



FOOD AND FARMING GROUP

Veterinary Sciences Core Team

EPIDEMIOLOGY REPORT

REPORT ON THE DISTRIBUTION OF BLUETONGUE INFECTION IN GREAT BRITAIN ON 15 MARCH 2008

MAY 2008

Prepared by the National Emergency Epidemiology Group

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1 EXECUTIVE SUMMARY

1. This report reviews the evidence to assess where else BTV may have existed in the period up to 15 March 2008, the end of the winter 2007/8 vector free period (VFP). It uses data gathered during the implementation of three disease control measures and two targeted surveillance activities. All analyses have been conducted at the county level.
2. By 15 March 2008 BTV has been confirmed on 125 holdings in 13 counties in the east and south of England as a result of the investigation of suspect clinical cases, local surveillance and pre-movement testing (PMT) of animals moved under licence from the Protection Zone (PZ) and Surveillance Zone (SZ) during the VFP. The known geographic distribution of bluetongue virus type 8 infection (BTV) in domestic livestock in Great Britain (GB) and the location of current and initial disease control zones is shown in Figure 1.
3. BTV has also been found, in individual animals that originated from East Anglia, on two holdings as a result of tracing potentially infected animals moved out of the East Anglia Protection Zone (PZ1) prior to disclosure of disease. One is in Leicestershire, close to the PZ boundary, and the other in Staffordshire, towards the western side of the SZ. Testing of other animals on these premises is in progress; the PMT data suggests widespread infection has a higher likelihood in Leicestershire than Staffordshire.
4. Review of the available evidence indicates that BTV is likely to have become widespread in the East Anglian PZ (PZ1) during 2007, with many holdings affected. The likelihood of infection of susceptible species with BTV reduces across the country from east to west, however some evidence raises the possibility that the western boundary of PZ1 should be further west. Therefore this boundary line may be treated with a slight degree of caution, although no specific evidence points to it being incorrectly defined. Nevertheless, this boundary should be reviewed, if it is to be used to define those holdings with similar high likelihood of having become infected during 2007, and therefore most likely to provide a focus for recrudescence of BTV in 2008.
5. The surveillance of cattle herds within 10 km of the Poole case (a single infected animal disclosed by PMT) is almost complete and, to date, there is no evidence of BTV in any other herds in this area. There is little evidence to inform discussion as to the likelihood of BTV being present in the area between PZ1 and PZ2.
6. The evidence raises concern that BTV is present, possibly to the same extent as in East Anglia, further north along the east coast of England. However there is no evidence to suggest that such widespread infection is present elsewhere in GB. The evidence from tracings that shows that BTV was not moved by animal movements into the SZ and Free Area, other than the two cases described above, and the distribution of confirmed and negative report cases provide supporting evidence that BT is unlikely to be in the Free Area.
7. The statements in this report are based on the best available evidence. It is important to note that this evidence is far from complete for a full epidemiological analysis, and that much of the data used was collected for purposes other than this analysis. However, the purpose of this report is to use the available evidence to inform whether further surveillance work is required.

8. The limitations in our knowledge about BTV and reconciliation of the data to allow collation of different datasets has required a number of assumptions to be made that could reduce the accuracy and representativeness of these estimates. In particular (i) the lack of knowledge as to how BT over-winters, (ii) its rate of spread within herds and across the country through local midge infection, and (iii) the extent of illegal or unreported movements of animals, coupled with the variable quality of these data that has necessitated estimation of missing data and extensive cross-verification.
9. Although there has been no additional widespread surveillance, such as sentinel animal or bulk milk testing, over 55,000 animals in the SZ have been examined for BTV by pre-movement testing. Thus the level of certainty about BT distribution is different in different areas of GB.

2 INTRODUCTION

10. The presence of circulating infection due to BTV was confirmed on 28th September 2007 in a cow born on a farm in Suffolk. Epidemiological investigation identified that virus was most likely to have been introduced to GB by windborne transmission of infected midges from continental Europe on 4th August 2007 (Bluetongue Epidemiology Report, Defra, 19 October 2007). Further cases were identified in East Anglia in the following weeks. The timeframe and various definitions of time periods referred to in this report are shown in Annex 1.
11. During the period between 4th August and 20th December 2007, BTV was probably introduced to several locations along the south eastern seaboard of England from continental Europe, and spread locally from these by infection of local midge populations. This period constitutes the 'at-risk' period for infection, based upon estimated vector activity, and runs from the putative date of virus incursion to the end of the vector transmission period.
12. Between 4th August and 28th September, when movement restrictions were applied, it is possible that BTV was spread by movement of (unrecognised) infected animals to previously uninfected areas. Additionally, further unintentional spread of BTV may have occurred from infected holdings that were later categorised into the PZ following disclosure of infection on nearby holdings later in the year.
13. This report provides an epidemiological assessment of the distribution of BTV in GB at the end of the vector-free period (VFP) from the data available from four distinct surveillance activities.

3 EPIDEMIOLOGICAL ANALYSIS STRATEGY

3.1 HYPOTHESIS

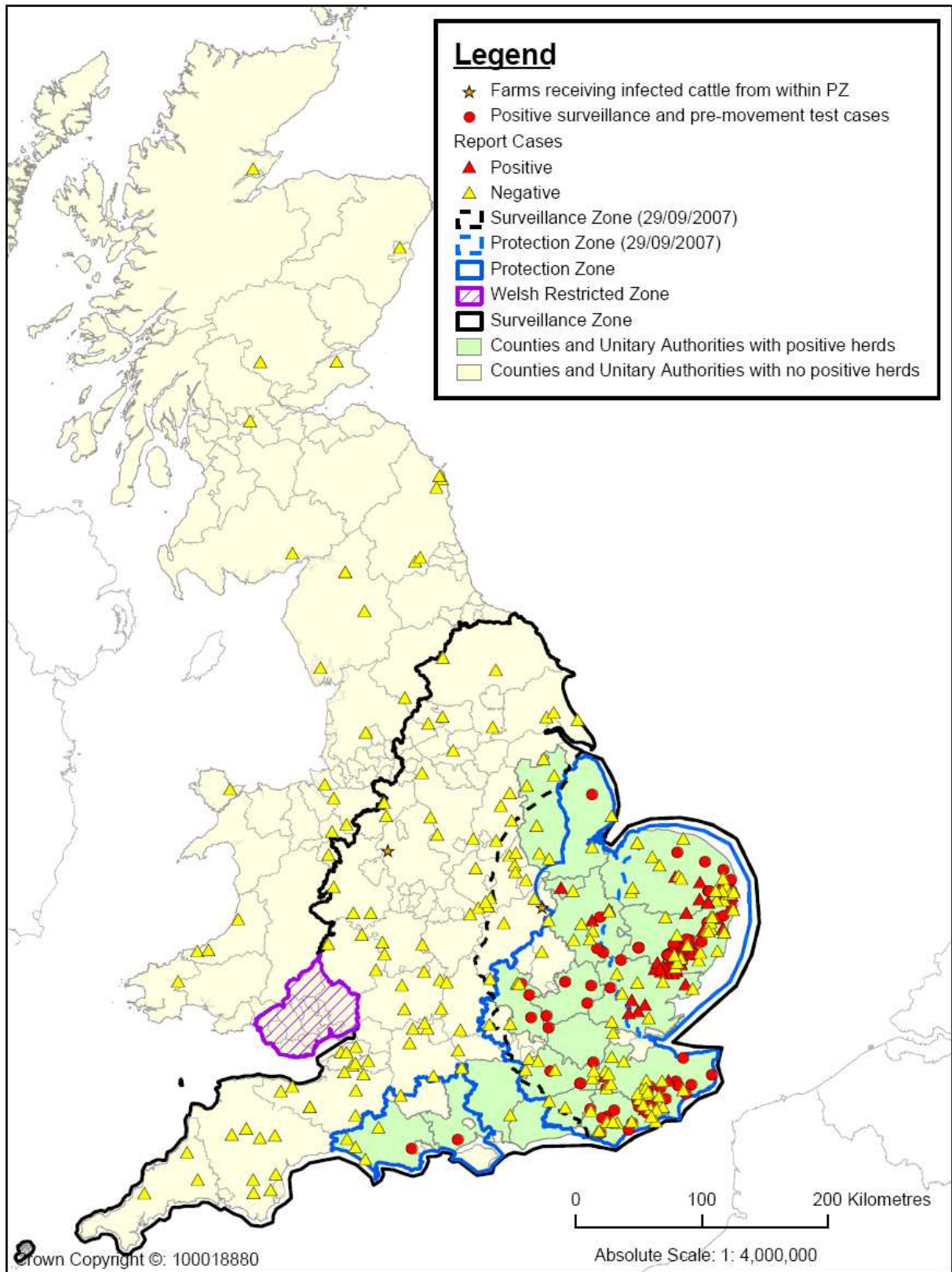
14. The report reviews the available evidence to test the hypothesis that BTV infection that affects more than a single animal on a holding is contained within the current Protection Zones and has spread locally by local midge movement.
15. The hypothesis and analysis are based on a number of assumptions that are listed in Annex 2. Of particular note is the assumption that if BT has moved outside the PZ it is as a result of infected animals or infected midges being transported. The single case detected outside PZ1, which gave rise to the second Protection Zone centred on the Poole area of Dorset, referred to in this report as PZ2, challenges this hypothesis and is discussed.

3.2 SURVEILLANCE STRATEGY

16. The surveillance strategy to test the hypothesis has four different arms . These are:

- Investigation of clinical reports of suspect disease.
- Tracing and testing of potentially infected livestock moved out of an infected area before disclosure of disease (tracings) .
- Surveillance of livestock moved out of the Restricted Area during the 2007/8 Vector Free Period, through pre-movement testing (PMT).
- Targeted surveillance around selected cases to determine prevalence of BTV at both herd and animal level.

Figure 1: Known geographic distribution of bluetongue virus (BTV) infected livestock at the end of the 2007 transmission period, and the location of current and initial disease control zones. [current at 4 April 2008]



CREATOR: RADAR Team, Defra

DATE CREATED: 4 April 2008

QUALITY: NDI forms and MOSS dataset

SOURCES: NDI and MOSS database



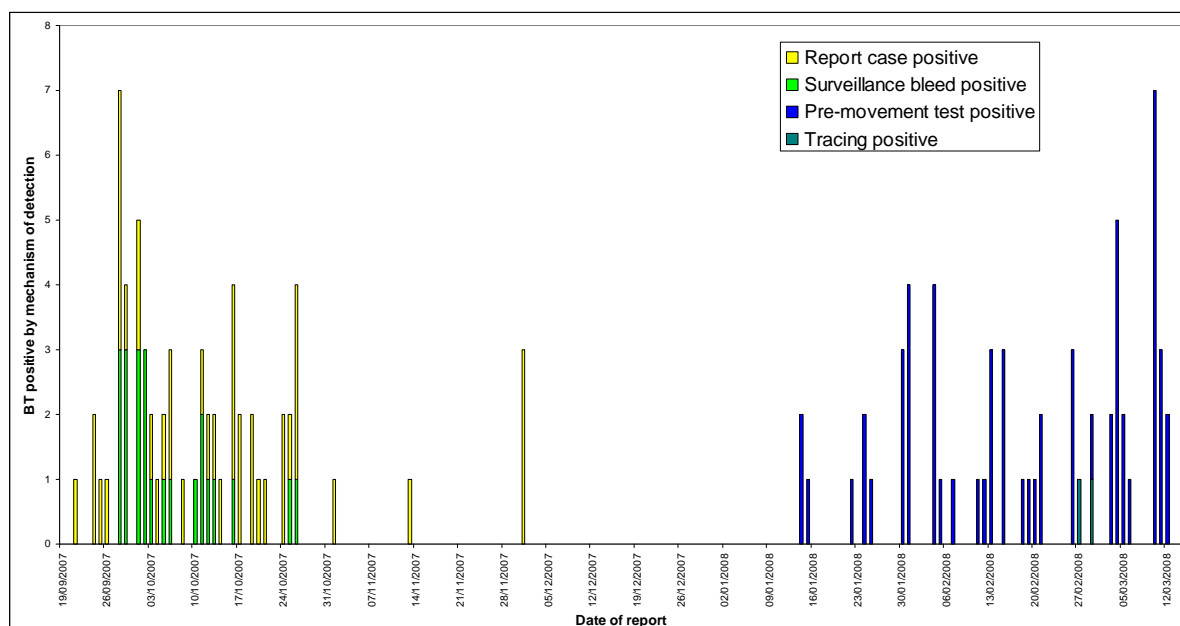
4 EPIDEMIOLOGICAL FINDINGS

17. To 15th March 2008 BTV had been confirmed (i.e. virus believed to be circulating between susceptible mammals and the midge vector) on a total of 125 premises in 13 counties of England. Of the 125 premises, two were identified in Leicestershire and Staffordshire respectively; in these cases the infected animals are believed to have acquired infection in PZ1 and it is not clear whether BTV is circulating locally between mammals and midges.
18. A distribution of the confirmed cases according to the surveillance mechanism by which they were first identified is provided in Table 1 and is shown as an epidemic curve in Figure 2. This shows that cases were identified as a result of clinical appearance during the at risk period, whilst PMT resulted in identification of clinically inapparent cases during the VFP when testing was undertaken. These are further discussed below.

Table 1: Number of BT cases according to the surveillance mechanism of identification

Surveillance mechanism	Number of premises
Clinical report (i.e. disease notification)	42
Surveillance bleeding	23
Tracings	2
Pre-movement testing	58
TOTAL	125

Figure 2: Epidemic curve of BT cases in GB confirmed between 22nd September 2007 and 15th March 2008 by surveillance mechanism of identification

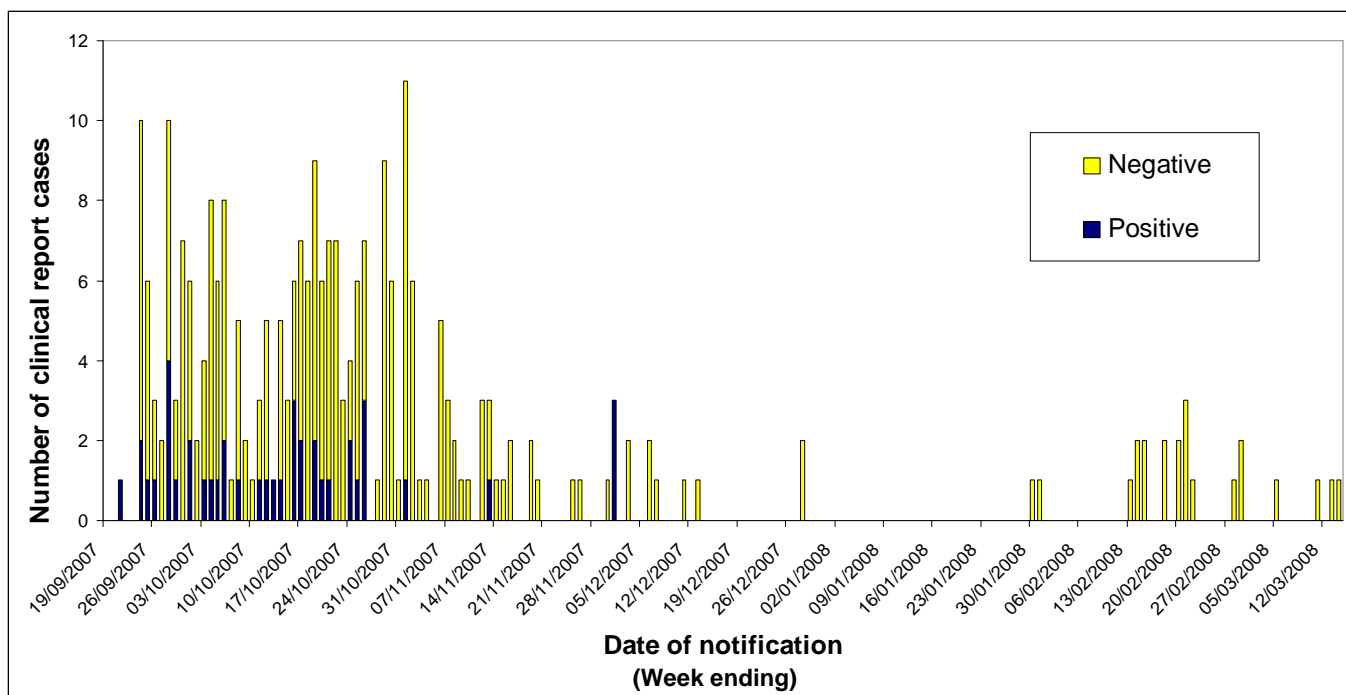


4.1 DISTRIBUTION OF CLINICAL REPORT CASES

19. There were 268 reports of clinical disease suspected due to BTV from 28 counties in GB between 4th August 2007 and 15th March 2008. BTV was confirmed on 42 (16%) of these holdings, of the remaining 226, 81 (36%) were negated on clinical grounds and the remainder following laboratory testing.

20. Most reports were received before the end of October 2007 but the number of reports increased over the 5 weeks leading up to the end of the VFP (Figure 2). BTV was not confirmed as the cause of clinical disease in any report cases between 1st December 2007 and 15th March 2008.

Figure 3: Daily number & status of BT report cases in GB, 22nd September 2007 -15th March 2008



21. The geographical distribution and species affected, of the 42 confirmed cases detected by the statutory notifications is given in Table 2. The location of these holdings (red triangles), of the report cases in which BTV was ruled out as the cause of clinical disease (yellow triangles), and of those infected holdings detected through targeted surveillance or pre-movement testing (red circles) is shown in Figure 1.

Table 2: Number of confirmed clinical cases of BT by county and affected species

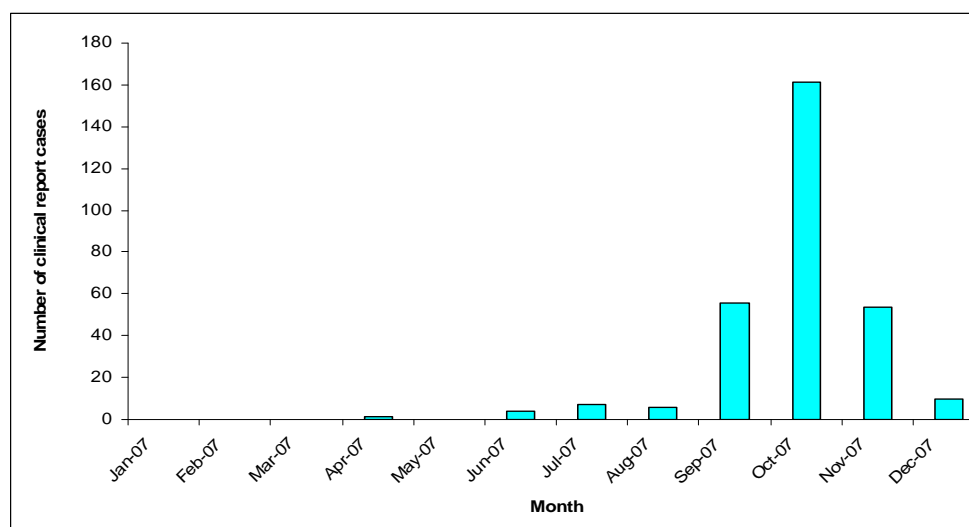
County	Total	Cattle	Sheep	Cattle & sheep	Cattle & goats
Cambridgeshire	2	1	1	0	0
East Sussex	1	0	0	1	0
Essex	12	8	4	0	0
Kent	3	1	2	0	0
Norfolk	6	6	0	0	0
Suffolk	18	13	4	0	1
Grand Total	42	29	11	1	1

22. Overall, suspect cases have been reported from across England and Wales. A few cases were also reported from Scotland. Proportionately fewer premises keeping susceptible species reported suspicion of disease the further west and north from they are located. It is unlikely that the observed spatial distribution is as a result of the lack of uneven awareness of BT by the farming community, although in counties further away from the affected areas people may wait longer before they report. Since BT usually results in severe clinical disease in a large proportion of sheep and goats in infected flocks, it is likely that if infection were present in areas of high sheep density (northern, central and south-western England and Wales) that it would have been observed and reported.

23. Confirmed report incidents remain largely restricted to the south-eastern seaboard in the counties of Suffolk, Norfolk, Essex, Kent and East Sussex. These areas are broadly situated within the area identified by meteorological modelling as being at risk of airborne spread of BTV from Europe in August 2007. Despite clinical disease being more severe in sheep and the presence of a substantial sheep population in East Anglia and the eastern part of England, most confirmed report cases arose in cattle; a pattern seen in the first year of reports from affected countries in continental Europe.

24. The increased level of awareness is well demonstrated by the greatly increased number of reports (statutory notifications) later in 2007, as shown in Figure 4.

Figure 4: Number of statutory notifications of BT in 2007, by month of report



4.2 MOVEMENTS PRIOR TO DISCLOSURE OF DISEASE - TRACINGS

25. Animal movements undertaken from the PZ during the “at risk” period and prior to the first clinical case being confirmed (i.e. 4th August to 28th September 2007) risked moving infected animals into uninfected areas during a period when onward transmission was possible, with the result that the local vector and animal population may have been infected. Consequently, these movements may have inadvertently resulted in the spread of BT.
26. In order to establish the possible degree of spread due to movements prior to disease disclosure on 28th September, all movements of livestock to live (i.e. not to slaughter) from holdings within the PZ, including all the movements off the early infected premises (IPs), have been identified and followed up if within the SZ or Free Area. Details are provided in Annex 4.
27. As more cases were found and the PZ expanded many of the movement destinations originally within the SZ fell within PZ restrictions, and no longer presented a risk of dissemination of BTV beyond the PZ.
28. Overall, there were a total 82,106 susceptible animals (17,891 cattle, 64,090 sheep and 125 goats) recorded to have moved from 1,693 holdings designated as being within the limits of PZ1 on 12th November (the PZ as extant at the time the VFP commenced); most of these movements were to premises within the current PZ. Movements assessed as out of the current PZ led to 1,417 cattle, 3,345 sheep and 16 goats being identified for tracing, having moved from 223 premises. Animals that had moved to slaughter or been exported were excluded. In total, 396 cattle, 1,543 sheep and 11 goats were identified for sampling. The majority had moved to premises in the SZ, however 580 animals have moved into the Free Area (Table 3). These tracings from PZ1 are almost complete, with the exception of 186 cattle that moved within the Bury St Edmunds and Reigate AHDO areas and are most likely on premises within the current PZ.
29. In total 29,037 cattle moved into the current SZ and FA to a maximum of 967 premises from premises that were not in the original PZ1 (28th September) but have since been added as a result of the expansions of PZ1 (including those detailed above in paragraph 28). There have been few clinical cases of BT reported in the areas of the original PZ1 expansion, suggesting that infection was not actively circulating outside the original PZ1 at a high level prior to the onset of the VFP and the onset of PMT. Consequently, and because of the required prioritisation of resources, the tracing of animals moved from the areas of the expanded PZ has been given a lower priority.

Movements to the SZ

30. Of the 1,340 cattle, moved from the original PZ1 to the SZ, 319 were sampled, two of which tested positive by ELISA (i.e. for antibody); one each had been moved to premises within the Stafford and Leicester AHDO areas. These animals had been moved on 28th October and 13th November respectively, increasing the risk of local transmission before the VFP started by 54 and 38 days respectively. Investigation is underway to determine whether local spread may have occurred by testing all the herd.
31. There were a total of 27,672 cattle moves to a maximum of 908 premises in the SZ from premises that were not in the original PZ1 (28th September) but have since been added as a result of the expansions to the PZ1.

32. There were also 2,849 sheep moved to approximately 48 premises including markets and 9 goats to 7 premises in the SZ; 1,047 sheep and 4 goats were tested. All animals tested negative for BT.

Movements to the Free Area

33. A total of 77 cattle, 496 sheep and 7 goats were moved to 14, 3 and 1 premises respectively within the Free Area. These have been traced and those that are alive and in GB have been sampled; all have been found negative for BTV. The results are presented in Table 3.

34. A total of 1,365 cattle moves to a maximum of 59 premises in the current FA originated from premises that were not in the original PZ1 but have since been added as a result of the expansion of PZ1.

Table 3: Tracings of susceptible livestock from PZ (as extant at start of VFP) to premises located in current Free Area

Receiving AHDO	Species			Sampled		Not sampled	
	Cattle	Sheep	Goats	Positive	Negative	Dead	Exported
Galashiels	0	0	7	0	7	0	0
Carlisle	0	14	0	0	14	0	0
Newcastle	1	481	0	0	482	0	0
Carmarthen	18	1	0	0	19	0	0
Cardiff	8	0	0	0	7	1	0
Preston	37	0	0	0	5	0	32
Stafford	13	0	0	0	13	0	0
Total	77	496	7	0	547	1	32

Movements of cattle to unknown locations

35. There were 43 cattle moves (98 cattle) to unknown locations (see Annex 4). However approximately 80% of the 17,891 cattle moved from premises in the PZ remained within the PZ, so it is likely that only 20 of these animals moved out of the PZ. The estimated prevalence of BTV infection in these animals is 0.5% (i.e. 1 in 200 animals, see below), so the likelihood of these untraceable movements disseminating BTV into the SZ or Free Area is very low.

Summary

36. Overall, the total number of animals identified for tracing was 4,778 from 223 premises which resulted in 1,950 being sampled (396 cattle, 1,543 sheep and 11 goats). Two holdings to which BTV has been introduced by infected cattle could become the starting point of a local BTV epidemic in 2008, and additional investigations are in progress to assess this likelihood.

37. A full tracing exercise has not been carried out for the movements off the additional holdings included in the PZ as a result of extensions during the VFP when disease was identified due to PMT. It is likely that 80% of the cattle movements are likely to be within the PZ, and the evidence collected from the previous tracings indicates a very low likelihood that these movements would carry infection. Cattle traced from the original PZ1 are estimated to have a 0.5% likelihood of having been infected with BTV (2/396).

38.If this likelihood were applied to the extended PZ1 area, an estimated 140 infected cattle may have moved out of the original PZ1 (29th September 2007) areas into the SZ and a further 7 may have moved into the FA. This is likely to be an over estimate given that there is a lower prevalence of infection in the extended PZ than in the original PZ1. There is no evidence of past infection having been found in traced sheep or goats. Similarly no tracings have been carried for animals moved out of the Poole PZ; the surveillance evidence indicates that the risk of BTV being moved with these animals is negligible.

4.3 MOVEMENTS IN THE VECTOR-FREE PERIOD – PRE-MOVEMENT TESTING

39.The movements undertaken during the VFP (20th December 2007 to 15th March 2008) may risk further dissemination once the 2008 vector transmission period starts. To minimise the risk of spread out of the Restricted Area all movements from the PZs and SZ of animals to live undertaken during the VFP must be pre-movement tested (PMT) to demonstrate they are free from BTV. A total of approximately 88,000 animals on 3,500 premises were tested by this route (Table 4).

40.Farmers were responsible for ensuring that the appropriate licence and documentation was acquired prior to movement of stock, other than to slaughter, from a premises within the PZ or SZ to the SZ or Free Area. As part of this PMT is undertaken by the private veterinary surgeon on request from the farmer. Since transmission is assumed not to occur during the VFP the result of a test taken at any time during the VFP applies to the whole of the VFP.

Table 4: Number of holdings and animals subjected to PMT by zone

Location of origin	Cattle				Sheep/Goat			
	Premises			Animals	Premises			Animals
	Tested	Negative	Positive	Tested	Tested	Negative	Positive	Tested
PZ 1	796	751	44	14097	164	163	1	6485
PZ 2	530	529	1	9658	27	27	0	1644
SZ	1431	1431	0	20392	201	201	0	8559
Welsh SZ	147	147	0	2543	239	239	0	25195
Total	2904	2858	45	46690	631	630	1	41883
Approx total no. of premises in Restricted Area (to nearest 1,000)	Cattle: 40,000			Sheep/Goat: 48,000				

41.Whilst report cases inform of the presence of clinical disease, infections in particular in cattle are often inapparent; 46 such infections have been disclosed by PMT (Table 4). This work has shown that BT infection is present throughout the PZ and that infection is more prevalent within the PZ than can be established by reporting of clinical disease alone.

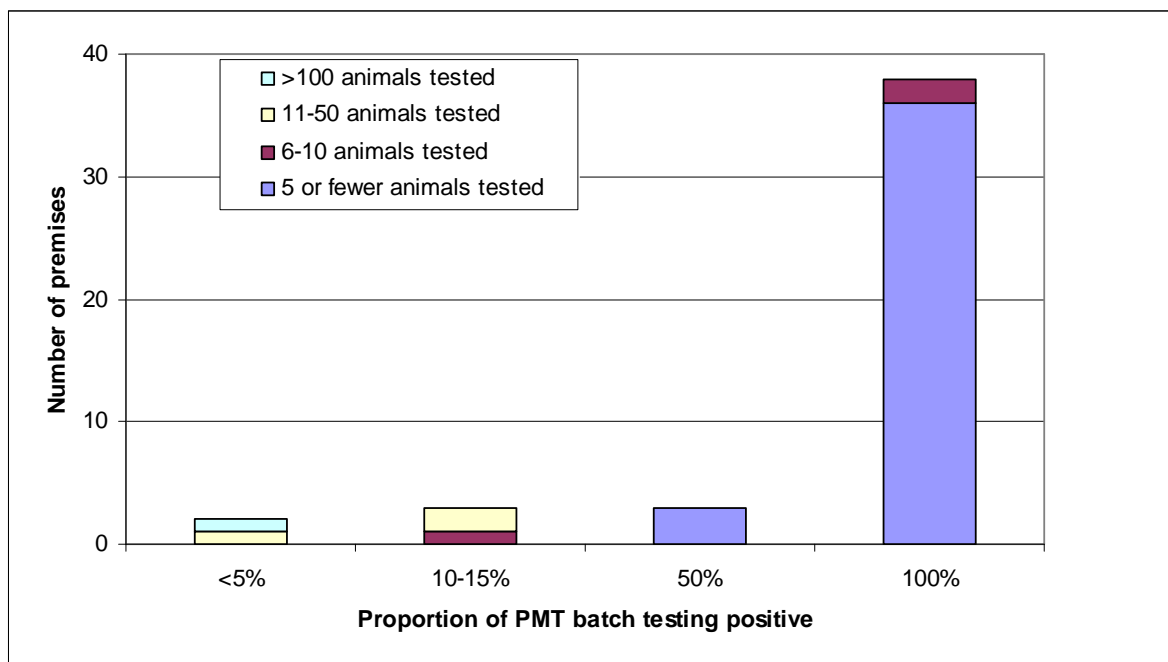
42.Only stock intended for movement were tested, and among these only one or two BTV positive animals were identified on the majority of PMT positive

premises (Table 5), results which could arise because either (i) only single animals have been infected or (ii) infection is widespread and insufficient animals have been tested to show this. However 8 positive premises had 5 or more animals tested. Of these 8, 3 had positive results for all the animals tested, whilst of the remainder the proportion of positive animals was less than 15% (Figure 5). This suggests that there is some variation in the proportion of infected animals on farms within the RZ, which may reflect the level of infection in the local midge populations. All but one of these premises were located in the PZ or in the SZ close to the western edge of the existing PZ at the time of disclosure.

Table 5: Number of PMT test positive animals per positive premises

Number of positive animals per premises	Number of premises		
	Species		Grand Total
	Cattle	Sheep	
1	29	1	30
2	5		5
3	3		3
4	3		3
5	2		2
6	3		3
Grand Total	45	1	46

Figure 5: Number of positive PMT premises by proportion of animals in PMT batch that tested positive



43. Of concern is that one of the premises that submitted 6 samples all of which were positive, was situated in Lincolnshire, some distance north of the PZ boundary in place at the time of testing. This suggests that the local midge population may be infected and that animals on other nearby premises are at

risk once transmission restarts. More surveillance around this premises is required in order to establish how widespread infection is here.

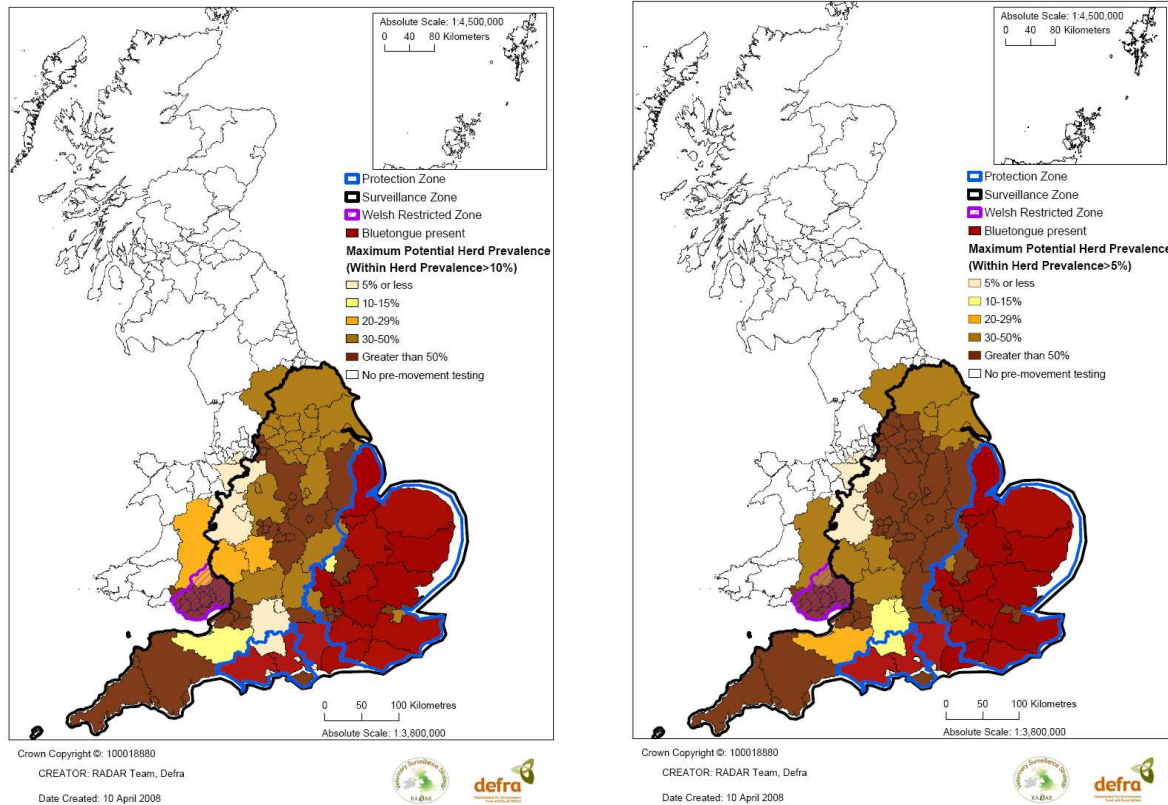
44. The use of PMT has also provided some evidence the BT has not spread beyond the current PZ boundaries. The confidence with which we can state that BT is absent from a farm or an area is provided by estimating the maximum potential prevalence of infection given that all of the samples taken have proved negative for BTV.
45. The county location of holdings subjected to PMT with negative results has been analysed to assess the extent to which these results provide reassurance that BTV is unlikely to be present in that country (described in detail in Annex 6). Thus the greater the number of holdings that have been tested for the presence of BTV through PMT, and been found negative, the lower the likelihood that BTV is present in that county. There is uncertainty both due to the many assumptions associated with this analysis (see Annex 6), and as to the likely within herd prevalence (see next section) that could have developed by the time of PMT, if BTV entered a herd in 2007. Thus two possibilities are presented, one a more conservative estimate than the other.
46. Figure 3a shows the likelihood that BTV could be present despite all PMT results being negative, if the within herd prevalence is estimated as >10%, with those counties in which there is most evidence that BTV is not present shown in paler colours. The greater level of testing with negative results carried out in the west of the SZ near Wales (paler counties in Figure 6) provides some reassurance that BT has not reached these areas. Similarly the paler counties bordering the Poole PZ supports the surveillance evidence from around this case (see next section) that suggests that there is not widespread BTV infection in this area, by contrast with the East Anglia PZ.
47. Figure 6b is similar to Figure 6a, but assumes a within herd prevalence of 5%. If this is true there is complete uncertainty as to the potential extent of BTV in the Midlands, however there continues to be some reassurance that it is not present along the western side of the SZ.

Figure 6: Maximum potential prevalence of BTV infected herds given the expected within herd prevalence, based on negative PMT data (see assumptions, Annex 6)

(paler counties have a lower likelihood that BTV is present)

(a) Within herd prevalence >10%

(b) Within herd prevalence >5%



48. Note that all PMT is expected to have taken place within the Restricted Zone (RZ), however the poor quality of address data associated with PMT has required a county level analysis. Hence some PMT results are attributed to areas outside the RZ where the county crosses the boundary, or where the best estimate of the likely address falls in a county outside the RZ.

Summary

49. The likelihood that BT is present in the SZ decreases the further west the location considered, as shown in Figure 3. There is a high level of uncertainty about whether BT is present in the darker coloured counties next to the PZ boundary. The greater level of testing with negative results carried out in the west of the SZ near Wales (paler counties in Figure 6) provides some reassurance that BT has not reached these areas.

4.4 TARGETED SURVEILLANCE AROUND CONFIRMED CASES

50. Surveillance of cattle on the premises around confirmed cases was undertaken to determine if infection is more widely spread than the holdings first identified as infected, when BT is first confirmed in an area. Two phases of such targeted surveillance have been undertaken in relation to this outbreak of BT, one in East Anglia following the initial confirmation of disease on 28th September 2007 and

the second near Poole in Dorset following confirmation of infection on a premises there on 7th February 2008 following a pre-movement test.

51. The surveillance is based upon a number of assumptions, listed in Annex 2.

East Anglia (PZ1)

52. As previously reported, 22 cases of BTV infection were confirmed in cattle herds as a result of surveillance in the Ipswich and Lowestoft areas. The prevalence of infected herds by herd size in the Ipswich and Lowestoft areas suggested an increasing likelihood of infection with increasing herd size (Table 6). Similar surveillance was carried out on the eight cattle herds within 5km of the Peterborough case; all cattle tested were negative. This provides supporting evidence that the likelihood of infection decreases from east to west across England

Table 6: Prevalence of BTV infected cattle herds (report and surveillance cases) in the targeted surveillance areas, by herd size

Area	Herd Size	Total Herds	Percent Positive
Ipswich	1-50	32	50%
Ipswich	51-100	18	66%
Ipswich	101+	12	83%
Ipswich	Total	62	61%
Lowestoft	1-50	14	57%
Lowestoft	51-100	8	50%
Lowestoft	101+	17	80%
Lowestoft	Total	39	66%
Peterborough	1-50	4	0%
Peterborough	51-100	4	0%
Peterborough	Total	8	0%
Poole	1-50	2	0%
Poole	51-100	8	12%
Poole	101+	7	0%
Poole	Total	17	5%

Poole, Dorset (PZ2)

53. The single confirmed case on a premises near Poole in Dorset was identified in one of nine cattle following PMT on 7th February 2008. Subsequently all eligible cattle on the farm were tested together; the one positive calf remained positive, whilst all the other 56 cattle on the same premises and a further 76 on an additional premises under the same ownership tested negative. Forensic examination of the calf, including genetic DNA matching analysis with its dam and movement records, indicated that this calf was unlikely to have been imported and therefore supports the hypothesis that infection occurred on the farm. No cattle had been imported, or moved on to the farm from PZ1, during the at risk period or VFP.

54. Surveillance activities around the Poole IP were designed to determine if the local cattle population, and by therefore by inference the midge population, had been infected; details of the design are provided in Annex 3. The three working hypotheses for infection of this premises are that either (1) BTV-8 is circulating in the local midge population and that cattle have been infected locally; (2) that illegal movements have occurred of animals that were previously infected within

PZ1; (3) infection resulted from a single infectious midge bite from a stray infected midge.

55. To 15th March 2008, a total of 14 eligible premises within a 7km radius of the IP have been identified. Over 1,500 cattle on the 13 premises sampled to date have tested negative. Surveillance on the 14th farm is still in progress.
56. In addition to the evidence provided for those premises around the infected one, no evidence of movements of animals from PZ1 to PZ2 since 4th August, or from infected areas of Europe, has been found as part of the tracing exercise (see section 4.2 above). The possibility exists that the IP may have been infected as a result of infected animals being moved to a local abattoir or market and resulting in infection of the local midge population, or of the importation of infected midges from within the PZ. There are no abattoirs or markets within 10km of the IP, the nearest is approximately 30km away.
57. The negative results of the surveillance to date mean that, despite being unlikely, the hypothesis that infection of the single calf on the IP was as a result of a single infectious midge bite from a stray infected midge cannot be refuted.

Within herd prevalence (cattle)

58. The proportion of animals infected within a herd differed widely between areas at the time BTV was confirmed, probably reflecting the differing periods of time since infection was introduced to the herd (see Bluetongue Epidemiology Report, Defra, 19 October 2007). The final prevalence in 39 affected cattle herds in East Anglia was established by repeat sampling of all previously negative cattle in the herd during January 2008, results are shown in Table 6. The figures indicate that the within herd prevalence for beef and dairy herds is similar and there is a wide range. This is likely to reflect both time in of introduction of infection, as discussed above, and other confounding effects such as herd size, that have not been fully explored in this analysis.

Table 7: Within Herd prevalence of BTV infection as assessed by serological testing during the Vector Free Period, by herd type

Herd type	Mean	Median	Min	Max	No. herds
Beef	11%	9%	1%	41%	29
Dairy	11%	5%	1%	57%	9
Mixed	2%	2%	2%	2%	1
Total (all herd types)	11%	6%	1%	57%	39

5 LIKELIHOOD THAT BTV IS CONFINED TO THE PZ AS DEFINED ON 3RD APRIL 2008

5.1 LIKELIHOOD THAT BTV IS IN THE SZ AS DEFINED ON 3RD APRIL 2008

59. Active BTV infection has not been found on any holding in the SZ despite the testing of over 55,000 animals on approximately 2,000 premises (Table 4).

60. The two occurrences of BT infection detected in Stafford and Leicester AHDO were identified during the course of tracing exercises. These animals were moved prior to the VFP and therefore, if they were infectious at the time, or at any time from their move and prior to the start of the VFP on 20th December, may have acted as a source of infection for the local midge populations. No confirmed report cases have been identified in these areas. However, further investigation of the receiving herds is being undertaken to assess whether local midge infection has occurred.
61. The confirmation of BTV among all of six animals tested prior to movement on a farm in the west of Lincolnshire on 11th March 2008 led to an extension of the PZ northwards (Figure 1) and therefore all known BTV infection is confined to the current PZ. However the finding gives rise to concern that BTV may be present in the east of the country north of the current PZ; there is insufficient data from PMT to allay this concern.
62. An indication of the likelihood of BT having spread undetected into the SZ from the PZ area as a result of local midge movements has been provided by determining the maximum potential prevalence of undetected BT that could be present by county. The analysis has shown uncertainty as to the extent of infection in counties immediately bordering the western boundary of the PZ, however the likelihood of infection on individual holdings decreases from east to west.

5.2 LIKELIHOOD THAT BTV IS IN THE FREE AREA AS DEFINED ON 3RD APRIL 2008

63. There is no evidence to suggest that BTV is present in the Free Area. Awareness among animal owners has been raised, and demonstrated by widely geographically distributed statutory notifications of suspect disease due to BTV, and where practical possible 'vehicles' of transmission to this area have been explored.
64. All report cases of clinical disease suspicious of BTV in the Free Area have been investigated with negative results. The high density of sheep in the west of England and southern Scotland, and of cattle in western and northern England, together with the demonstrated level of awareness that would encourage reporting of suspect clinical cases, provide reassurance that BTV has not reached these livestock dense areas.
65. All susceptible animals moved off premises in the PZ as defined up to 14 November 2007 into the Free Area have been traced and where still alive, have been tested for BTV with negative results. Although this exercise cannot trace animals with incomplete documentation or moved illegally, the likelihood of such untraced movements being infected is considered to be very low.
66. PMT results cannot directly assess the likelihood of BTV in the Free Area as animals in this area did not require PMT. However the increased level of certainty that BTV is absent given by the level of PMT in the western parts of the SZ, and to a lesser extent, in the northern part of the SZ, provide reassurance that BTV has not spread by cross country midge transmission into the Free Area.

6.3 RISK FROM IMPORTED ANIMALS

67. Although surveillance is limited to Great Britain, information indicates a very low probability that BTV positive animals imported before the end of the VFP disseminated BTV to local midge populations before they were slaughtered. There is also a low likelihood that the offspring of animals imported from BTV positive areas, although negative themselves, may give birth to BTV viraemic calves.
68. Animals are allowed to be imported into the PZ from BTV-8 infected areas irrespective of their infection status with BTV-8. However, there is 100% BT testing of susceptible livestock imported to GB for those animals coming into the SZ or FA. From the 4th August to 20th December 2008 (i.e. prior to the VFP), 3 consignments of cattle tested positive for BTV. They all arrived in GB on or after 1st December and one consignment each went to Kirkcudbright, Middlesbrough and Worcestershire. All were slaughtered following confirmation of the positive tests. Given that these animals arrived during the period approaching the VFP and were slaughtered, the likelihood of local midge infection and successful overwintering of BTV is considered to be very low.
69. Two additional consignments of pregnant heifers were received in the VFP, one of each went to Wiltshire and Gloucestershire, and a further two, which went to Gloucestershire and Cheshire arrived just after the end of the VFP. Many of the animals were ELISA (but not PCR) positive which does not necessarily pose a disease threat, however, given recent evidence of potential trans-placental transmission of disease their unborn calves do potentially pose a risk (investigations are ongoing to assess the risk). Consequently, three premises in Gloucestershire and Wiltshire remain under restriction, and the new born calves will be tested at birth. If these animals are found to be PCR positive they will be destroyed immediately as a precautionary measure.
70. The one positive consignment of sheep, which arrived during the VFP, went to Ceredigion where all the sheep were slaughtered.

6 UPDATE: 16TH MARCH 2008 TO 9TH APRIL 2008

71. Twenty five further cases of BTV were confirmed between 16th March and 9th April (one of which was a clinical report case, the rest were identified by PMT).

6.1 DISTRIBUTION OF CLINICAL REPORT CASES

72. A further 26 reports of suspect clinical disease due to BTV were received between 15th March and 9th April 2008; in 24 cases BTV has been ruled out as the cause of clinical signs. Eight were negated on clinical grounds and 13 on the basis of laboratory tests. Results are pending for the 2 other case reports.

6.2 TARGETED SURVEILLANCE AROUND CONFIRMED CASES

Poole, Dorset (PZ2)

73. An additional single premises in Hampshire within PZ2 was confirmed BTV positive on 27th March 2008 (tested on 13th March), resulting in PZ2 being slightly extended. A single cow, resident on the premises since 2004 tested positive out of the entire herd of 70 that were tested. Investigations are ongoing

as to the possible route of infection of this premises, which lies outside PZ1 but was previously within the SZ. Investigation of movements on to the premises has shown that no moves occurred onto the premises from the PZ1 during the risk period. This premises is approximately 37km (23 miles) east of the previously confirmed case in PZ2. Therefore, currently the presence of this positive herd does not preferentially support any of the hypotheses presented for the Poole case.

74. This case does further raise the possibility that infection occurred through airborne spread from Northern France other than in the plume of 4th August and which might have landed on the south coast. However, we might expect to have detected wider infection if this were the case. Further investigation is required to confirm or refute this theory.
75. Surveillance conducted around the original PZ2 IP has been completed. None of the cattle premises within 10km of the IP have returned positive test results despite a total of over 1,000 animals being tested.

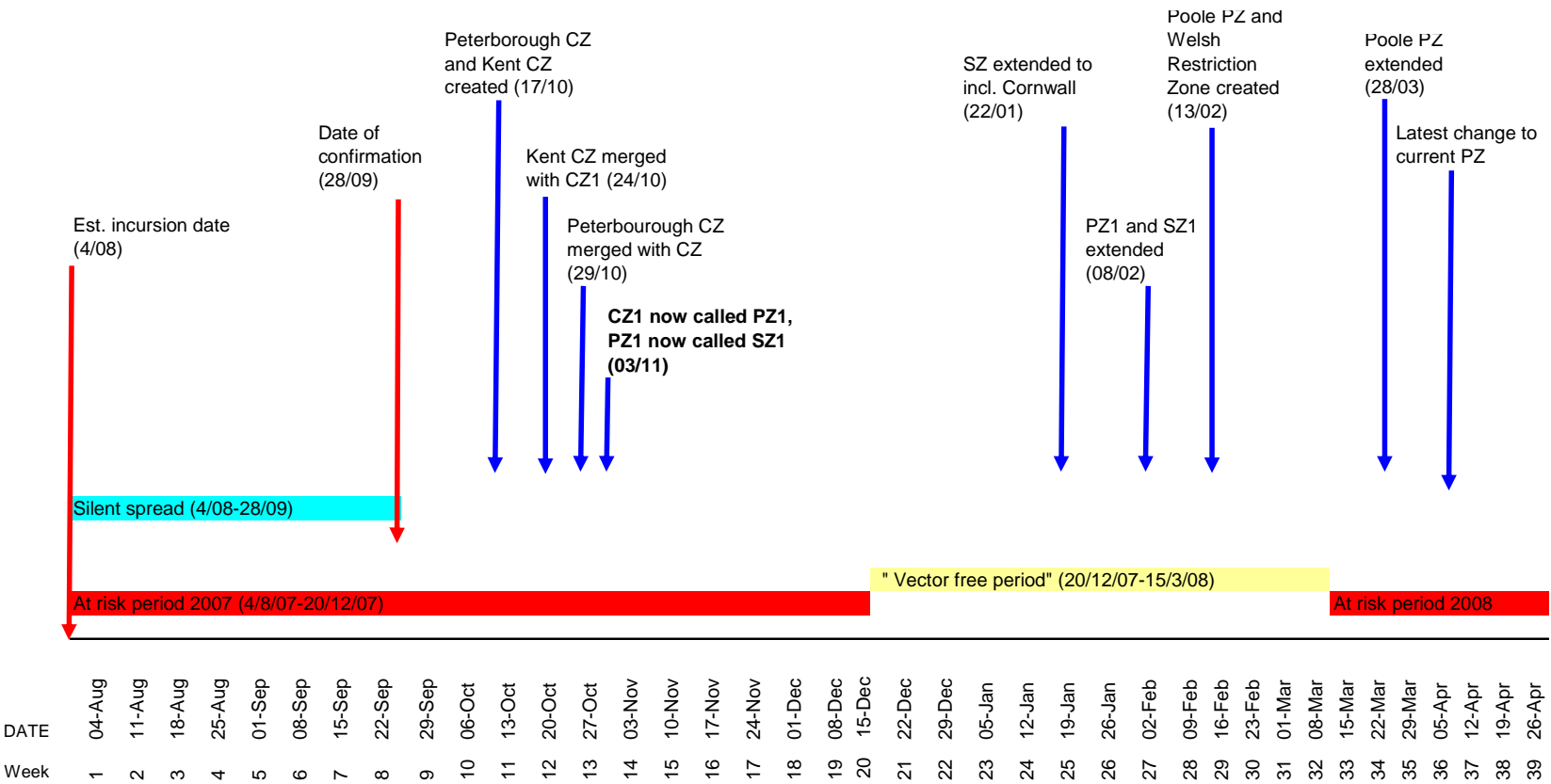
7 CONCLUSIONS

76. The evidence has been reviewed and partly supports the hypothesis presented. It suggests that BTV at a level greater than an individual animal is contained within PZ1 as defined on 3rd April. However it indicates that level of BTV in PZ2 is substantially different from PZ1, and that BTV is not widespread in PZ2.
77. The evidence also indicates uncertainty around the precise extent of herd level infection (here defined as more than 1 animal on a holding affected) beyond the current western and northern boundaries of PZ1. If such infection exists it could provide a focus for recrudescence of BTV in 2008.
78. Note that the evidence available was not collected for the purposes of this analysis and in consequence a number of important assumptions, and estimates to replace missing data have been made. These add to the uncertainty over the extent of BTV in GB.

National Emergency Epidemiology Group
18 April 2008 [Revised 30 April]

8 ANNEX 1: TIMEFRAME AND DEFINITIONS OF PERIODS OF BLUETONGUE SURVEILLANCE ACTIVITIES

The analyses presented here have been selected on the basis of the epidemiology of Bluetongue and the risk periods resulting from the date of likely incursion and the biology of the disease.



- NOTES: 1. Pre-movement testing took place only during the "Vector Free Period"
 2. Blue (darker) colour arrows show dates of significant PZ expansion
 3. Each time a zone expanded, additional premises were identified that may have already moved animals off the premises to other holdings not contained within the PZ

9 ANNEX 2: ANALYTICAL ASSUMPTIONS

No long distance infected midge movements have occurred (i.e. that individual midges have not moved further than a few kilometres at most from known infected locations).

Should long distance moves of infected midges have occurred, as a result of windborne spread or lorry transportation, certain considerations are necessary. If movement occurred during the transmission period, we might expect transmission to have taken place and the identification of spread would rely on the reporting of clinical cases outside the PZ. If movement of infected midges occurred during the Vector Free Period (VFP), depending upon midge survival rates, there is a risk of transmission once the at risk period has resumed from 16th March. Whilst this risk cannot be specifically tested, its likelihood is considered to be low particularly since no confirmed report cases have been identified further than 60 km from edge of the original PZ1 and no cases have been identified beyond the current PZ1 as defined at the start of the VFP.

All animals that have been moved, and identified as potentially exposed to infection and therefore require testing can be identified and sampled.

Susceptible animals that were located in the at risk area defined by PZ1, and that were moved before this was known, may have carried infection to other parts of the country. Tracing of such animal movements used CTS and AMLS data. The collation of accurate movement data from these sources can take up to 6 weeks to obtain. In addition, the amount of resource required for this work is high, and therefore some tracing work, including movements from the premises in the PZ area extensions made after the start of the VFP, is yet to be completed. This means that there is a risk that infected animals may have been moved from the edges of the current PZ before the VFP and are now in the SZ or beyond and could potentially act as a source of infection for local midge populations once the 2008 risk period resumes.

Although some sheep and goats moved to the SZ, the fact that they have a shorter viraemia compared with cattle and greater propensity to display clinical signs (sheep at least) would mitigate against the risk of undetected infection being carried further afield by sheep and goats.

Pre-movement testing is reactive to a farmer's requirement to move an animal out of the PZ or SZ during the VFP, and requires submission through the Private Veterinary Surgeon of relevant samples for testing. Consequently, the use of the information on testing has been opportunistic (i.e. unstructured) and is not statistically valid for confirming the absence of disease with uniform and set degree of confidence. Nevertheless, due to the large numbers (over 3,500) and widespread geographical location of these animals, these data are valuable in that they provide us with an estimate of the confidence with which we can say that infection is not present in an area.

Illegal movements, whether deliberate or by accident may circumvent the planned controls and result in infection of the local midge population and onward spread of disease. Illegal moves where correct submission of CTS or AMLS movement records will enable these to be identified retrospectively.

Address data associated with tracing and pre movement test results indicates the location of the animals tested

The address data provided with the samples will usually, but not always be the same location as that of the animals tested, and thus results are indicative of the presence or

absence of infection at that location. However, where the supplied details could not confirm this, the county of the submitting veterinary practice was used as a proxy for the location of the animals. This is considered to be a reasonably good approximation of the animal location.

The laboratory testing regime for Bluetongue is 100% sensitive and 100% specific

The tests used to detect the presence of BT (i.e. tests for virus or antibody) have a high degree of test sensitivity and specificity, however, as with all biological tests, 100% sensitivity and specificity cannot be guaranteed. Therefore, there is a very small probability that some test results are incorrect and thus the animals incorrectly identified as infected, exposed or neither.

Species covered

Camelids and deer have not been included in any of the targeted surveillance activities. However, they would be covered by the report cases should disease become clinically apparent.

Assumptions for targeted surveillance around confirmed cases

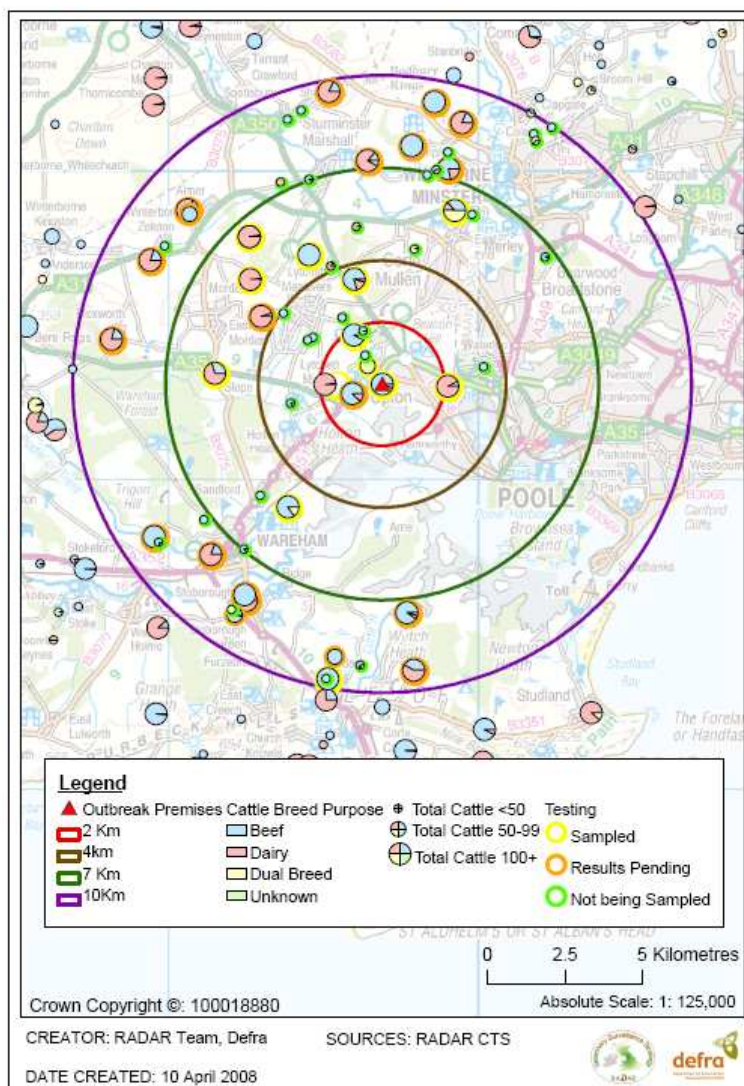
- Infection would have reached the area between 4th August and 20th December 2007 and not during the VFP. Movement by animals would be expected to be identified by the tracing exercise described below.
- Infection by midges results in a high prevalence of locally infected animals, as seen in Europe. Therefore testing animals that were resident on the premises during the at risk period would detect midge-transmitted infection and confirm that the local midge population was infected with BTV.
- Infection in sheep and goats is likely to result in clinical disease and would have been reported through normal channels.
- Cattle are less likely show clinical signs of infection than are sheep or goats.

10 ANNEX 3: DESIGN OF SURVEILLANCE AROUND THE POOLE CASE

Surveillance was focussed on cattle farms within 10km of the case premises with 50 or more cattle that would have been present during the risk period. Sufficient animals were sampled in order to have a 95% certainty of detecting at least one positive animal if the within herd prevalence of infection was 5%. Surveillance was designed to be carried out in a progressive fashion so that the results from the IP itself, and the premises at greatest risk (i.e. closest to the IP), could inform the need for the surveillance to be carried out on more distant premises.

So far, a further 21 premises have been identified to 10km from the IP; surveillance on these premises is expected to be completed by 25th April. The distribution of premises with cattle and those that have been sampled within the 10km area around the IP are shown in Figure 7.

Figure 7: Distribution of cattle premises around the Poole IP



11 ANNEX 4: DESIGN OF TRACING

Animals were traced using data from the CTS and AMLS databases provided by RADAR and then were tested to establish if they harboured undetected disease. Testing of all cattle moved to premises in the SZ or Free Area, and of sheep and goats moved to premises in the Free Area, was undertaken. This differentiation reflects the increased likelihood of sub-clinical disease in cattle compared to small ruminants, and the greater impact of failing to detect disease in the Free Area.

Cattle

Initial RADAR data indicated that 17,030 cattle had moved off premises in PZ1 to destination premises located in the Bury (7,527), Chelmsford (1,574) and Reigate (7,929) AHDO areas which are largely within the PZ. Resource constraints have precluded checking all 17,030 eartags individually through CTS. However cattle moved to destinations within the PZ were likely to have remained there as the PZ expanded and more premises became subject to restrictions; more than 50 random checks of eartags through CTS tend to support this. Only movements to destination holdings in areas of these Divisions that are not within the PZ were important with regard to further dissemination of BT. These were identified by mapping their location, and reduced the number of cattle to be traced from a potential 17,030 to 195. Further recent extensions to PZ1 are likely to mean that many of these 195 cattle are now located in the PZ and hence will not require sampling.

There is a risk that some cattle may have moved onwards from the original destination holding and so may have been missed from this analysis. The only way to be sure is to check all cattle against CTS to see if moves have occurred. The level of risk is not believed to justify the considerable resource needed to do this. However, the risk is mitigated by the fact that any animal moved from the SZ after the disclosure of disease would have to have been tested prior to the movement.

Moves to unknown locations occur as a result of the location details not being available in the source CTS data (e.g. awaiting return of passport movement ticket, destination location C of CPH is coded 99, blocked passports, etc).

Sheep and goats

Of the 64,090 sheep and 125 goats that moved from the PZ, none of the 496 sheep or 7 goats that have been sampled have tested positive (Table 3). However, because these animals are not individually identified it is possible that batches of animals may have been split following moves and the individual animals may well have moved on again. No evidence of how likely or frequently this is likely to have happened. However given the sensitivity of these species to infection with BT it is likely that clinical disease would have developed and the infection picked up by reporting.

12 ANNEX 5: DETAIL OF CATTLE TRACINGS FROM PZ

Tracings of cattle from premises within the PZ1 in force on 12th November was undertaken to identify all cattle that posed a risk of disease out of the PZ during the period between 4th August and the date of disclosure of disease in GB (i.e. 28th September 2007). The summary results for the tracing and testing of these cattle are shown in Table 8.

Table 8: Results of tracings and laboratory testing of all cattle that moved out of PZ1 (in force on 12th November) between 4th August and 28th September 2007

Receiving AHDO	Traced		Sampled			Not Sampled				
	Animals	Premises	Negative	Positive	Pending	Final destination PZ	Already sampled with negative result [^]	Dead or slaughtered	Exported	
Bury St Edmunds	107	16	0	0	94*	13	0	0	0	
Cardiff	8	1	7	0	0	0	0	0	0	
Carlisle	1	1	0	0	0	1**	0	0	0	
Carmarthen	18	4	18	0	0	0	0	0	0	
Chelmsford	5	4	0	0	3*	1**	0	1	0	
Exeter	10	5	7	0	0	0	0	3	0	
Gloucester	246	4	7	0	0	4**	0	91	144	
Leeds	17	3	17	0	0	0	0	0	0	
Leicester	212	16	127	1	0	3	0	81	0	
Lincoln	306	9	26	0	0	15	0	265	0	
Newcastle	2	2	1	0	0	1**	0	0	0	
Preston	40	6	7	0	0	1**	0	0	32	
Reading	174	8	71	0	0	47	0	56	0	
Reigate	128	11	4	0	89*	6	0	29	0	
Stafford	91	17	73	1	0	3	1	13	0	
Taunton	15	7	9	0	0	2	0	0	4	
Truro	1	1	1	0	0	0	0	0	0	
Worcester	36	7	19	0	0	0	0	17	0	
Total	1417	122	394	2	186*	97	1	556	180	

* due to recent changes to PZ many of these tracings may no longer require action as premises likely to be in PZ

[^] Pre-movement/report case /surveillance

** Incorrectly reported moves - moved into PZ, not out of it

13 **ANNEX 6: ANALYSIS OF PMT DETAIL**

An analysis, undertaken on a county basis, was conducted using the PMT data to estimate the level of uncertainty regarding the absence of BT within some areas of GB. Based upon a 10% within-herd prevalence of infection found in the herds where complete herd testing was undertaken as part of the targeted surveillance activities (see section 4.4), the number of herds that have been adequately PMT tested with 95% confidence to detect a maximum prevalence of 10% was calculated. The number of adequately tested herds was then used to determine the maximum prevalence of herd-level infection within each county given a 95% confidence to detect at least one positive herd among those tested. Given the number of herds in each county, most counties require between 50 and 58 herds to be adequately tested to detect one positive herd in the county given a herd-level prevalence of 5% with 95% confidence.

It must be noted that given the hypothesis that BT is not present in the SZ, there are a number of limitations to this approach, in particular the samples cannot be deemed to be fully representative of the population of susceptible stock in each county, and the proportion of susceptible animals tested will vary between counties. Thus some estimates of the likelihood of the presence of BT in a county will be less reliable or impossible to calculate.

Additionally, the assumptions are made for the sampled animals that the population at risk is homogenous (i.e. that an infected animal is just as likely to be selected for testing as is an uninfected one) and that the risk of becoming infected with BT is equal across each county. We believe these assumptions are valid and appropriate for the purpose and level of analysis conducted here..

Table 9: Maximum potential undetected prevalence of Bluetongue infection in cattle herds by county given adequate PMT to detect within-herd prevalence of 10% with 95% confidence

AT GIS County	Median Herd Size	Total no. of Herds	Total number of herds tested adequately	Maximum prevalence in population	Number of animals tested
ENGLAND					
AVON	47	862	7	40%	320
BEDFORDSHIRE	25	194	2	>50%	46
BERKSHIRE	35	254	0	>50%	335
BUCKINGHAMSHIRE	49	595	34	10%	1492
CAMBRIDGESHIRE	25	342	15	20%	536
CHESHIRE	69	1767	86	5%	3454
CLEVELAND	48	165	0	>50%	0
CORNWALL	54	3145	2	>50%	108
CUMBRIA	89	3469	1	>50%	44
DERBYSHIRE	49	1879	16	20%	658
DEVON	63	5030	14	20%	455
DORSET	65	1334	243	2%	8700
DURHAM	51	1025	2	>50%	20
EAST SUSSEX	35	687	20	15%	1265
ESSEX	19	464	8	>50%	451
GLOUCESTERSHIRE	46	1179	14	20%	492
GREATER LONDON	6	77	3	>50%	159
GREATER MANCHESTER	25	489	4	>50%	111
HAMPSHIRE	22	1028	63	5%	2208
HEREFORD & WORCESTER	45	2092	32	10%	1242
HERTFORDSHIRE	25	237	16	20%	748
HUMBERSIDE	39	782	19	20%	877
ISLE OF WIGHT	32	180	3	>50%	123
KENT	24	762	19	10%	963
LANCASHIRE	61	2069	0	>50%	1
LEICESTERSHIRE	54	1132	7	50%	337
LINCOLNSHIRE	43	957	5	50%	131
MERSEYSIDE	49	74	0	>50%	2
NORFOLK	33	972	23	15%	1539
NORTH YORKSHIRE	60	3636	9	30%	387
NORTHAMPTONSHIRE	40	631	9	30%	413
NORTHUMBERLAND	90	1092	0	>50%	0
NOTTINGHAMSHIRE	39	550	6	40%	547
OXFORDSHIRE	51	618	10	30%	394
SCILLY ISLES	6	19	0	>50%	0
SHROPSHIRE	65	2200	76	5%	2240
SOMERSET	63	2638	55	10%	1815
SOUTH YORKSHIRE	35	500	11	25%	460
STAFFORDSHIRE	48	2284	26	15%	801
SUFFOLK	24	565	4	>50%	360
SURREY	20	373	14	20%	807
TYNE & WEAR	43	79	0	>50%	0
WARWICKSHIRE	42	719	7	40%	186
WEST MIDLANDS	22	137	1	>50%	18
WEST SUSSEX	39	503	18	20%	554
WEST YORKSHIRE	25	1157	9	25%	291
WILTSHIRE	66	1242	74	5%	2770
TOTAL		52185	987		38860

WALES						
CLWYD	57	1742	5	>50%	203	
DYFED	54	4854	1	>50%	86	
MID GLAMORGAN	27	403	3	>50%	92	
SOUTH GLAMORGAN	53	195	1	>50%	17	
WEST GLAMORGAN	41	318	4	>50%	126	
GWENT	37	850	7	>50%	219	
GWYNEDD	40	2113	0	NS	0	
POWYS	52	2516	34	10%	1412	
TOTAL		12991	55		2155	
SCOTLAND						
BORDERS	117	724	0	NS	0	
CENTRAL	73	453	0	NS	0	
DUMFRIES & GALLOWAY	168	1799	0	NS	0	
FIFE	99	338	0	NS	0	
GRAMPIAN	80	2628	0	NS	0	
HIGHLAND	21	2023	0	NS	0	
LOTHIAN	107	292	0	NS	0	
ORKNEY	84	602	0	NS	0	
SHETLAND	13	184	0	NS	0	
STRATHCLYDE	99	2722	0	NS	0	
TAYSIDE	73	910	0	NS	0	
WESTERN ISLES	6	458	0	NS	0	
TOTAL		13133	0		0	
Unknown county	11	144			5556	
TOTAL		78309	1042		46571	

Note: NS – not sampled