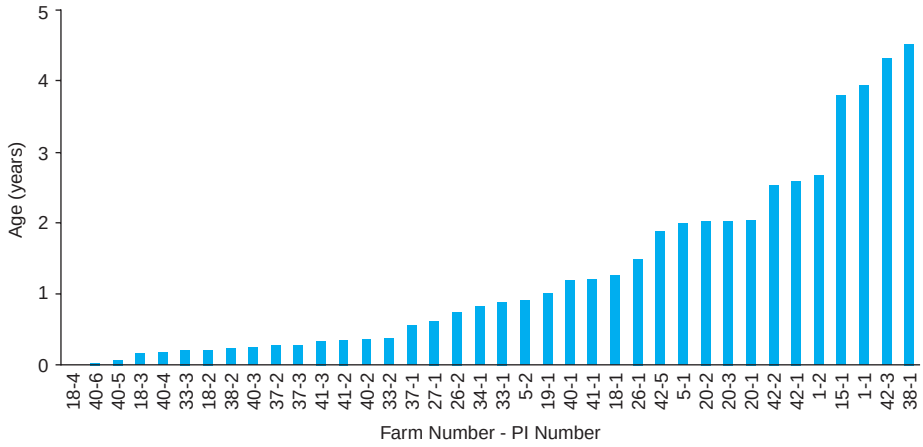

FIG 4: Ages of PI animals identified in the initial herd screens. Numbers on the x axis represent 'Farm number'-'PI number', for example, 33-3 is farm 33, third PI identified in the herd screen

identified in the study were older than two years of age and so it is a misconception that most of the PI animals die from mucosal disease (MD) between six and 24 months of age (Ramsey and Chivers 1953, Brownlie and others 1984). While not shown in the results, of all of the PIs identified in this study, only one had begun to develop MD, which was subsequently confirmed upon postmortem and virological examination, while two others had suspected MD, which was not confirmed.

It can be seen in Fig 3d that at the end of 2009, while good progress has been made on most farms, two (farms 2 and 36) remain infected and are not classified as eradicating. Farm 36 experienced a recent BVDV breakdown that is currently being investigated. At the time of writing, 21 potential PI animals had been identified on farm 2 (12 PI confirmed). The farmer refuses to vaccinate and is reluctant to cull confirmed PIs, convinced that they can be reared for beef while kept separate to other stock. Farm 2 rears heifers on a separate unit alongside animals from two other farms (not study members). The heifers are served on this 'communal' unit and before calving return to the main farm. It is highly likely that mixing animals from several locations has resulted in the production of a PI fetus that has returned and been born onto the main farm thus infecting the adult herd. It was strongly recommended that if this situation had to continue that the farmer undertake whole herd vaccination including the heifers before moving to the second site. However, this advice was not heeded.

As yet, no societal survey has been performed on the participants of this study. Some farms completed the study, others joined but dropped out and some attended the initial farmers' meetings yet decided not to join. The motivations of the three groups and reasons as to why they did or did not decide to join a funded eradication programme are currently being reviewed. Over the course of the project, a total of 41 farms were involved and at the end of December 2009, the authors have 33 committed farms and one, farm 2, which seems unlikely to eradicate BVDV without major changes to biosecurity and vaccination protocols. It was disappointing that 17 per cent of farms left the study, but it is perhaps inevitable that there would be some exits from a scheme of this sort. Multiple reasons were given to explain why seven farms elected to leave ranging from the enterprise selling up or changing veterinary practices to farmers failing to respond to requests for samples or dates for testing.

In conclusion, in total, almost 11,000 animals have been tested throughout the course of this study and 61 PI animals have been identified. At the end of the study, the number of BVDV-free farms involved have risen from 14 (41 per cent) to 24 (71 per cent) farms and the authors believe that, with several more farms on the brink of BVDV freedom, this number will soon rise to 29 farms (85 per cent). Ongoing support is currently being provided to the farms that are still infected in order to reach BVDV freedom, while conducting continued surveillance on the farms that have attained a BVDV-free state. Valuable data have been collected from these study farms regarding the logistics of WHTs and the prevalence of BVDV in a cattle-dense area of the UK. The work on these farms has shown that BVDV eradication is a real possibility even in cattle-dense areas where biosecurity is a major issue. The participants in this study are currently providing data to enable a detailed analysis of the risk factors associated with herd infection and the calculation of the cost benefits of BVDV eradication.

Acknowledgements

This study was funded by Defra under project grant SE0777. The authors thank Mick Cranwell (VLA) for his help and support with the laboratory testing, Paddy Gordon for his insightful comments during the study design and setup, Professor George Gunn for his invaluable expertise on the epidemiology of livestock diseases and the practitioners at Shepton Veterinary Group and Synergy Farm Health for their extensive involvement in this work.

References

Anon (2010) Cattle Health Certification Standards-Technical Document. www.checs.co.uk. Accessed March 7, 2011

BENNETT, R. & IJPELAAR, J. (2003) Economic Assessment of Livestock Diseases in Great Britain. Final Report to Defra. The Department of Agricultural and Food Economics. The University of Reading. www.apd.reading.ac.uk/AgEcon/livestockdisease/lstockdisfinrepRMB.pdf

BROWNLIE, J., CLARKE, M. C. & HOWARD, C. J. (1984) Experimental production of fatal mucosal disease in cattle. *Veterinary Record* **114,** 535-536

BROWNLIE, J., CLARKE, M. C. & HOWARD, C. J. (1989) Experimental infection of cattle in early pregnancy with a cytopathic strain of BVDV. *Research in Veterinary Science* **46,** 307-311

DEFRA (2008) The Cattle Book 2008. www.defra.gov.uk/foodfarm/farmanimal/diseases/vetsurveillance/documents/cattlebook-2008.pdf. Accessed March 7, 2011

EDWARDS, S., WOOD, L., HEWITT-TAYLOR, C. & DREW, T. W. (1986) Evidence for an immunocompromising effect of bovine pestivirus on bovid herpesvirus 1 vaccination. *Veterinary Research Communications* **10,** 297-302

ELLIS, J. A., DAVIS, W. C., BELDEN, E. L. & PRATT, D. L. (1988) Flow cytofluorimetric analysis of lymphocyte subset alterations in cattle infected with bovine viral diarrhea virus. *Veterinary Pathology* **25,** 231-236

FREDRIKSEN, B., SANDVIK, T., LØKEN, Y. & ØDEGAARD, S. A. (1999) Level and duration of serum antibodies in cattle infected experimentally and naturally with bovine virus diarrhoea virus *Veterinary Record* **144,** 111-114

HOUE, H. (1993) Suvivorship of animals persistently infected with bovine viral diarrhoea virus (BVDV). *Preventive Veterinary Medicine* **15,** 275-283

HOUE, H., UTTENTHAL, A., PEDERSEN, K. M., JENSEN, A. M. & BARTLETT, P. (1997) Risk factors for a change in bovine virus diarrhoea seropositivity in 41 Danish dairy herds during two years. In Proceedings of the 3rd ESVV Symposium on Pestivirus Infections. Eds S. Edwards, D. J. Paton, G. Wensvoort. Lelystad, September 19 to 20, 1996

HOUE, H. (1999) Epidemiological features and economical importance of bovine virus diarrhoea virus (BVDV) infections. *Veterinary Microbiology* **64,** 89-107

HOUE, H. (2003) Economic impact of BVDV infection in dairies. *Biologicals* **31,** 137-143

HOUE, H., LINDBERG, A. & MOENNIG, V. (2006) Test strategies in bovine viral diarrhea virus control and eradication campaigns in Europe. *Journal of Veterinary Diagnostic Investigation* **18,** 427-436

LINDBERG, A. L. & ALENIUS, S. (1999) Principles for eradication of bovine viral diarrhoea virus (BVDV) infections in cattle populations. *Veterinary Microbiology* **64,** 197-222

MARS, M. H., BRUSCHKE, C. J. & VAN OIRSCHOT, J. T. (1999) Airborne transmission of BHV1, BRSV, and BVDV among cattle is possible under experimental conditions. *Veterinary Microbiology* **66,** 197-207

MCGOWAN, M. R., KIRKLAND, P. D., RICHARDS, S. G. & LITTLEJOHNS, I. R. (1993) Increased reproductive losses in cattle infected with bovine pestivirus around the time of insemination. *Veterinary Record* **133,** 39-43

MOERMAN, A., STRAVER, P. J., DE JONG, M. C., QUAK, J., BAANVINGER, T. & VAN OIRSCHOT, J. T. (1993) A long term epidemiological study of bovine viral diarrhoea infections in a large herd of dairy cattle. *Veterinary Record* **132,** 622-626

NETTLETON, P. F. & ENTRICAN, G. (1995) Ruminant pestiviruses. *British Veterinary Journal* **151 (6),** 615-642

PATON, D. J., CHRISTIANSEN, K. H., ALENIUS, S., CRANWELL, M. P., PRITCHARD, G. C. & DREW, T. W. (1998) Prevalence of antibodies to bovine virus diarrhoea virus and other viruses in bulk tank milk in England and Wales. *Veterinary Record* **142,** 385-391

PETERHANS, E., JUNGI, T. W. & SCHWEIZER, M. (2003) BVDV and innate immunity. *Biologicals* **31,** 107-112

POTGIETER, L. N. (1995) Immunology of BVDV. *Veterinary Clinics of North America: Food Animal Practice* **11,** 501-520

PRESI, P., STRUCHEN, R., KNIGHT-JONES, T., SCHOLL, S. & HEIM, D. (2011) Bovine viral diarrhea (BVD) eradication in Switzerland–experiences of the first two years. *Preventive Veterinary Medicine* **99,** 112-121

RAMSEY, F. K. & CHIVERS, W. H. (1953) Mucosal disease of cattle. *North American Veterinarian* **34,** 629-633

RÜFENACHT, J., SCHALLER, P., AUDIGÉ, L., STRASSER, M. & PETERHANS, E. (2000) Prevalence of cattle infected with bovine viral diarrhoea virus in Switzerland. *Veterinary Record* **147,** 413-417

SANDVIK, T. (2004) Progress of control and prevention programs for bovine viral diarrhoea virus in Europe. *Veterinary Clinics of North America: Food Animal Practice* **20,** 151-169

SYNGE, B. A., CLARK, A. M., MOAR, J. A. E., NICOLSON, J. T., NETTLETON, P. F. & HERRING, J. A. (1999) The control of bovine diarrhoea virus in Shetland. *Veterinary Microbiology* **64,** 229-233

TRUYERS, I. G., MELLOR, D. J., NORQUAY, R., GUNN, G. J. & ELLIS, K. A. (2010) Eradication programme for bovine viral diarrhoea virus in Orkney 2001 to 2008. *Veterinary Record* **167,** 566-570

VALLE, P. S., MARTIN, S. W. & SKJERVE, E. (2001) A babeysian approach to estimating the performance of a bovine viral diarrhoea virus (BVDV) antibody ELISA bulk tank milk test. *Preventive Veterinary Medicine* **50,** 71-87

VIRAKUL, P., FAHNING, M. L., JOO, H. S. & ZEMJANIS, R. (1988) Fertility of cows challenged with a cytopathic strain of bovine viral diarrhea virus during an outbreak of spontaneous infection with a noncytopathic strain. *Theriogenology* **29,** 441-449

WRAY, C. & ROEDER, P. L. (1987) Effect of bovine virus diarrhoea-mucosal disease virus infection on salmonella infection in calves. *Research in Veterinary Science* **42,** 213-218

Establishing a pilot bovine viral diarrhoea virus eradication scheme in Somerset

R. E. Booth and J. Brownlie

Veterinary Record published online October 25, 2011
doi: 10.1136/vr.100191