Table S1. Premises where two or more isolates were sequenced and more than one DT case identified

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Source** | **Phagetype** | | **Number of isolates** | **SNP addressa** | **Days between sample collection** | **SNP differences** |
|  | | 104b | 1 | 1.2.2.2.1656.1922.2317 |  |  |
| Cattle | | U302 | 1 | 1.2.2.2.1656.1922.2270 | 43 | ≤5 |
|  | | 104 | 1 | 1.2.2.2.7.7.29 |  |  |
| Cattle | | 104 | 1 | 1.2.2.2.7.7.29 | 36 | 0 |
|  | | U302 | 1 | 1.2.2.2.7.7.29 | 86 | 0 |
| Cattle | | 104 | 1 | 1.2.2.2.121.1193.2241 |  |  |
| 104b | 1 | 1.2.2.2.121.1193.2280 | 33 | ≤5 |
| Cattle | | 104 | 1 | 1.2.2.2.5.976.2269 |  |  |
| Other | | 12 | 1 | 1.2.2.2.5.976.1374 | 16 | ≤5 |
| Sheep | | 104b  U302 | 1 | 1.2.2.2.121.1193.1337 |  |  |
| 2 | 1.2.2.2.121.1193.x | 0 | ≤5 |
| Pig | | U302 | 1 | 1.2.2.2.1120.1215.1265 |  |  |
| 104b | 1 | 1.2.2.2.1120.1215.1283 | 31 | ≤5 |
| Chicken | | 104 | 1 | 1.2.2.2.216.223.2478 |  |  |
| 2 | 1.2.2.2.216.223.1204 | 7 | ≤5 |
| 3 | 1.2.2.2.216.223.x | 11 | ≤5 |
| Other | | 2 | 1.2.2.2.216.223.x | 8 | ≤5 |
| U302 | 1 | 1.2.2.2.216.223.1404 | 0 | ≤5 |
| Turkey | | U302 | 1 | 1.2.2.635.1090.1174.1209 |  |  |
| 104b | 1 | 1.2.2.635.1219.1346.1449 | 0 | ≤25 |

a Multiple isolates collected on the same day with ≤5 SNP differences have the 0 SNP groups represented as ‘x’

Table S2. Time intervals (days) between isolate pairs (n=202) from same premises by SNP cluster threshold

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **snp cluster threshold** | **0** | **5** | **10** | **25** | **50** | **100** | **250** |
| **Number of pairs** | 38 | 118 | 15 | 23 | 6 | 2 | 0 |
| **Minimum interval** | 0 | 0 | 0 | 0 | 0 | 1 | n/a |
| **Median interval** | 20 | 18 | 119 | 1192 | 3.5 | 3 | n/a |
| **Maximum interval** | 799 | 756 | 889 | 2521 | 226 | 5 | n/a |

**Table S3:** SaTScan spatio-temporal clusters identified by Bernoulli models for each quarter. Cases are the first and subsequent isolates belonging to the same SNP group on any individual premises. Controls are any other sequenced isolates. Clusters with a p-value < 0.05 are highlighted and shown in **bold** **type**.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Case  definition | SNP-5  Group 7 | | SNP-10  Group 5 | | | SNP-5  Group 20 | | SNP-5 Group 1163 | SNP-5  Group 976 | | | SNP-10  Group 450 | | SNP-5 Group 1195 | | SNP-10 Group 88 | SNP-5 Group 221 | SNP-5 Group 1223 | SNP-5 Group 424 | SNP-5 Group 1170 | |
| Mar-03 |  |  | C |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Jun-03 |  |  | C |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Sep-03 |  |  | C | D |  |  |  | M |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Dec-03 |  |  | C | D |  |  |  | **M** |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Mar-04 |  |  | C | D |  |  |  | **M** |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Jun-04 |  |  | C | D |  |  |  | **M** |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Sep-04 |  |  | C | D |  |  |  | M |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Dec-04 |  |  | C | D |  |  |  | M |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Mar-05 |  |  | C | D |  |  |  | M | N |  |  |  |  |  |  |  |  |  |  |  |  |
| Jun-05 |  |  | C | D |  |  |  | M | N |  |  |  |  |  |  |  |  |  |  |  |  |
| Sep-05 |  |  | C | D |  |  |  | M | N |  |  |  |  |  |  |  |  |  |  |  |  |
| Dec-05 |  |  | **C** | D |  |  |  | M | N |  |  |  |  |  |  |  |  |  |  |  |  |
| Mar-06 |  |  | C | D |  |  |  | M | N |  |  |  |  |  |  |  |  |  |  |  |  |
| Jun-06 |  |  | C | D |  |  |  | M | N |  |  | S |  | **U** |  |  |  |  |  |  |  |
| Sep-06 |  |  | C | D |  |  |  | M | **N** |  |  | **S** |  | **U** |  |  |  |  |  |  |  |
| Dec-06 |  |  | C | D | E | J |  |  | **N** |  |  | **S** |  | **U** |  |  |  |  |  |  |  |
| Mar-07 |  |  | C | D |  | **J** |  |  | **N** |  |  | **S** |  | **U** |  |  |  |  |  |  |  |
| Jun-07 |  |  | C | D |  | **J** |  |  | **N** | R |  | **S** |  | **U** |  |  |  |  |  |  |  |
| Sep-07 |  |  | C | D | F | **J** |  |  | **N** | R |  | **S** |  | **U** |  |  |  |  |  |  |  |
| Dec-07 |  |  | C | D |  | J |  |  | N | R |  | **S** |  | **U** |  | V |  |  |  |  |  |
| Mar-08 |  |  | C | D |  | J |  |  | N | R | O | **S** |  | **U** |  | V |  |  |  |  |  |
| Jun-08 |  |  | C | D |  | J |  |  | N | R | O | **S** |  | **U** |  | V |  |  |  |  |  |
| Sep-08 |  |  | C |  |  | K | L |  | N | R |  | **S** |  | **U** |  | V |  |  |  |  |  |
| Dec-08 |  |  | C |  |  | K | L |  | N | R |  | **S** |  | **U** |  | V |  |  |  |  |  |
| Mar-09 |  |  | C |  |  | K | L |  | N | R |  | **S** |  | **U** |  | V |  |  |  |  |  |
| Jun-09 |  |  | C |  |  | K | L |  | N | R |  | **S** |  | **U** |  | V | **W** |  |  |  |  |
| Sep-09 |  |  | C |  |  | K | L |  | N | R |  | **S** |  | **U** |  | **V** | **W** |  |  |  |  |
| Dec-09 |  |  | C |  |  | K | L |  | N | R |  | **S** |  | **U** |  | **V** | **W** |  | **X** |  |  |
| Mar-10 |  |  | C |  |  | K | L |  | N | R |  | **S** |  | **U** |  | **V** | **W** |  | **X** |  |  |
| Jun-10 |  |  | C | G |  | K | L |  | **N** | R |  | **S** |  | **U** | U2 | **V** | **W** |  | **X** |  |  |
| Sep-10 |  |  | C |  |  | K | L |  | **N** | R |  | **S** |  | **U** |  | **V** | **W** |  | **X** |  |  |
| Dec-10 |  |  | C |  |  | K | L |  | N | R | P | **S** |  | **U** |  | **V** | **W** |  | **X** |  |  |
| Mar-11 |  |  | C |  |  | K | L |  | N | R | P | **S** |  |  |  | **V** | **W** |  | **X** |  |  |
| Jun-11 |  |  | C |  |  | K | L |  | **N** | R | P | **S** |  |  |  | **V** | **W** |  | **X** |  |  |
| Sep-11 |  |  | C | H |  |  |  |  | **N** | R |  | **S** |  |  |  | **V** | **W** |  | **X** |  |  |
| Dec-11 |  |  | C |  |  |  |  |  | **N** | R |  | **S** |  |  |  | **V** | **W** |  | **X** |  |  |
| Mar-12 |  |  | C | I |  |  |  |  | **N** | R |  | **S** |  |  |  | **V** | **W** |  | **X** |  |  |
| Jun-12 |  |  | C | I |  |  |  |  | **N** | R |  | **S** |  |  |  | **V** | **W** |  | **X** |  |  |
| Sep-12 |  |  | C |  |  |  |  |  | **N** | Q |  | **S** |  |  |  | **V** | **W** |  | **X** |  |  |
| Dec-12 |  |  |  |  |  |  |  |  |  |  |  | **S** |  |  |  | **V** | **W** |  | **X** |  |  |
| Mar-13 |  |  |  |  |  |  |  |  |  |  |  | **S** | T |  |  | **V** | **W** |  | **X** |  |  |
| Jun-13 |  |  |  |  |  |  |  |  |  |  |  | **S** | T |  |  | **V** | **W** |  |  |  |  |
| Sep-13 |  |  |  |  |  |  |  |  |  |  |  | **S** | T |  |  | **V** | **W** |  |  |  |  |
| Dec-13 |  |  |  |  |  |  |  |  |  |  |  | **S** | T |  |  | **V** | **W** |  |  |  |  |
| Mar-14 |  |  |  |  |  |  |  |  |  |  |  | **S** | T |  |  | **V** | **W** |  |  |  |  |
| Jun-14 | **A** |  |  |  |  |  |  |  |  |  |  | **S** | T |  |  | **V** | **W** |  |  | **Z** |  |
| Sep-14 | **A** |  |  |  |  |  |  |  |  |  |  | **S** | T |  |  | **V** | **W** |  |  | **Z** |  |
| Dec-14 | **A** |  |  |  |  |  |  |  |  |  |  | **S** | T |  |  | **V** |  |  |  | **Z** |  |
| Mar-15 | **A** |  |  |  |  |  |  |  |  |  |  | **S** | T |  |  | **V** |  |  |  | **Z** |  |
| Jun-15 | **A** |  |  |  |  |  |  |  |  |  |  | **S** | T |  |  | **V** |  |  |  | **Z** |  |
| Sep-15 | **A** |  |  |  |  |  |  |  |  |  |  | **S** | T |  |  | **V** |  |  |  | **Z** |  |
| Dec-15 | **A** |  |  |  |  |  |  |  |  |  |  | **S** | T |  |  | **V** |  |  |  | **Z** |  |
| Mar-16 | **A** |  |  |  |  |  |  |  |  |  |  | **S** | T |  |  | **V** |  |  |  |  |  |
| Jun-16 | **A** |  |  |  |  |  |  |  |  |  |  | **S** | T |  |  | **V** |  | **Y** |  |  |  |
| Sep-16 | **A** | **B** |  |  |  |  |  |  |  |  |  | **S** | T |  |  | **V** |  | **Y** |  |  |  |
| Dec-16 | **A** | **B** |  |  |  |  |  |  |  |  |  | **S** | T |  |  | **V** |  | **Y** |  |  |  |
| Mar-17 | **A** | **B** |  |  |  |  |  |  |  |  |  | **S** | T |  |  | **V** |  | **Y** |  |  |  |
| Jun-17 | **A** | **B** |  |  |  |  |  |  |  |  |  | **S** | T |  |  | **V** |  | **Y** |  |  |  |
| Sep-17 | **A** | **B** |  |  |  |  |  |  |  |  |  | S | T |  |  | **V** |  | **Y** |  |  |  |
| Dec-17 | **A** |  |  |  |  |  |  |  |  |  |  | S | T |  |  | **V** |  | **Y** |  |  |  |
| Mar-18 | **A** |  |  |  |  |  |  |  |  |  |  | S | T |  |  | **V** |  | **Y** |  |  |  |
| Jun-18 | **A** |  |  |  |  |  |  |  |  |  |  | S | T |  |  | **V** |  | **Y** |  |  |  |
| Sep-18 | **A** |  |  |  |  |  |  |  |  |  |  | S | T |  |  |  |  | **Y** |  |  |  |
| Dec-18 | **A** |  |  |  |  |  |  |  |  |  |  | S |  |  |  |  |  | **Y** |  |  |  |
| Mar-19 | **A** |  |  |  |  |  |  |  |  |  |  | S |  |  |  |  |  | **Y** |  |  |  |
| Jun-19 | **A** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | **Y** |  |  |  |
| Sep-19 | **A** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

**Table S4**. Satscan spatio-temporal clusters identified by Bernoulli models for each quarter. Cases are the first and subsequent isolate of the same phagetype on any premises where the phage type is DT104, DT104 variant or U302, and controls are any other phagetype. Clusters highlighted and shown in **bold type** have a p-value < 0.05.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Quarter** | **Number of clusters** | **Cluster identities** | | | | | | | |
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| Mar-03 | 2 |  |  |  |  |  |  |  |  |
| Jun-03 | 4 |  |  |  |  |  |  |  |  |
| Sep-03 | 3 |  |  |  |  |  |  |  |  |
| Dec-03 | 4 |  |  |  |  |  |  |  |  |
| Mar-04 | 4 |  |  |  |  |  |  |  |  |
| Jun-04 | 3 | **** |  |  |  |  |  |  |  |
| Sep-04 | 4 |  |  |  |  |  |  |  |  |
| Dec-04 | 3 |  |  |  |  |  |  |  |  |
| Mar-05 | 3 | **** |  |  |  |  |  |  |  |
| Jun-05 | 4 | **** | **** |  |  |  |  |  |  |
| Sep-05 | 4 | **** | **** |  |  |  |  |  |  |
| Dec-05 | 5 | **** | **** |  |  |  |  |  |  |
| Mar-06 | 4 | **** | **** | **** |  |  |  |  |  |
| Jun-06 | 4 | **** | **** | **** |  |  |  |  |  |
| Sep-06 | 6 | **** | **** |  |  |  |  |  |  |
| Dec-06 | 5 | **** | **** |  |  |  |  |  |  |
| Mar-07 | 5 | **** | **** |  |  |  |  |  |  |
| Jun-07 | 3 | **** | **** |  |  |  |  |  |  |
| Sep-07 | 4 | **** | **** |  |  |  |  |  |  |
| Dec-07 | 4 | **** | **** |  |  |  |  |  |  |
| Mar-08 | 4 | **** | **** |  |  |  |  |  |  |
| Jun-08 | 4 | **** | **** |  |  |  |  |  |  |
| Sep-08 | 4 | **** | **** |  |  |  |  |  |  |
| Dec-08 | 5 | **** | **** |  |  |  |  |  |  |
| Mar-09 | 5 | **** | **** |  |  |  |  |  |  |
| Jun-09 | 6 | **** | **** |  |  |  |  |  |  |
| Sep-09 | 6 | **** | **** |  |  |  |  |  |  |
| Dec-09 | 7 | **** | **** |  |  |  |  |  |  |
| Mar-10 | 8 | **** | **** |  |  |  |  |  |  |
| Jun-10 | 7 | **** | **** |  |  |  |  |  |  |
| Sep-10 | 6 | **** | **** |  |  |  |  |  |  |
| Dec-10 | 4 | **** | **** |  |  |  |  |  |  |
| Mar-11 | 4 | **** | **** |  |  |  |  |  |  |
| Jun-11 | 5 | **** | **** |  |  |  |  |  |  |
| Sep-11 | 4 | **** | **** |  |  |  |  |  |  |
| Dec-11 | 5 | **** | **** |  |  |  |  |  |  |
| Mar-12 | 5 | **** |  |  |  |  |  |  |  |
| Jun-12 | 6 | **** | **** |  |  |  |  |  |  |
| Sep-12 | 5 | **** | **** |  |  |  |  |  |  |
| Dec-12 | 5 | **** | **** |  |  |  |  |  |  |
| Mar-13 | 5 | **** |  |  |  |  |  |  |  |
| Jun-13 | 5 | **** | **** |  |  |  |  |  |  |
| Sep-13 | 5 | **** | **** |  |  |  |  |  |  |
| Dec-13 | 6 | **** |  |  |  |  |  |  |  |
| Mar-14 | 5 | **** |  |  |  |  |  |  |  |
| Jun-14 | 5 | **** |  |  |  |  |  |  |  |
| Sep-14 | 4 | **** |  |  |  |  |  |  |  |
| Dec-14 | 3 | **** |  |  |  |  |  |  |  |
| Mar-15 | 3 | **** |  |  |  |  |  |  |  |
| Jun-15 | 4 | **** |  |  |  |  |  |  |  |
| Sep-15 | 7 | **** |  |  |  |  |  |  |  |
| Dec-15 | 4 | **** |  |  |  |  |  |  |  |
| Mar-16 | 6 | **** |  |  |  |  |  |  |  |
| Jun-16 | 4 | **** |  |  |  |  |  |  |  |
| Sep-16 | 6 |  |  |  |  |  |  |  |  |
| Dec-16 | 6 |  |  |  |  |  |  |  |  |
| Mar-17 | 5 | **** |  |  |  |  |  |  |  |
| Jun-17 | 6 | **** |  |  |  |  |  |  |  |
| Sep-17 | 4 | **** |  |  |  |  |  |  |  |
| Dec-17 | 4 | **** |  |  |  |  |  |  |  |
| Mar-18 | 6 | **** |  |  |  |  |  |  |  |
| Jun-18 | 4 | **** |  |  |  |  |  |  |  |
| Sep-18 | 4 | **** |  |  |  |  |  |  |  |
| Dec-18 | 3 | **** |  |  |  |  |  |  |  |
| Mar-19 | 5 | **** |  |  |  |  |  |  |  |
| Jun-19 | 5 | **** |  |  |  |  |  |  |  |
| Sep-19 | 4 | **** |  |  |  |  |  |  |  |

**Table S5.** Descriptions of SaTScan spatio-temporal clusters identified in Table S4

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Case Definition** | **Cluster ID** | **Status at first detection** | | | | | **Observations** |
| **Date** | **Number of cases** | **Radius (km)** | **Species (n)** | **Relative risk\***  **(p value)** |
| Phage Type DT104, 104a, 104b, 104c, U302  Phage Type DT104, 104a, 104b, 104c, U302  Phage Type DT104, 104a, 104b, 104c, U302  Phage Type DT104, 104a, 104b, 104c, U302 | α | Mar 2003 | 8 | 40.86 | Cattle (1)  Horse(1)  Pig (6) | 2.03  (0.82) | Small cluster in the East Midlands persisted for one year |
| β | Mar 2003 | 7 | 107.35 | Cattle (4)  Sheep (1)  Pig (1)  Turkey (1) | 2.03  (0.92) | This cluster persisted until Sept 2008, although with some shifts in size and location. It began in North Wales, shifted southwards, then back again. Eventually it covered the whole of Wales and parts of the southwest and west of England, absorbing some smaller clusters. In Dec 2008 it splits into two smaller clusters. |
| γ | June 2003 | 9 | 30.22 | Cattle (4)  Pig (3)  Dog (1)  Chicken (1) | 2.09  (0.52) | Small cluster in Oxfordshire that becomes partially absorbed into the β cluster and partially into the δ:1 cluster. |
| δ | June 2003 | 7 | 114.02 | Cattle (5)  Pig (1)  Cat (1) | 2.08  (0.94) | Cluster begins in Lancashire, Cumbria and Galloway, and persists until the end of 2009. The size is highly variable, at one point reaching as far north as the Firth of Forth. There is a transient split in Dec 2005 into two sub-clusters which recombine, and a second split in Mar 2010, after which the northern focus is no longer detected |
| ε:1 | Dec 2003 | 7 | 37.93 | Cattle (4)  Pig (2)  Pheasant (1) | 2.18  (0.951) | Cluster spanning Oxfordshire, Hampshire and West Berkshire. Lasts for 9 months without any significant reduction in the p value. |
| ζ | Mar 2004 | 7 | 25.69 | Chicken (1)  Turkey(4)  Cat (2) | 2.35  (0.904) | Transient cluster in the East Midlands, containing three cases previously part of the β cluster plus four not included elsewhere |
| η:1 | Sep2004 | 8 | 26.13 | Cattle (5)  Pig (3) | 2.38  (0.745) | Transient cluster in Wiltshire |
| θ | Sep 2004 | 8 | 23.8 | Cattle (8) | 2.38 (0.745) | Small cluster in Cheshire / Wrexham area that is absorbed into the β cluster in Jun 2005 |
| ε:2 | June 2005 | 6 | 56.50 | Cattle (1)  Sheep (1)  Pig (3)  Turkey (1) | 2.51 (0.998) | Transient cluster, covering a large area to the north and west of London. Contains ε:1 cases, but with 9 month gap after end of ε:1 |
| ι | June 2005 | 9 | 57.97 | Cattle (7)  Pig (2) | 2.52  (0.42) | Cluster begins in Somerset, Wiltshire and Dorset, then drifts north-wards and combines with the β cluster |
| η:2 | Sep 2005 | 7 | 25.13 | Cattle (3)  Pig (3)  Turkey (1) | 2.54  (0.901) | Transient cluster in Wiltshire and Hampshire, sharing cases with η:1 and ι clusters. Overlaps spatially, but not temporally with ε clusters. Reappears in Sep 2006 |
| κ | Dec 2005 | 11 | 49.49 | Cattle (3)  Dog (1)  Chicken (1)  Turkey (6) | 2.57 (0.132) | Transient cluster spanning four counties in the west of England and into south Wales. Becomes incorporated into the β cluster |
| λ | June 2006 | 6 | 26.18 | Cattle (4)  Sheep (1)  Pig (1) | 2.69 (0.997) | Small cluster in East Cheshire/ North Staffordshire that is absorbed into the β cluster |
| μ:1 | Sep 2006 | 6 | 23.37 | Cattle (3)  Horse (1)  Chicken (1)  Turkey (1) | 2.70 (0.995) | Transient cluster in the East Midlands, partially incorporated into the κ cluster, and partially incorporated, a year later into the μ:2 cluster |
| ν | Dec 2006 | 7 | 13.74 | Cattle (7) | 2.71 (0.932) | Small cluster in North Yorkshire, persisted until 2010 with only a minor increase in size, confined to cattle |
| ξ | Mar 2007 | 6 | 32.82 | Cattle (2)  Turkey (1)  Other species (3) | 2.76 (0.999) | Transient cluster in Hampshire involving mixed groups of avian species and exotic mammals |
| μ:2 | Sep 2007 | 6 | 14.55 | Cattle (3)  Chicken (1)  Turkey (2) | 2.84 (0.996) | Small cluster in Leicestershire, persisted until 2010 |
| β:1 | Dec 2008 | 38 | 30.93 | Cattle (35)  Pig (2)  Dog (1) | 2.29  (<0.001) | Continuation of the β cluster after it splits into two foci. This cluster is focused in East Cheshire, Shropshire and Staffordshire, and persists until 2017, with transient reappearances in 2018 and 2019. Some cases in Staffordshire split off into a second, transient cluster in Jun 2011. |
| π | Dec 2008 | 19 | 100.63 | Cattle (14)  Pig (4)  Chicken (1) | 2.31  (0.235) | Eight cases from the β cluster after it splits into two foci, plus 11 new cases. Transient large cluster in Dorset and Hampshire, with isolated cases in Surrey, West Sussex, Somerset and Oxfordshire |
| π:1 | Mar 2009 | 11 | 28.69 | Cattle (9)  Pig (1)  Mixed avian species (1) | 2.70  (0.537 | Seven cases from π cluster plus four new ones in eastern Hampshire, West Sussex and Surrey |
| ρ | Jun 2009 | 13 | 27.17 | Cattle (9)  Horse (1)  Pig (3) | 2.77  (0.129) | Cluster on the Devon / Cornwall border. Most cases were part of the large β cluster that was present in Sep 2008. Persists until the end of 2016, gradually reducing in size. Some cases reappear in a transient cluster in September 2015 |
| π:2 | Dec 2009 | 11 | 45.22 | Cattle (9)  Pig (1)  Dog (1) | 2.35  (0.999) | Cluster in Dorset, Somerset and West Hampshire with nine cases from π cluster plus two new ones. Persists until Jun 2017, although with periodic disappearances between Sep 2010 to Sep 2011, and Dec 2014 to Mar 2015 |
| δ:2 | Mar 2010 | 24 | 34.48 | Cattle (17)  Sheep (4)  Horse (1)  Pig (1)  Turkey (1) | 2.22  (0.179) | Continuation of the δ cluster after it splits into two foci. This cluster is focused in Cumbria, and just over the border into Scotland, and persists until Dec 2013 |
| β:2 | Jun 2011 | 15 | 27.80 | Cattle (11)  Pig (2)  Dog (1)  Pheasant (1) | 2.26  (0.924) | Transient cluster in south-east Staffordshire that splits off from β:1 cluster |
| σ | Dec 2011 | 6 | 55.52 | Cattle (3)  Pig (1)  Dog (1)  Cat (1) | 3.17  (0.987) | Cluster in Worcestershire and Shropshire, persists until Mar 2018 |
| τ:1 | Jun 2012 | 5 | 37.49 | Cattle (3)  Sheep (1)  Turkey (1) | 3.18  (0.999) | Transient cluster in Gwynedd and Anglesey |
| υ | Dec 2013 | 6 | 28.97 | Cattle (1)  Pig (5) | 3.19  (0.981) | Cluster in East Riding of Yorkshire and North Lincolnshire that persists for 9 months, with a rapid expansion and shrinkage. |
| ρ:2 | Sep 2015 | 5 | 23.89 | Cattle (4)  Sheep (1) | 3.23  (0.998) | Transient cluster in northwest Devon |
| δ:3 | Sep 2015 | 5 | 26.88 | Cattle (2)  Dog (1)  Chicken (1)  Other (1) | 3.23  (0.998) | Transient cluster in West Lothian, North Lanarkshire, East Dunbartonshire and Glasgow City. Spatial, but not temporal overlap with the δ cluster. It reappears briefly in March and June 2018. |
| φ | Sep 2015 | 5 | 38.62 | Cattle (1)  Horse (2)  Pig (1)  Dog (1) | 3.23  (0.998) | Cluster begins in Kent and Essex, and spreads into the London area, persisting until the end of the study. |
| τ:2 | Mar 2016 | 6 | 65.04 | Cattle (5)  Sheep (1) | 3.24  (0.976) | Cluster initially contained cases in Anglesey, Conwy and Flintshire, showing spatial, but no temporal overlap with the τ1 cluster. It later spread to Powys and Carmarthenshire, and persisted until the end of the study. |
| χ | June 2017 | 10 | 39.55 | Cattle (9)  Pig (1) | 2.94  (0.578) | Cluster in Dumfries and Galloway that persisted unchanged until the end of the study |
| β:3 | Mar 2018 | 5 | 55.01 | Cattle (4)  Chicken (1) | 3.23  (0.999) | Transient cluster comprising two close cases in East Cheshire, plus cases in Staffordshire, Calderdale and Nottinghamshire. Spatial, but no temporal overlap with β:1 cluster |
| Ψ | Mar 2019 | 6 | 8.38 | Pig (2)  Horse (2)  Other (2) | 3.28  (0.983) | Localised cluster around Leeds, Bradford, Calderdale and Kirklees that is also detected in Jun, but not Sep 2019. Although closely located to the β:3 cluster, no cases are shared |
| ω | Mar 2019 | 5 | 14.29 | Cattle (3)  Horse (1)  Dog (1) | 3.28  (0.999) | Transient cluster in Staffordshire and Walsall, including one case from the β:3 cluster |

**Table S6.** Table of whether cases were included at any point within a SaTScan cluster according to source type

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |
|  |  | SNP-5 Clusters | | SNP-10 Clusters | | Phagetype Clusters | |
|  |  | No | Yes | No | Yes | No | Yes |
| Raw counts | CATTLE | 80 | 69 | 97 | 52 | 561 | 358 |
| CHICKEN | 12 | 0 | 11 | 1 | 161 | 13 |
| DOM\_CARN | 12 | 7 | 15 | 4 | 167 | 35 |
| EQUID | 31 | 8 | 38 | 1 | 232 | 20 |
| OTHER | 6 | 2 | 8 | 0 | 168 | 12 |
| OTHER\_AV | 7 | 1 | 8 | 0 | 702 | 6 |
| PIG | 41 | 4 | 43 | 2 | 1430 | 55 |
| SHEEP | 15 | 23 | 26 | 12 | 46 | 49 |
| TURKEY | 5 | 6 | 7 | 4 | 119 | 31 |
|  |  |  |  |  |  |  |  |
| Standardised χ² residuals | CATTLE | -1.51 | 1.99 | -1.64 | 3.00 | -8.19 | 20.37 |
| CHICKEN | 1.59 | -2.09 | 0.58 | -1.06 | 0.91 | -2.27 |
| DOM\_CARN | -0.02 | 0.03 | 0.10 | -0.19 | -0.52 | 1.31 |
| EQUID | 1.25 | -1.65 | 1.46 | -2.67 | 1.02 | -2.54 |
| OTHER | 0.41 | -0.54 | 0.75 | -1.36 | 1.05 | -2.60 |
| OTHER\_AV | 0.85 | -1.12 | 0.75 | -1.36 | 3.74 | -9.32 |
| PIG | 2.32 | -3.06 | 1.43 | -2.60 | 4.24 | -10.54 |
| SHEEP | -1.86 | 2.46 | -0.60 | 1.09 | -3.96 | 9.85 |
| TURKEY | -0.75 | 0.99 | -0.50 | 0.92 | -0.89 | 2.22 |

Figure S1. Distribution of SNP-cases by source and year of collection.

