Animal & Plant Health Agency

Cattle Enhanced Demographic Report 2019

To inform assessment of disease: entry/spread/detection

2018 - 2019

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The Animal and Plant Health Agency (APHA) is an executive agency of the Department for Environment, Food & Rural Affairs, and also works on behalf of the Scottish Government and Welsh Government.

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LDDG Cattle Indicators Report 2018-19

A report of work done within APHA Contract G 2018-19

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Preface

The general aim of the Livestock Demographic Data Groups (LDDGs)[1] is to enhance knowledge of livestock demographics. The need to better understand our livestock populations, their movements and behaviours was identified as a lesson learned from previous Foot and Mouth Disease (FMD) outbreaks and was raised to the Veterinary Risk Group (VRG).

Thus, the work presented in this report is the outcome of discussions between the Animal and Plant Health Agency (APHA), the Department for Environment Food and Rural Affairs (Defra), and the Agriculture and Horticulture Development Board (AHDB). Accordingly, this work was carried out at APHA, within the Department of Epidemiological Sciences (DES). The project is funded by Defra, the Scottish and Welsh Governments under *Contract G - Enhancing Surveillance*. The APHA Advice Services Epidemiology & Risk Policy Advice team maintain oversight of the groups and deliverables on behalf of the policy customers. Management of the project is provided by the Science Strategy and Planning team at Weybridge (APHA). The LDDGs are divided into five groups based on livestock species – cattle (for this report), sheep and goats, pigs, poultry and horses. Each group is made up of an epidemiologist, a data scientist (GIS support from the DES), and a Veterinary Lead from the Species Expert Group from the Surveillance Intelligence Unit (SIU).

The considerable interest in this work from the different groups resulted in a long list of indicators, serving several different causes, including surveillance, disease risk, animal welfare and industry productivity or performance. The list of indicators was prioritised in order to identify those that were considered of highest value to understand and inform assessments of: disease entry/transmission/detection/control. It is recognised that not all indicators are distinct in their purpose and that some could fall under multiple headings. Nevertheless, the more specific key outcomes for the LDDGs reports are to:

[1] N.B. A list of abbreviations is provided at the end (in the Appendix).

a) Provide regularly updated population estimates for key livestock species; for policy development and outbreak response.

b) Building capability, understanding and expertise in livestock demographic data and its quality for both provider and user.

c) Establish criteria to monitor changes in livestock demographics that could indicate a change in likelihood of either disease introduction or dissemination, or affect the probability of effective detection/control.

From a practical point of view, descriptive statistics presented in this report could be used in different ways, for example by scientists to parametrize simulation models used to inform policy, but also by the industry (AHDB) to get an overview of production parameters per GB country (England, Scotland and Wales) and cattle sector (dairy vs. beef).

Introduction

In this document the cattle indicators from the Livestock Demographic Data Group (LDDG) are presented. The indicators are reported as descriptive statistics per surveillance period (year or quarter), GB country and sector. For indicators affected by seasonality, a period greater than a year (or quarter) was considered. Dairy herds were defined as those where statutory quarterly testing of bulk tank milk (BTM) samples was undertaken for surveillance for bovine brucellosis, while the remaining were defined as non-dairy (beef) herds. Indicators were estimated combining data from five national databases: the Livestock Information Management System (LIMS), the Cattle Tracing System (CTS), the Rapid Analysis and Detection of Animal Related Threats (RADAR), the Scottish Rural College (SRUC) and Sam. Then 46 indicators were investigated and grouped into four main types (Chapters 1 to 4):

Chapter 1: Denominators, herd sizes and types present in each GB country and sector (dairy and non-dairy). Denominators and sizes were also evaluated on quarterly basis, per herd type (dairy, suckler, finisher-heifer, veal-rearer, markets, and “other”). Those indicators were considered because they are needed for evaluating surveillance systems (for example: to estimate disease incidence and prevalence, to assess surveillance system sensitivity and confidence in freedom from exotic diseases, etc.).

Chapter 2: Herd structure and calving (management and within-herd) indicators were investigated on quarterly basis, per GB country and sector. Those indicators (herd structure, age at first calving, age at culling/death after last calving, calving seasonality, population of calving dams per parity, and inter-calving period), were studied because they can be used to parametrize simulation models, which can simulate within-herd disease spread dynamics.

Chapter 3: Import indicators were investigated because they can be used to inform risk assessment models for exotic diseases (to quantitatively assess risk of disease entry by imported animals). Those included are: the GB “general” import patterns (CTS data 2011 to 2016), countries sending animals to GB, sex of imported animals (2011-2016), import seasonality (2011-2016), number of importing herds, size of importing herds, number of imported animals and consignments per importing herd.

Chapter 4: Cattle movements within GB, where investigated because they can be considered to simulate/interpret between-herds spread of diseases (both exotic and endemic). Such indicators were: the “general” movement patterns between British cattle herds, number of open (O) herds receiving animals from other British herds, quarterly number of received consignments, seasonality of consignments received, frequency where the received consignment originated from the same GB country, frequency where the received consignment originated from the same county, size of open herds receiving animals, quarterly number of animals received per open herd, quarterly number of consignments received per open herd, number of animals received per consignment, quarterly number of “partner” sending (contact source, i.e. the single most frequent source - see note 28 below) herds per open herd, number of source (S) herds sending animals to other British herds, quarterly number of sent consignments, seasonality of sent consignments, frequency at which the sent consignment stayed in the same GB country, frequency the sent consignment stayed in the same county, size of source herds sending animals, quarterly number of animals sent per source herd, quarterly number of consignments sent per source herd, number of animals sent per consignment, quarterly number of “partner” (open) receiving herds per source herd. Those indicators were presented for dairy herds, non-dairy herds (beef plus markets) and just for markets.

Quality statement: results of this analysis compared well with previous studies and had similar precision (see Chapter 5). Nevertheless, the combination of the several datasets used required time-consuming and extensive data handling/analysis, especially to identify actual milking herds (the dairy sector). Precision could be increased (and time could be reduced) if a list of dairy herds delivering milk (with CPH and date) updated at least on quarterly basis, was available e.g. from industry (see Appendix for limitations on list used). Nevertheless, mismatches of the number of CPHs between the datasets appeared very low. It should be noted that more indicators could be added in the next financial year(s) and a prioritization list is provided at the end of this report (Section 6). Methods and respective limitations are addressed in detail in the Appendix. Comparison with other studies should be made with caution, especially if based on different surveillance periods (e.g. annual figures instead of quarterly) and/or if based on different datasets.

Executive Summary

In this summary, the main descriptive statistics for each indicator per GB country and sector are presented. For indicators affected by seasonality, a period greater than a year (and/or quarter) was considered. Dairy herds were defined as those where statutory testing of bulk tank milk (BTM) samples was undertaken for surveillance of bovine brucellosis, while the remaining were defined as non-dairy/beef herds.

Chapter 1: Denominators, herd types and sizes

1) General GB annual denominator (2013-2016). According to data from the Cattle Tracing System (CTS) and from the Rapid Analysis and Detection of Animal Related Threats (RADAR) databases, between 2013 and 2016, the overall annual number of GB herds (County Parish Holding Numbers, CPHs and CPHHs, registering at least one bovine animal during at least one month of the investigated year) was: 76043, 75249, 74334, and 73253, respectively. Between these, ≈ 99.8% could be considered as “actual” production herds; whereas ≈ 0.2% CPHs had only four digits and were considered as other kind of holdings (e.g. slaughterhouses).

2) Denominator per GB country and sector (2013-2016). After combining CTS/RADAR data with other data sources, it was found that in 2016 (the most recent datasets used) 49322 cattle herds were located in England (67.5% of the GB herds), 12225 (16.7%) in Scotland and 11573 in Wales (15.8%). The quarterly percentage of milking dairy herds per country was ≈12-14%, ≈7% and ≈11-13%, in England, Scotland and Wales, respectively. These figures were relatively stable between 2013 and 2016.

3) Quarterly herd size distributions per GB country and sector (2016). In English dairy herds, the quarterly overall median size was ≈ 276 cattle, while in beef herds it was ≈ 40. When considering only the number of adult females (older than 24 months), the median quarterly herd size was ≈ 153 cows in dairy herds and ≈ 9 cows in beef herds. In Scotland, these values were ≈ 390, ≈ 58. ≈ 188 and ≈19, respectively; whereas in Wales, estimates were ≈ 251, ≈ 43, ≈ 140 and ≈ 14, respectively. In all the three countries the herd size increased across quarters of 2016, especially in Scottish dairy herds.

4) Herd subtypes within the non-dairy (beef) sector per GB country and quarter (2016). In each GB country, suckler herds represented most of the non-dairy (beef) herds (≈ 62.3% in England, ≈ 74.6% in Scotland and ≈ 71.5% in Wales). Finisher-heifer herds were ≈ 35.8%, 24.3% and 27.2%, respectively, whereas veal-rearer herds were ≈ 1.0%, 0.2% and 0.7% (for caveats used in this categorization see Section 3.3.1). Markets comprised ≈ 0.1% in England and Wales and ≈ 0.2% of the non-dairy Scottish herds. Other herds not classified in these categories, represented ≈ 0.8% of the non-dairy herds in England and Scotland and ≈ 0.7% in Wales.

5) Quarterly herd size distributions per non-dairy subtype (2016). English suckler herds had quarterly median size ≈ 61 cattle. Finisher-heifer herds had ≈ 13 cattle, while veal-rearer, markets and “other” herd types had median size ≈ 7, 5, and 1 cattle, respectively. In Scotland these sizes were ≈ 85, 9, 3, 12, and 1 cattle whereas in Wales they were ≈ 57, 14, 5, 5, and 1 cattle, respectively.

Chapter 2: Herd structure and calvings

6) Quarterly within-herd structure per GB country and sector (2016). In all three countries and especially within dairy holdings, females older than two years represented most of the herd (average of quarterly medians > 49.0% in dairy holdings and > 39.0% in beef holdings, with some variation depending on GB country), followed in order by young stock (7-24 months old, heifers/steers), calves (0-6 months) and adult males (> 2 years).

7) Age at first calving per GB country and sector (2016). When considering cows calving for the first time at minimum 22 months of age, the median age at first calving was similar between countries and was around 29-30 months for dairy dams and ≈ 34-35 months for beef dams.

8) Age at culling/death after last calving in 2016, per GB country and sector. In England, dairy cows which were slaughtered (or died) after the last calving in 2016, had a median age around 5.8 years, while beef cows had age ≈ 7.3 years. In Scotland, dairy cows had median age ≈ 5.6 years, while beef cows had age ≈ 8.4 years. In Wales, dairy cows had median age ≈ 5.9 years, while beef cows had age ≈ 7.6 years. Thus, small differences were present between dairy cows of the three countries, while beef cows seem to be kept longer in Scottish beef herds compared to the same kind of herds in England and Wales.

9) Calving seasonality per GB country and sector (2016). In all three countries two peaks in calving frequency appeared for the dairy dams (February-March and August-September). In beef herds a single main peak was observed in April-May. The 2 calving peaks in the dairy sector were more distinct for England and Wales compared to Scotland, where most of the calved dams were located in beef herds.

10) Population of calving dams per parity, across GB countries and sectors (2016). In England, 1,669,108 cows calved in 2016. Between these 53.3% were in dairy herds and 46.7% in the beef sector. In Scotland, 544,208 dams calved, 26.4% of which were in dairy herds and 73.6% were in beef herds. In Wales, 373,547 dams calved; of these 49.4% were dairy and 50.6% beef. In all three countries (especially in dairy herds) most of the dams were in parities 1 to 4. Scotland had a higher percentage of beef dams in parities 5 to 8 compared to the same sector in the other two countries.

11) Inter-calving period per GB country and sector (2016). In England the average of median periods elapsed between two consecutive calving events (parities 1-2 up to 7-8); was ≈ 384 days in the dairy sector and ≈ 371 days in the beef sector. In Scotland, it was ≈ 384 days in the dairy sector and ≈ 370 days in the beef sector. In Wales, it was ≈ 382 days in the dairy sector and ≈ 373 days in the beef sector. Thus, in all three countries, the overall average inter-calving interval was shorter in beef dams than in dairy dams.

Chapter 3: Imports

12) GB "general" import patterns (CTS data 2011 to 2016). Most (97.0%) of the animals imported to GB production cattle herds between 2011 and 2016 arrived (in order of frequency) from: Ireland, Northern Ireland, the Netherlands, Germany, Denmark, Isle of Man, and France. The remainder arrived in small percentages from several other countries. The median number of animals received per consignment (on the same date from the same country) per herd was 13 (min = 1; 2.5th percentile = 1; 97.5th percentile = 68; max = 265). In total 13,815 consignments arrived into GB production cattle herds (CPH with more than four digits including separation bars) during the six years.

13) Import trading partners and sex of imported animals per GB country (2011-2016). In England, most (99.0%) of the live animals imported in 2016 into production cattle herds arrived (in the order of frequency) from: Ireland, Germany, Northern Ireland, Isle of Man, the Netherlands, France, Denmark, Belgium and Luxembourg. In Scotland, most (98.7%) of the imported cattle arrived from: Northern Ireland, Ireland, Germany, The Netherlands, Denmark, and Isle of Man. In Wales, most (98.5%) of the cattle arrived from: Ireland, Belgium, the Netherlands, Germany, France, Denmark, Northern Ireland, and Jersey. The remaining percentages (1.0% in England, 1.3% in Scotland and 1.5% in Wales) arrived from other countries. Those patterns were similar between years 2011 to 2016. Moreover, especially in England and Wales, most of the imported animals were females.

14) Import seasonality per GB country (2011-2016). For the three GB countries, 2014 was the year with the highest number of imported cattle and number of involved production herds. England was always the country with the highest number of imported cattle and herds involved. Nevertheless, according to the most recently investigated datasets (2016), importing herds represent a very small proportion of the denominator in the respective country. In fact considering the denominators reported above (for indicator no. 2) the annual percentage of herds importing cattle at least once (2016), was 1.3% (620/49322) in England, 2.1% (261/12225) in Scotland and 1.1% (125/11573) in Wales.

15) Size of importing herds across GB countries, sectors and quarters (2016). In England, dairy herds importing cattle had a quarterly median herd size around 375-486 animals (minimum 40; maximum 3906), while beef importing herds had ≈ 169-221 cattle (1; 2553). In Scotland, dairy herds importing cattle had quarterly median size ≈ 593-687 cattle (106; 4571), while beef herds had ≈ 205-276 cattle (1; 2891). In Wales, dairy herds importing cattle had median size ≈ 280-394 cattle (32; 2892), while beef herds had ≈ 110-211 cattle (2; 877). Thus, usually importing herds were large, although animals were also imported into CPHs that had very few animals during some periods (especially non-milking herds). These could be market, heifers or finisher herds that could apply "all-in / all-out" production cycles, or transition herds used by the importer to gather cattle before onward selling.

16) Number of importing herds per GB country, sector and quarter (2016). In all the three countries, during each quarter of 2016, the number of importing beef herds was higher than the number of importing dairy herds.

17) Imported animals per importing herd, across GB countries, sectors and quarters (2016). From a general point of view, the importer dairy herds imported approximately (average of quarterly medians of 2016) 21-22 cattle per quarter; while in importer beef herds these values were 2-5 imported cattle. Nevertheless, large variability was present between herds located in different sectors and GB countries.

Chapter 4: Cattle movements within GB

18) GB "general" movement patterns between British cattle herds (2016). According to CTS data (after removing births, deaths and moves to abattoir) 4,451,552 moves occurred in 2016 (Note: a 'move' refers to the movement of one animal between two holdings. This may occur as part of a 'consignment' of more than one animal). Most moves had agricultural holdings (AH, 58.2%) or markets (MA, 37.7%), as "ON" premises type (premises that had 'on' movements). The remaining % had calf collection centres, or were landless keepers, show grounds, temporary holdings, export assemblies centres, or were not defined (ie missing the "ON" premises type). There was variability in the quarterly number of moves. Moreover, the quarterly median number of moves per moved animal was ≈ 1.6 times (2.5th p. = 1; 97.5th p. = 3). Generally, per Q-period, ≈ 713,479 animals were moved. Between those, ≈ 345,416 (48.4%) were moved once; 347,161 (48.7%) were moved twice (usually through markets on the same date) and 20902 (2.9%) were moved more than twice.

19) Open (O) herds receiving animals from other British herds (2016). In England, ≈ 2236 dairy open (O-Dairy) herds and 15994 non-dairy (O-Beef) herds received cattle from other British farms during a single Q-period. In Scotland, the quarterly number of O-Dairy and O-Beef herds was ≈ 359 and 4002, while in Wales it was ≈ 433 and 3696, respectively.

20) Quarterly number of received consignments per GB country, sector (2016). English O-herds received ≈ 118,974 consignments per quarter (average of quarterly medians). Scottish O-herds received ≈ 24785, while Welsh O-herds received ≈ 20901. Within all GB countries most consignments (≈ 94-95%) were received into non-dairy herds (which included markets, see below).

21) Seasonality of consignments received across GB countries and sectors (2016). In all GB countries, consignments received by non-dairy (O-Beef) herds peaked in May and October. These peaks (see below) were mainly due to markets. In contrast, the monthly number of consignments received by O-Dairy herds did not show relevant monthly variability.

22) How often did the received consignment originate from the same GB country? Generally, ≈ 96.9% of the consignments received quarterly into English O-Dairy herds and ≈ 94.2% of those received into English O-Beef herds originated from England (from herds of any type). The remaining percentage received within each sector originated mainly from Wales. In Scotland, these percentages (originating from other Scottish herds) were ≈ 89.0% and ≈ 95.6%, respectively. The balance came mainly from England. In Wales ≈

76.0% of the consignments received into O-Dairy herds and ≈ 85.6% of those received into O-Beef herds originated from the same country. The balance originated mainly from English herds.

23) How often did the received consignment originate from the same county? On average ≈ 59.4% of the quarterly consignments received into English O-Dairy herds and 53.9% of those received into O-Beef herds, originated from farms located in the same county. In Scotland these percentages were 51.2% and 45.8%, respectively, whereas in Wales they were 68.8% and 70.9%.

24) Size of open herds receiving animals, across GB countries, sectors and quarters (2016). English, Scottish and Welsh O-Dairy herds had quarterly median sizes of ≈ 297, 425 and 270 cattle, while English, Scottish and Welsh O-Beef herds had quarterly median sizes of ≈ 74, 125 and 69 cattle, respectively.

25) Quarterly number of animals received per open herd across GB countries and sectors (2016). English O-Dairy herds received ≈ 6 (average of quarterly medians) animals per quarter (in one or more consignments), while Scottish and Welsh O-Dairy herds received ≈ 5 cattle. Usually, English O-Beef herds received ≈ 9 animals per quarter; while Scottish and Welsh O-Beef herds received ≈ 5 and 6 cattle, respectively.

26) Quarterly consignments received per open herd across GB countries and sectors (2016). The total quarterly number of consignments received by each open herd was similar across GB countries and sectors. Usually (as an average of quarterly medians) 2 consignments were received by English, Scottish and Welsh O-Dairy or O-Beef herds during a single quarter.

27) Number of animals received per consignment. Usually (average of quarterly medians) 2 animals were received in a single consignment by English, Scottish and Welsh O-Dairy herds, while O-Beef herds received 3 (England and Wales) or 4 (Scotland) cattle per consignment.

28) Quarterly number of "partners" sending (contact source) herds per open herd (2016). Usually, apart from markets (see below), during a single Q-period both kind of herds (O-Dairy and O-Beef) received animals from a single other (source) British cattle herd. This was valid for all three GB countries.

29) Source (S) herds sending animals to other British herds (2016). In England, ≈ 4940 dairy source (S-Dairy) herds and 19536 non-dairy (S-Beef) herds sent cattle to other British farms during a single Q-period. In Scotland, the quarterly number of S-Dairy and S-Beef herds was ≈ 711 and 5662, while in Wales they were ≈ 1010 and 4962, respectively.

30) Quarterly number of sent consignments per GB country and sector (2016). English S-herds sent ≈ 119277 consignments per quarter (average of quarterly medians). Scottish S-herds sent ≈ 26329; while Welsh S-herds sent ≈ 24992. Within all GB countries, most consignments (≈73-75%) were sent by non-dairy herds (which included markets, see below).

31) Seasonality of consignments sent across GB countries and sectors (2016). In all GB countries, consignments sent by non-dairy (S-Beef) herds peaked in May and October. These peaks (see below) were mainly due to markets. In contrast, the monthly number of consignments sent by S-Dairy herds did not show relevant monthly variability.

32) *How often did the sent consignment stay in the same GB country?* On average, ≈ 97.1% of the consignments sent quarterly from English S-Dairy herds and ≈ 96.6% of those sent by English S-Beef herds remained in England (into herds of any type). The remaining percentage sent out of each sector went mainly to Wales. In Scotland, these percentages (sent to other Scottish herds) were ≈ 87.0% and ≈ 92.1%, respectively. The remaining went mainly to England. In Wales ≈ 84.3% of the consignments sent by S-Dairy herds and ≈ 81.3% of those sent by S-Beef herds stayed within the same country. The remaining percentage went mainly to English herds.

33) How often did the sent consignment stay in the same county? On average ≈ 67.2% of the quarterly consignments sent out by English S-Dairy herds and 54.2% of those sent out by S-Beef herds, went to farms located in the same county. In Scotland these percentages were 52.2% and 43.6%, respectively. Whereas in Wales these were 78.3% and 66.2%.

34) Size of source herds sending animals, across GB countries, sectors and quarters (2016). English, Scottish and Welsh S-Dairy herds had quarterly median sizes of ≈ 274, 393 and 247 cattle, respectively, while English, Scottish and Welsh O-Beef herds had quarterly median sizes of ≈ 67, 109 and 65 cattle, respectively.

35) Quarterly number of animals sent per source herd across GB countries and sectors (2016). English S-Dairy herds sent ≈ 21 (average of quarterly medians) animals per quarter (in one or more consignments); while Scottish and Welsh S-Dairy herds sent ≈ 22 and 18 cattle, respectively. Usually, English S-Beef herds sent ≈ 9 animals per quarter; while Scottish and Welsh S-Beef herds sent ≈ 10 and 8 cattle, respectively.

36) Quarterly consignments sent per source herd across GB countries and sectors (2016). The total quarterly number of consignments sent out of each source herd was similar across GB countries and sectors. Usually (*ie* the average of quarterly medians) 5 consignments were sent out from English, Scottish and Welsh S-Dairy herds and 2 from S-Beef herds.

37) Number of animals sent per consignment. Usually (ie the average of quarterly medians) 3 animals were sent in a single consignment by English, Scottish and Welsh S-Dairy herds; while S-Beef herds usually sent 4 cattle (England and Scotland) or 3 (Wales) per consignment.

38) Quarterly number of "partners" (open contacts) receiving herds per source herd (2016). Usually during a single Q-period an S-Dairy herd would send animals to two other CPHs (partners open herds), while S-Beef herds (apart from markets, see below) sent animals to a single British cattle herd. This was valid within the three GB countries.

39) GB markets which received (or sent) animals from (or to) other British herds per quarter of 2016. The overall quarterly number of GB markets, which received cattle (open O-Markets) from other British herds ranged from 115 (in Q-3) to 129 (in Q-4). The overall quarterly number of GB markets which instead sent cattle (sending S-Markets) to other British cattle herds ranged from 113 (in Q-3) to 127 (in Q-4). Usually animals stayed less than 24 hours at markets (median "stay length" registered in CTS = 0 days). England had ≈ 75 markets, while Scotland and Wales had ≈ 24 each.

40) Overall number of moves, animals and consignments received (or sent) by markets from (or to) other herds. The overall quarterly number of moves received by GB O-Markets ranged from 397,331 in Q-3 to 448,818 in Q-4. These moves corresponded to 392,186 and 442,459, respectively, animals received by O-Markets from other British cattle herds. The number of received consignments ranged from 74264 in Q-3 to 80166 in Q-2. The overall quarterly number of moves sent out from GB S-Markets ranged from 327,452 in Q-1 to 380,656 in Q-4. These moves corresponded to 322,852 and 374,991 animals, respectively, sent by S-Markets to other British cattle herds. The number of consignments sent ranged from 48426 in Q-3 to 58630 in Q-2. The overall monthly number of consignments received by O-Markets peaked in May (28171 consignments) and October (32431). The overall monthly number of consignments sent out of S-Markets peaked in the same months (21597 in May and 24057 in October). Consignments sent to abattoirs were not included. This is the reason why the number of moves, animals and consignments received by O-Markets from other British cattle herds were higher than the number of moves, animals and consignments sent out of S-markets to other British herds. Also, the number of moves or consignments is higher than the number of animals because a small number of animals make multiple moves within the quarter (eg to a rearing holding and back, or to a market and back).

41) GB country of origin (or destination) of consignments received (or sent) by markets. Most often (approximately 69.6% of the times) the quarterly consignments received by O-Markets (located in any part of GB) arrived from English cattle herds, while approximately 15.2% of the consignments arrived from Scottish or Welsh cattle herds, respectively. Only 0.1% of the consignments arrived from administrative CPHs (99/999/999) for which we could not determine the GB country of origin. Approximately 71.1% of the quarterly consignments sent out of S-Markets (located in any part of GB) went to English cattle herds, while approximately 14.8% and 14.0% of the consignments went to Scottish or Welsh cattle herds, respectively. Only 0.1% of the consignments were sent from S-Markets to administrative CPHs. The higher percentages of consignments coming (or going) from (or to) English herds seems related to the higher number of markets and bigger overall denominator in England.

42) How often did consignments received (or sent) by markets come (or go) from (or to) other British herds located in the same county? Approximately 36.1% of the consignments received by O-Markets during a single Q-period originated from British cattle herds located in another county (*ie* different from the county in which the O-Market was located). By contrast, approximately (55.7%) of consignments sent by S-Markets during a single Q-period were then received by British cattle herds located in another county. Thus, markets appeared more likely to source animals from the same county where they are located, whereas if not sent to slaughter, most consignments were sent to cattle herds located in other counties.

43) Quarterly number of animals received (or sent) by each market herd from (or to) other British cattle herds. The quarterly median number of animals received by a single O-Market from other British herds was ≈ 2036 animals, while the quarterly median number of animals sent by an S-Market to other British herds was ≈ 1694 animals. The difference in the number of received and sent animals (as described above) is due to the animals which were received but then sent by the market to slaughter. In those cases, we considered only the first move as a potential source of disease spread between herds (due to moved cattle), while moves to slaughter were considered dead ends. Some markets received (or sent) several thousand animals during a single Q-period.

44) Quarterly number of consignments received (or sent) by a market from (or to) other British herds. The quarterly median number of consignments received by each O-Market from other British herds was ≈ 332 (mean ≈ 631; maximum 4495), while the quarterly median number of consignments sent by an S-Market to other British herds was ≈ 268 (mean ≈ 438; maximum 3146).

45) Number of animals per consignment received (or sent) by a market from (or to) other British herds. Usually O-Markets received 3 cattle per consignment (mean ≈ 5; maximum = 569) and S-Markets sent 4 cattle per consignment (mean ≈ 7; maximum 239).

46) Quarterly number of (partner) herds sending (or receiving) animals to (or from) markets (per market). Generally a single O-Market would receive animals from ≈ 181 British herds during a single Q-period. Nevertheless, some markets could have up to 1725 source partner CPHs. On average (average of quarterly medians) an S-Market could send animals to ≈ 140 British herds during a single Q-period and some S-market could have up to 1587 receiving partner CPHs.

A. Background

This paper gives information on 46 indicators relevant to the cattle population in Great Britain per GB country (England, Scotland and Wales) and sector.

For each indicator, actual values and frequency distributions are provided through the report, in such a way that they can be extracted and used in other studies for different purposes, e.g. parameterisation of simulation models used for risk assessment, within-herd disease spread simulations and disease detection at national level.

Moreover, indicators are discussed in this paper and compared with results of previous papers. Examples of their potential use (e.g. to parameterise/interpret stochastic models of risk assessment, disease spread and surveillance evaluation) are given with references. Other indicators, not prioritised for implementation in this financial year (but which could be added in the future), are listed at the end of this report as well.

B. Main methods and data

Several datasets were used to carry out the analysis per GB country, sector (dairy vs. non-dairy/beef) and period (annual or quarterly statistics). Firstly, general figures were obtained for GB using data from two databases: the Cattle Tracing System (CTS) and the Rapid Analysis and Detection of Animal Related Threats (RADAR) (cohorts 2013-2016 for the general denominators, and cohorts 2011-2016 for the general import patterns).

Then, more detailed figures are reported for 2016 on a quarterly basis, per country and sector after combining datasets from CTS-RADAR (by County Parish Holding number CPH-CPHH and period) with information on actual milking herds (dairy sector) statutory tested for surveillance of bovine brucellosis in the bulk tank milk (BTM quarterly testing data from APHA Laboratory Information Management System LIMS), at first Post Import Calving (PIC), and in samples submitted from abortions (data from APHA-LIMS and from the Scotland's Rural College (SRUC).

A detailed description of the methods (with limitations and possible improvements) is provided in the Appendix. Nevertheless, from a general point of view, the datasets considered were:

CTS and RADAR data; to identify the population of cattle herds present in each country.

LIMS data on statutory quarterly BTM testing (to identify the milking dairy herds of each country), Post Import Calving Testing (PIC) and abortion submissions for surveillance of bovine brucellosis (to improve denominators).

CTS and RADAR data on cows calving in 2016 and their calving history.

CTS data on imported live animals and within GB cattle movements.

Data on brucellosis surveillance was used for two main reasons: a) datasets and R-codes used for a previous project on surveillance of bovine brucellosis were already available, and b) as stated in the previous Livestock Demographic Data Group (LDDG) dairy indicator report, to increase precision: "further consideration is put toward the process of identifying dairy holdings" (APHA, 2016). To our knowledge the CPH list of dairy herds tested quarterly for bovine brucellosis was the most frequently updated list of GB dairy herds. Moreover, the reason for presenting figures per quarter (and in some cases per month), is that by using this method seasonality patterns could be investigated, and the indicators could be used for purposes of risk assessment and surveillance evaluation across surveillance periods of one year or even shorter.

For statistics at sector level, cohorts after 2013 were considered especially for indicators on herd size and structure, because the Sam database (which was used to improve the list of milking herds) stabilized after this year. Moreover, for the herd indicators, year 2016 was the most recently used and small variability from previous years was expected (e.g. in the inter-calving periods).

The non-dairy sector was subdivided into five further subtypes: i) suckler herds, ii) finishers and heifer herds, iii) veal and rearer, iv) markets and v) other. This classification was not directly possible (apart for the market herds) according to the way data are currently entered into RADAR/CTS, and thus some caveats were used. For limitations and potential improvement of the data see below (see Limitations for the Appendix on animal movements). The same caveats were applied to England, Scotland and Wales (adapting the same R-codes).

Then, indicators about calving and parity distributions were calculated considering dams (up to parity 8) calving in 2016, and according to date of birth of their respective calves which were ear-tagged and registered in CTS (hence aborted dams were not considered). Because the inter-calving indicator was calculated based on dates of birth of the last two calves, and since the minimum inter-calving periods considered were ≥ 280 days (in line with Gates et al., 2013), dams calving twins were not used for the inter-calving indicator (this was because of the structure of the data and because calculations of the calving interval applied to the whole dataset). Additionally, the minimum age at first calving was set at ≥ 660 days (22 months). In the latter case, fresh cows calving twins were considered. Estimates could be re-calculated using different cut-offs per sector and as suggested by the GB Cattle Expert Group. Those cut-offs were used because usually heifers get pregnant when they are at least 13 months old and the pregnancy lasts around 280 days in cows (though variability between breeds and number of parities exist). The cut-off at 280 days was chosen also to make an equivalent comparison with a previous published study (Gates et al., 2013).

For import indicators, seasonality was investigated considering data 2011-2016. Furthermore, Northern Ireland (NI), the Isle of Man, Jersey and Guernsey were considered as “sending countries” because, from the perspective of animal health status (and disease epidemiology), they differed from England, Scotland and Wales. For example, the latter three countries and the Isle of Man are officially free from bovine brucellosis (OBF), while the others are not. Northern Ireland is expected to finalize OBF status in 2020 and is currently in the period of enhanced surveillance. These differences must be considered e.g. when national risk assessment is carried out, since risk mitigation measures could change according to country of origin of imported animals and their number. For instance, currently, imported cattle from NI must be tested for bovine brucellosis at their first calving in GB (PIC testing), while for animals imported from OBF countries (i.e. Isle of Man) no specific risk mitigation measures are in place.

Data on movements of British cattle, including births and deaths, were extracted from CTS. Thirteen files were produced by the Data System Group (DSG, Jon Weston). Twelve of those files consisted of 1,000,000 records (data lines) each, while the last file contained 345,687 records. Each data line represented the move of an animal between two CPHs. The same animals could move more than once. Column variables included: CPH of origin (source herds) and CPH of arrival (open herds), date of movement, holding type, premises type, date of birth, date of death, animal ear tag, birth move (‘true’ or ‘false’) and death move (‘true’ or ‘false’).

After removing births, deaths and moves to slaughterhouses (ON premises type = SH or SM or SR or SW) and to CPHs with 4 digits; 4,451,522 (36.1%) records remained and were used for the analysis. Between those, 58.2% had agricultural holdings (AH) as “ON” (receiving) premises, 37.8% had markets, 1.6% had calf collection centres, and 1.1% had landless keepers (LK). The remaining percentage had as “ON” premises type: show grounds (0.7%), temporary holdings (0.3%), export assemblies centres (0.2%), or were not defined (missing ON premises type, 0.1%). Very few records had ON premises type as hunt kennel or knackers yards.

A consignment was defined as a move of at least one animal from one CPH to another during the same date. So if several animals were moved and more trucks were used within the same date from herd “A” to herd “B” they were still counted as one consignment.

Thus, in the sections below a first general overview of the cattle population denominators, herd types and sizes per GB country (Chapter 1, Section 1.1 - 1.2.3) is described. In Chapter 2, (Sections 2.1 to 2.6) the herd structure/management indicators are described while in Chapter 3 (Sections 3.1 to 3.6), import indicators are presented. In Chapter 4 (Sections 4.1 to 4.19) the between-herds cattle movement indicators are explained. Finally, in Chapter 5 (Sections 5 to 5.5), comparisons with previous studies (internal and external to APHA) and potential uses/interpretations of indicators are discussed.

List of abbreviations

Abbreviation	Meaning
AHDB	*Agriculture and Horticulture Development Board*
APHA	*Animal & Plant Health Agency*
BTM	*Bulk Tank Milk*
CPH	*County Parish Holding number*
CPHH	*County Parish Holding Herd number*
CTS	*Cattle Tracing System*
FMD	*Foot and Mouth Disease*
LDDGs	*Livestock Demographic Data Groups*
LIMS	*Laboratory Information Management System*
NML	*National Milk Laboratories*
OBF	*Officially Brucellosis Free status*
O	*Open herds / markets which received cattle from other GB herds / markets*
S	*Source herds / markets which sent cattle to other herds / markets*
PIC	*Post Import Calving Testing for bovine brucellosis*
RADAR	*Rapid Analysis and Detection of Animal Related Risks*
Sam	*Sam*
VRG	*Veterinary Risk Group*
WHP	*Within herd prevalence*

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Appendix: Materials & methods, with respective limitations

Data sources

Several national datasets available at APHA (DES, DSG) for the three GB countries were handled and formatted using R, so that they could be combined in a straightforward and consistent manner, across the investigated periods. The datasets considered were:

1. CTS, RADAR and Sam data; to identify the population of cattle herds present in each country.
2. LIMS data on statutory quarterly BTM testing (to identify the milking dairy herds of each country) and data on statutory testing of post import calved cows (PIC) and abortions samples for surveillance of bovine brucellosis (those datasets were used to improve the overall national denominators).
3. Abortion testing data from Scotland (Scottish Agricultural Colleges, SAC)
4. CTS and RADAR data on cows calving in 2009-2016 and their calving history
5. CTS data on imported live cattle and within GB herd movements

The relevant differences between databases and variables available, required an intensive process of data handling using R. Nevertheless, the R-codes created for this analysis could be used in the future, provided that similar datasets are used.

CTS-RADAR datasets on local GB cattle herds

The CTS and RADAR datasets represented the most complete and updated overall denominator data (at animal and herd level, respectively), for each GB country, because information at animal level is entered into those databases on a monthly basis.

The CTS database does not belong to APHA, and thus, at the moment of data extraction (Jon Weston, Data System Group), some checks had to be carried out by comparing the extracted files with information contained in other national published reports. The CTS-RADAR combined files were extracted for years 2011 to 2016, for the three GB countries altogether. Nevertheless, due to the large size of the files, the datasets of each year were extracted as sub-datasets (one for each quarter of year). Each sub-dataset contained ten columns (and within each column, there could be different sub-levels):

1. Month
2. Year
3. Country name (sub-levels: England, Scotland or Wales)
4. County Parish Holding (CPH) number or County Parish Holding Herd Number (CPHH)
5. Postcode
6. Easting location coordinate of the CPH/CPHH
7. Northing location coordinate of the CPH/CPHH
8. Number of animals per age group/month/herd (four age groups: 0-6, 7-24, >=25 months and unknown age)
9. Sex (number of males and females within each age group/month/herd)
10. Breed purpose (Levels: Dairy, Beef, Dual, or Unknown)

For each investigated year a code was developed in R, to import and bind the four sub-datasets into a unique table. For example, for 2011, sub-datasets of periods Q-1-2011, Q-2-2011, Q-3-2011 and Q-4-2011, were imported, bound and handled altogether.

Thereafter, a column was added to the combined table, to define the surveillance period (Q) number according to the month number and year when cattle were registered at the respective CPH/CPHH. The number of herds per surveillance period was counted by the number of CPHs appearing at least once. Moreover, the number of production herds was identified by the CPHs with more than four digits. Herds with four digits were considered as non-producing herds, such as slaughterhouses, and were disregarded for the data analysis.

The final table was printed as a unique txt file, so that it could be combined (using other R codes) with the other datasets (for analysis) by CPH, month/quarter and surveillance year. Therefore, in each line of the final table, the CPH, the GB country of location, the month number, the quarter period within the year, and the number of animals present in the herd were reported as: overall total number (herd size), females older than 24 months, males older than 24 months, calves (of any sex) ≤ 6 months of age, and heifers/steers ≥ 7 to 24 months of age. Accordingly, a CPH could appear in up to 12 lines per year (one for each month of the year) in the table ready for combining/analysis.

BTM testing data from LIMS

The datasets on BTM testing for surveillance of bovine brucellosis, were used to identify the population of milking herds (truly dairy) in each country, and thus, defining the herd type of each CPH (dairy vs. non-dairy/beef). The herd type is an important parameter that affects the testing scheme used for surveillance of animal diseases (e.g. BTM testing vs. individual blood testing in non-dairy herds), but also the risk of disease introduction (e.g. by imported animals from specific countries). During the data collection, a big investigation was carried out to find the best dataset, which could be used to identify “actual” dairy milking herds.

It was difficult to find a list of all milking herds updated at least on quarterly basis. The CTS datasets (as explained above) contained only information at animal level and not at the herd level (i.e. missed herd production type).

The RADAR database contained information on herd type, but this is based on the breed of the animals located in the CPH, and does not have information on the true production type of the herd (delivery of milk or not).

The Sam database has information on herd type, but it is updated when official visits are carried out by the veterinarians for control of bovine tuberculosis (bTB). On these occasions the herd type is updated (as dairy or beef) if needed. However, for some herds the herd type could be outdated, if the farm is bTB free and is tested with low frequency (e.g. bTB free herds could be tested at four-year intervals, and meanwhile the production type could change) (Alisson Prosser, DSG, personal communication).

It was also known that a list of milking CPHs is available from the Milk Hygiene Register (which does not belong to APHA), but this is updated every 2-3 years (APHA, 2016, see previous LDDG dairy indicator report).

Therefore, the list of CPHs tested quarterly on BTM (from LIMS) for antibodies against bovine brucellosis, was considered the most updated list, because it is compulsory to test quarterly dairy herds for surveillance of Bovine Brucellosis.

On the other hand, original datasets on BTM testing missed the CPH in several records (up to 25-32% depending on GB country and considering years 2013-2016, see table below) because they are retrieved from the National Milk Laboratories (NML) to APHA. The two institutes use the BTM samples for different purposes. At the lab level the CPH is not always required since eventually positive herds could be easily traced just after test results (usually within a week from sampling). In contrast, in our case, the merging between files of different datasets needed to be carried out by the CPH/CPHH number (which identified each herd) for several thousand records at the same time, and therefore, before proceeding further, the datasets on BTM testing had to be improved. With the row datasets too much information (up to ≈ $1/4^{th}$ of the BTM testing records) would have been lost (see table 1 below).

Then, when the postcode was available in the BTM list, it was used to find the missing CPHs in other databases. In the BTM lists of Scotland (from 24 excel spreadsheets, one per Q-period) the postcode was registered in a separated column (when CPH was not provided), while for the other two countries (England and Wales) it was within the address column. In the latter case a new column had to be created in R, where the postcode was represented by the last 7 digits of the address. Then, the following procedure was applied:

a) If within the BTM dataset the same postcode appeared in more lines with and without the CPH, the line missing the CPH was filled with the CPH already available for the same postcode. Assumption: the farmer or NML reported the postcode only once for the same herd.

b) If the CPH was still missing after step a, it was searched in the CTS database, still through the postcode, but only if in CTS the latter had only one CPH (during the same year) and if in that herd at least one animal was moved on (meaning that the herd was actually open) or off during the last 12 months. The CTS had higher priority than Sam, because it is updated more often. Assumption: if in CTS only one CPH was available for the used postcode (in the investigated year), the correct CPH was found.

c) If the CPH was still missing after steps b and c, the Sam database was consulted, but the CPH cell was filled only if in Sam the postcode had 1 single CPH and the herd was classified as dairy (at April of the investigated year). Moreover, in the Sam database, priority was given to the CPH registered at the herd location postcode. If this was not available, then the owner location postcode was used. Sometimes the postcode was not available at all in Sam (Alison Prosser, DSG, APHA, personal communication). Assumption: if in Sam only one CPH was available for the used postcode (in the investigated year), the correct CPH was found.

d) If the CPH was not found after steps a, b, and c, the herd was counted as non-dairy.

Steps a, b and c were carried out in collaboration with the Data System Group (Alison Prosser, DSG, APHA). Once the percentage of BTM records missing the CPHs was reduced, as much as possible, the BTM datasets were improved and formatted using an R code.

The month number and the year was deduced from the date of BTM test completion (usually within a week from sampling). The date was used to define the period of BTM testing for each CPH, and thus when the herd could be considered to be dairy. Accordingly, for each year and country, a final table (ready for use) was printed as a CSV file out of R; so that it could be merged with the other datasets.

Abortion testing data from LIMS (England and Wales)

Data on abortion testing in England and Wales (LIMS database), was available in a single spreadsheet (RL spreadsheet), for all years. Thus, all years were handled with a single R code.

Before importing the dataset into R, some formatting was required on the excel file. From this dataset the main variables used were: the date the sample was received at the APHA Veterinary Investigation Centre, the CPH, and the contract number which identified surveillance for brucellosis. This dataset and the dataset from SAC (see below) were used because some further herds (not appearing in CTS/RADAR) were registered in those files and thus the overall denominators of herds could be better defined. Moreover, the R code used for another project was ready for use.

Abortion submissions from cattle herds were identified as these of contract SB4100 and had the letter “C” (for cow) within the submission reference. The month and surveillance period of testing were defined according to the month and year number contained within the submission reference code, which was always available.

The final table with the estimated number of tested herds per surveillance period/year was exported from R as a CSV file to be combined with the other datasets (in another R code). For PIC testing (all three GB countries on the same file from LIMS) a similar handling procedure was used.

Abortion testing data from SAC (Scotland)

The row dataset on abortion testing from Scotland (SAC database) was of good quality. Also in this case herds were counted according to submission date, per month and per quarter period. Accordingly, the final exported table to be merged with the other datasets had the CPH line, per month/quarter of each considered year.

Data on calving cows in GB

Eight CSV data files (A to H) on dams calved in GB between 2009 and 2016 (full years included), were extracted from CTS/RADAR. Files “A” to “G” had 1 million lines each and 43 columns, while file “H” had 332162 records and same number of columns. Information at cow level, used for this report included:

1. Dam’s ear-tag
2. Dam’s CPH of birth (if born in the UK)
3. Birth GB country
4. Birth date
5. Death date (if culled/dead by 2016 and before data extraction in 2017)
6. Age at death
7. Ear-tag of each calf from that cow (1st to 8th calf)
8. Date of birth of each calf from that cow (1st to 8th calf)
9. CPH of birth for each calf from that cow (1st to 8th calf)

Thus, in all files, each line represented a cow, and each cow had all calves (with ear-tag, CPH of birth and birth dates) on the same line. Therefore data on a total of 7,332,162 cows were extracted.

Before importing into R, each of the raw data files was formatted. The columns for animal ID and ear tags (of dams and their calves) were formatted by removing spaces to ensure that if the same dam was entered twice (once with spaces and once without) it was not counted twice (as two cows). Moreover, dealing with dates was faster in CSV than in R, and thus, 7 columns (to the original 43) were added in the CSV files, where inter-parity (1 to 7) number of days between two consecutive calving events (e.g. column "IntCparity1To2"…."IntCparity7To8") were calculated.

Then, the age at first calving of each cow was calculated as the difference between the date of first calving and date of birth. Whereas age of culling/death was given by date of death minus date of birth. For imported cows if the date/CPH of birth was not available then they were disregarded for calculating age at first calving and death.

Cows were considered as located in the CPH of their last calving in 2016. Those datasets were analysed for that year only (the most recent used).

In the data merging, the CPH and the quarter/year of calving were used to combine the dam information with the other datasets (e.g. on BTM testing) which were used instead for defining the herd type; and to allocate the calved cows (per quarter/year) in the dairy or in the non-dairy/beef sector.

Furthermore the parity number was defined for each cow according to last calving in 2016.

Imported live cattle (CTS)

Data on imported live cattle was extracted from CTS as a unique data file (txt format) for all six years and for the three GB countries. This dataset contained information on animals imported into British production cattle herds but also for slaughtering. The row dataset had 310923 data lines and the main variables were:

1. Animal ear tag (almost always available, missed only in three data lines)
2. Animal internal CTS ID
3. Sex
4. Date of birth of the imported animal
5. Breed description
6. Production type (beef, dairy, dual purpose)
7. Year of import
8. Country of origin
9. CPH of arrival in GB
10. Number of movements after arrival in GB
11. Date and CPH of first calving in GB when applicable. Missed for 168005 records, if animals did not calve by date of data extraction (beginning of 2017) or if they were males
12. Age at import

13. Age at death (when applicable. Not available/entered in 107839 records, possibly because animals were still alive at date of data extraction).

The column with the ear tag was formatted by removing the spaces between digits. In this way, the same animal (same ear tag) appearing more than once in the dataset could be individuated. If spaces had not been removed, animals appearing in two or more lines, with and without spaces between ear tag digits, would have been counted more than once.

It was found that the same animal could appear more than once in the dataset only in a few cases (4 ear-tags). This could have been caused by two main reasons: a) due to a typographical error, and/or b) the animal was exported and re-imported into GB (Jon Weston, DSG, personal communication). Hence it could be assumed that each data line represented an imported animal. When considering the internal CTS animal ID the overall number of animals was the same than when considering the eartags.

The month number was extracted from the date of import and it was used (combined with the year of import) to define the surveillance period/quarter when the animal(s) was (were) imported into each CPH. The CPH of arrival was considered to be the importing GB herd.

The country location of the importing herd was deduced from the first two digits of the CPH (England ≤ 51, Wales 52-60 and Scotland ≥ 66).

Additionally, the number of animals imported into production herds (and the number of herds involved), were identified according to the number of digits in the CPH/CPHH (e.g. four, 11 or 14 including separation bars), The animal was considered as imported for slaughter (dead end for disease introduction) and was excluded from the analysis if it entered into CPHs with 4 digits.

The number of animals imported per local British herd, per period, from each country was estimated by summing the ear tags imported.

Results of data handling

Optimized datasets on bulk tank milk (BTM) testing

Using procedure *a-d* described above, the percentage of BTM records missing the CPH was reduced (depending on year) from approximately 15.7-19.1% to 5.8-6.8% for England and Wales (together), whereas for Scotland these percentages changed from 11.1%-31.2% to 3.4-6.3% (Table 1 below). The final percentage of records (data lines) for which the CPH was not found, were assumed as non-dairy/beef herds, and ranged from 3.4% (2016 in Scotland) to 5.8% (in 2013 for England and Wales). Such a proportion was based on the number of BTM postcodes for which the CPH was not found in CTS or SAM. It must be taken into account that herds with more milk tanks and tested in more quarters could represent more than 1 data line. Thus the number/percentage of missing records should not be considered as the number of misclassified herds (which should be lower).

Table 1

The below image shows the comparison of the percentage of data lines missing the CPH in: a) the row datasets of Bulk Tank Milk testing (England, Wales and Scotland), b) after improving the CPH list by using the Cattle Tracing System (CTS), c) after improving the CPH list by using the herd location postcode registered in Sam, and d) after improving the CPH list by using the owner location postcode registered in Sam. Years 2013 to 2016.

Country	Year	Row dataset (all lines)	Missing CPH	Missing CPH after CTS	Missing CPH after herd postcode in Sam	Missing CPH after owner postcode in Sam
England and Wales	2013	39759	19.1%	11.1%	7.5%	6.8%
	2014	37871	16.3%	9.7%	6.7%	6.1%
	2015	39184	16.1%	9.4%	6.6%	5.9%
	2016	38276	15.7%	9.1%	6.4%	5.8%
Scotland	2013	4054	31.2%	22.2%	11.9%	6.3%
	2014	4027	20.2%	13.7%	7.3%	4.0%
	2015	4123	10.6%	8.2%	5.2%	3.5%
	2016	4121	11.1%	7.1%	4.3%	3.4%

Only BTM testing 2013 and after was used because the Sam database (founded in 2011) stabilized in this period and quarterly BTM testing for bovine brucellosis started in mid-April 2011 (before it was made on monthly basis).

LIMS data on testing of abortion submissions in England and Wales

Regarding the abortion submissions in England and Wales, 35545 out of 45609 records (77.9%) were reported under contract SB4100 and involved testing for bovine Brucellosis in cattle herds.

SAC data on testing of statutory abortion submissions from Scotland

In the datasets of abortion submissions from Scotland, the CPH of the herd from where the animal was sampled, was almost always available (≥ 99.7% of the records). Moreover, the date of submission was always available. The median number of days elapsed between sampling and completion of testing was around six.

Data on calving cows in GB 2016 ready to use

After the data handling process, 7 new “A-H” CSV files ready for use regarding 2,588,402 cows calved in 2016 were obtained and combined with the other datasets. Then the analysis was carried out for each GB country in a separate R-code.

Discussion on methods and limitations of data availability, handling, analysis

Data on cattle populations from CTS and RADAR

The datasets from CTS and RADAR were well formatted and contained relevant information on the population of cattle herds of each country. Therefore, the data handling process was not very difficult or time consuming. As shown in the results above, this kind of data could be used to estimate (most of) the overall denominator of cattle herds, their location and (if needed) the monthly/quarterly herd size and structure.

Data on BTM testing

Datasets on BTM testing were by far less formatted than data from CTS and RADAR. Therefore a more intensive handling was required to reduce the proportion of records where the CPH was missing. Information from CTS and Sam was used when possible. By using steps a-d, the number of truly milking herds could have been underestimated (compared to the real number in the field) for the considered surveillance period. Nevertheless, using e.g. all CPHs present in CTS and Sam for the same postcode (up to 10 per postcode), the number of BTM tested (milking) herds would have been overestimated (e.g. in both CTS and Sam, several CPHs could appear under the same postcode, and some of them could be beef herds). Especially for Scotland, a small percentage of milking herds could have been mis-classified as non-dairy (or beef) because the CPH was not available in the BTM list used to spot dairy herds. Nevertheless, such a list was largely improved with data from CTS and Sam before use (Table 1), and therefore, the degree of bias could be considered as low.

Moreover, in mid-2016 the NML was contacted to find out the overall number of milking herds submitting BTM samples. It was found that herds sampled by the NML are “likely to represent c.99% of all milking herds currently in GB, and represent all herds selling milk to milk purchasers. The only herds not on this list are ‘NML special’ which are producer-retailers”. Furthermore, we were advised that at May-2016 there were 9866 producers within the NML sampling scheme. Thus, it could be concluded that in 2016 (the most recent year we considered) approximately 9866 dairy cattle herds were active and represented ≈ 99.0% of the GB dairy herds. When summing the number of milking herds (we estimated this in the same year for herds appearing at least once in 2016, in the improved Brucella BTM list, from the three GB countries altogether), we found a lower number (Section 3.2 in the text): 6795 dairy herds in England, 949 in Scotland and 1481 in Wales = 9225. Thus it seems that by using the approach described in this appendix ≈ 9225/9866 = 94% of the milking herds present in GB were identified and were assigned correctly to the dairy sector. Those missing could be small dairy herds and/or retailers.

That margin of error could be reduced if e.g. a more complete list of milking herds was available on milk delivery per CPH and date. Alternatively, reporting in RADAR if the herd is actually milking or not would remarkably improve the process used for this report.

Considering the date of sampling for BTM testing records, it was found that usually the number of days elapsed between sampling and date of sample arrival (or of testing completion) was ≤ 7 days. Therefore, for most of the BTM tests, it could be assumed that the date of sample arrival at the laboratories and the date of testing completion could represent a reasonable approximation of the actual sampling date.

Data on abortion submissions

From a general point of view, data on PIC and abortion submissions from the three countries, was almost complete and could be assumed that the date of sampling and test were very close (if not the same).

Data on calving cows in GB

During the data handling, to allocate the cow in a herd, we used the CPH of last calf given in 2016. If a cow had two calves within the same year e.g. one in January 2016 and one in December 2016, and in different CPHs, the CPH we used was the latest. Nevertheless, this was a rare event and appeared mainly in England (≈ 1500 cows). Thus if year of calving number 2 <= 2016 and year of calving number 3 = 2016, the dam got the CPH of the third calf she had during 2016. If the dam had the two calves in two different CPHs in the same year, it was not reflected. So it was assumed that both calving were in the same CPH. This is a limitation when extracting number of dams per sector (e.g. if 1 calf was given in a dairy herd and the second in a beef herd). In those particular cases, the dam's ear tag is counted once for one CPH.

We can correct this with a more complex R-code in the data handling, but more handling leads to more time and costs. Since this limitation happened mainly in England in 0.2% of the records only, this is likely to be unnecessary. Additionally, when using figures at dam level (e.g. number of dams per year), it is better to count the ear tag (and thus the animal) only once, despite it having calved in two CPHs (since it is still one animal but in two different herds at different moments). When counting dams per month/quarter, those calving twice in the year were counted only at the end of the year.

The same reasoning applies for the GB country where the dam was counted. The country was defined according to CPH of last calving in 2016, and thus, a cow calving in quarter 1 in one GB country and in quarter 4 in another, was not counted in the first country.

Data on imports from CTS

The dataset on imported live cattle was well formatted and consistent across countries and periods. It was possible to identify the number of animals imported into production cattle herds with high precision, by the CPH where animals were introduced at their arrival in GB. The GB country of destination (England, Scotland and Wales) and the countries of origin could be defined as well.

Moreover, because the date of arrival was always available, it was possible to count with high precision the number of animals imported per herd and per period.

Final mismatch between datasets

After merging all datasets altogether per surveillance period there was a low level of mismatch; which was mainly between the CPHs present in the BTM list and those registered in CTS/RADAR.

When counting the number of herds per country and per quarter (e.g. in 2016) approximately 420 CPHs in England, 35 in Scotland and 76 in Wales appeared in the BTM list but not in CTS/RADAR data. These dairy herds could not be considered when investigating their size, structure etc. because for this LDDG report, such information arrived from CTS/RADAR.

Another ≈ 15 CPHs for England, 6 for Scotland and 4 for Wales appeared in the abortion list but not in CTS/RADAR. Therefore, the level of mismatch between the main data files appeared to be very small considering the overall number of herds present in each country. Thus, for future LDDG reports, the datasets on PIC abortion testing could be disregarded, while BTM Brucella lists used for identifying the dairy herds could be used if no other (more precise) list of actually milking herds becomes available.

Limitations for the Appendix on animal movements

Finisher-heifer herds were present in higher percentage in England and Wales compared to Scotland. In England and Wales, many of these herds might have been heifer herds which belonged to dairy farmers which raise heifers in a separate CPH until their first calving. In Scotland, most of the herds could, instead, belong to non-dairy (beef) farmers. To verify this reasoning a more detailed analysis should be made within this subtype, using the main breeds and production types registered per CPH in RADAR. Nevertheless, even in that case, some uncertainty will remain. To reduce this uncertainty farmers should enter the production type at herd level, and they should state if milk is actually delivered from the CPH or not.

Nevertheless, from an epidemiological point of view, heifer herds would be more similar to finisher or suckler herds than to actual milking dairy farms. Thus, for the purposes of this report, the aggregation of finishers and heifer herds into the same subtype was considered sufficient to inform models used to assess risk of disease introduction, spread and confidence in detection.

Furthermore with the caveats used, if a cow calved in a CPH and then during the rest of the year the farmer changed production to finisher, we still counted it as a suckler herd.

Moreover, not all market herds could be shown in the maps because, we had size and coordinates (from RADAR) only for those which entered their size at the 1st day of each month. Therefore, some of the markets could tend to register animals only during selling days when animals stay at the market for less than 24 hours, which is usually the case. If this is the case it would be preferable that markets provide average size (on selling day) at least once per month.

Conclusion and quality statement

The datasets and information used for this report, appeared to be very informative and the level of mismatch between files appeared small. R-codes used for the handling, merging and analysis could be optimized in the future if considered necessary.

The reason for the mismatch in the CPHs appearing in the BTM milk lists but not in CTS/RADAR should be investigated, though APHA has not control on CTS. For example, the herds that do not appear in CTS but were tested for brucellosis in BTM could represent very small milk retailers that rarely register data in CTS. Other reasons could regard database management etc. (at the source).