Cattle Health and Welfare Group Antimicrobial Usage Subgroup (CHAWG AMU) recommendations for measuring and comparing the use of antibiotics on beef farms

1. Responsible Antibiotic Use

Antibiotics are very important medicines. Every time an antibiotic is used, there is a risk that it will increase the number of bacteria resistant to that antibiotic. This means that these antibiotics will stop becoming effective for treating infections in people and animals. Responsible antibiotic use, alongside measures to prevent disease, is therefore vital to help preserve these life-saving medicines.

Some antibiotics are also very important as a last resort for use in the treatment of serious infections in people. These are called Highest Priority Critically Important Antibiotics (HP-CIAs). The HP-CIAs, as currently defined by the Antimicrobial Advice Expert Group (AMEG)[1], are quinolones (including fluoroquinolones), 3rd and 4th generation cephalosporins and polymyxins (including colistin). It is very important to minimise how much of these HP-CIAs are used on farms and to only use them when needed, for example when bacterial culture and sensitivity show it is the only antibiotic that is effective to treat a particular case.

Beef farmers and vets should work together to monitor antibiotic use on farm every year and ensure that antibiotics are used responsibly. This is part of the Red Tractor standards for beef farms[2].

2. Benchmarking Antibiotic Use

Farm benchmarking refers to the comparison of a farm's antibiotic usage with that of other equivalent farms in the region/country. This has several benefits:

- It allows farms to understand their antibiotic use and how this is changing over time and relative to the industry
- It stimulates the vet-farmer conversation and should encourage persistently high using farms to look into their management practices and make changes

When interpreting benchmarking data, it is vital to focus on encouraging responsible antibiotic use. Herd health planning and strategies to prevent disease are key to reducing the need to administer antibiotics and improving health and welfare on the farm. Reducing use by, for example, withholding necessary treatment, using lower than recommended doses or switching to an inappropriate antibiotic because it has a lower amount of active ingredient per dose is not responsible use.

The CHAWG AMU group have carried out an open consultation with a wide range of beef industry stakeholders to develop core metrics for benchmarking antibiotic use on UK beef farms, following a similar process that was completed for the dairy sector[3]. This document reports on the chosen core metrics, which will be incorporated into the electronic Medicines Hub for Cattle and Sheep, as well as additional metrics that could be considered. This does not, however, exclude the calculation of further antibiotic usage metrics, according to individual requirements and needs.

While systems are in place for the national monitoring of antibiotic sales in food producing animals, for example using the Population Correction Unit (PCU) method developed by the European Surveillance for Veterinary Antimicrobial Consumption (ESVAC) group[4], it is not possible to use these for benchmarking at farm level. This is because, when determining the weight of animals at risk of receiving an antibiotic for the beef sector, they are focused on measuring the number of slaughter animals. In the UK, many beef farms do not produce slaughter animals, or they produce so few that this number does not fairly represent the weight of animals at risk on the farm.

Ideally, full access to movement system records (such as the Cattle Tracing System for Great Britain and APHIS for Northern Ireland) will make it possible to collect accurate animal data, including number, age and breed, and take into account time on farm without having to ask the farmer for this information. However, when creating these metrics, it has been assumed that (at least in some cases) the information will need to be obtained directly from the farmer. The aim has therefore been to minimise the amount and complexity of the information that the farmer needs to provide. The recommendations should therefore be considered an interim step until data collection systems, such as the electronic Medicines Hub for Cattle and Sheep, develop full access to movement records. Once this happens, it will then be possible to improve the overall accuracy of the metrics.

There is always a balance between improving accuracy and having a metric that as many people as possible can work with. Given the wide variety of beef production systems, it is not possible to create a “perfect” metric. The aim is therefore to create one that provides a sensible balance between accuracy and pragmatism and works for the majority of farms. The metrics presented here rely on assumptions (such as standardised liveweights on farm) which may not reflect the actual situation on each farm. However, this is necessary because, while some farms may be able to easily provide this information, not all beef farms weigh their cattle or, if they do, record this information in a way that can be easily shared. The values created by such metrics should therefore be considered “technical units” rather than true values and need to be interpreted carefully by the farm’s veterinary surgeon on a case by case basis, considering specific factors on each farm.

CHAWG AMU recommend a 12-month recording period is used for benchmarking, based on a calendar year.

3. Core Metric

3.1. Core Metric – mg/ $kg^{beef\ farm}$ for both total use and use of HP-CIA's

These are calculated as follows:

a) mg = the total weight of antibiotic active ingredient used:

Every antibiotic product contains a known amount of active ingredient. This is part of its registration with the Veterinary Medicines Directorate (VMD) and is centrally recorded[5]. By measuring the number of units used on a farm in each recording period (for example in packs, grams (g) or millilitres (ml)) it is then possible to calculate the weight of active ingredient in milligrams (mg), see example below:

Antibiotic product	Amount used (A)	Concentration mg/unit (C)	Total antibiotic used in mg (A x C)
Duphapen 300mg/ml	600 ml	300 mg/ml	180000
Alamycin 100mg/ml	1000 ml	100 mg/ml	100000
Trimacare Bolus	42 boluses	1200 mg/bolus	50400
Terramycin Powder	250 g	200 mg/g	50000
Nuflor 300mg/ml	200 ml	300 mg/ml	60000
Total amount of antibiotic used (mg)			440400

The amount of antibiotic used can be collected from details of the antibiotics supplied/ prescribed to a farm (e.g. veterinary practice records) and/or records of actual use, for example from a farm medicine record book.

When calculating the weight of active ingredient used, the recommendation is to follow the methodology set out by ESVAC, which currently includes all antibiotics except topical antibiotics such as eye drops and sprays[6].

To help interested parties carry out these calculations, a master spreadsheet will be made available for each antibiotic licensed for cattle (linked to the Veterinary Medicine number) which will contain the amount of active ingredient in mg per item, g or ml (calculated using ESVAC principles).

b) $kg^{beef\ farm}$ = the average live-weight of animal population on the farm (in kg):

It is important that the weight of antibiotic used (in mg) is interpreted relative to the average live-weight of animal population on the farm (in kg) to create a mg/kg metric. This needs to take into account the number and live-weight of animals on the farm as well as the time that each animal spends on the farm over the recording period.

In this case $kg^{beef\ farm}$ relates to the live-weight of animals on the farm. This is different to the PCU methodology for beef farms used for national reporting, which uses standard weights that represent the "average weight at time of treatment". Live-weight was chosen in this case, as the average weight at treatment for the different beef age categories and system types was unknown.

3.11. Information provided by the farmer:

To calculate the $kg^{beef\ farm}$, the following information needs to be provided by the farmer, relating to a 12 month recording period. Not all questions need to be answered, depending on the farm enterprise(s) included within the farm:

- Suckler Herd:

  - In the recording period, how many cows and heifers did you put to the bull*? __
    *Please also include the number of any purchased in-calf heifers

  - In the recording period, how many home-bred beef cattle were sold for further feeding or breeding (not for slaughter)?

Age when leaving farm (not for slaughter)	Number
<1 yr	___
1-1.5 yrs	___
>1.5 years	___

  - In the recording period, how many home-bred beef cattle were sold for slaughter?

Age when leaving farm (for slaughter)	Number
<1 yr	___
1-1.5 yrs	___
>1.5 years	___

  - Of the calves born in the recording period, how many do you expect to be retained for breeding? __

    Note: cattle retained for feeding will be counted in the year they are sold from the farm

- Calf Rearing:

  - In the recording period, how many dairy-origin calves* (born on farm or purchased to rear on milk) were sold for further feeding or breeding (not for slaughter)?

Age when leaving farm (not for slaughter)	Number
<1 yr	___
1-1.5 yrs	___
>1.5 years	___

* Dairy or beef sired calves from the dairy herd reared for beef production

  - In the recording period, how many dairy-origin calves* (born on farm or purchased to rear on milk) were sold for slaughter? __

Age when leaving farm (for slaughter)	Number
<1 yr	___
1-1.5 yrs	___
>1.5 years	___

* Dairy or beef sired calves from the dairy herd reared for beef production

Note: cattle retained for feeding will be counted in the year they are sold from the farm

- Growing and finishing (of purchased weaned cattle):

  - Please provide the number of bought-in growing/ finishing cattle that were sold in the recording period for further feeding or breeding (not for slaughter) and their age at purchase/ arrival on the farm?

Age when leaving farm (not for slaughter)	Number (a)	Age at purchase/ arrival on farm (For those animals identified in (a))	Number (These numbers should add up to match the number provided in (a))
<1 year	___	(< 1 year)	(same as (a))
1-1.5 years	___	< 1 year 1-1.5 years	___ ___
>1.5 years	___	<1 year 1-1.5 years >1.5 years	___ ___ ___

- Please provide the number of bought-in growing/ finishing cattle that were sold in the recording period for slaughter and their age at purchase/ arrival on the farm?

Age when leaving farm (for slaughter)	Number (b)	Age at purchase/ arrival on farm (For those animals identified in (b))	Number (These numbers should add up to match the number provided in (b))
<1 year	___	(< 1 year)	(same as (b))
1-1.5 years	___	<1 year 1-1.5 years	___ ___
>1.5 years	___	<1 year 1-1.5 years >1.5 years	___ ___ ___

Note: cattle retained for feeding will be counted in the year they are sold from the farm

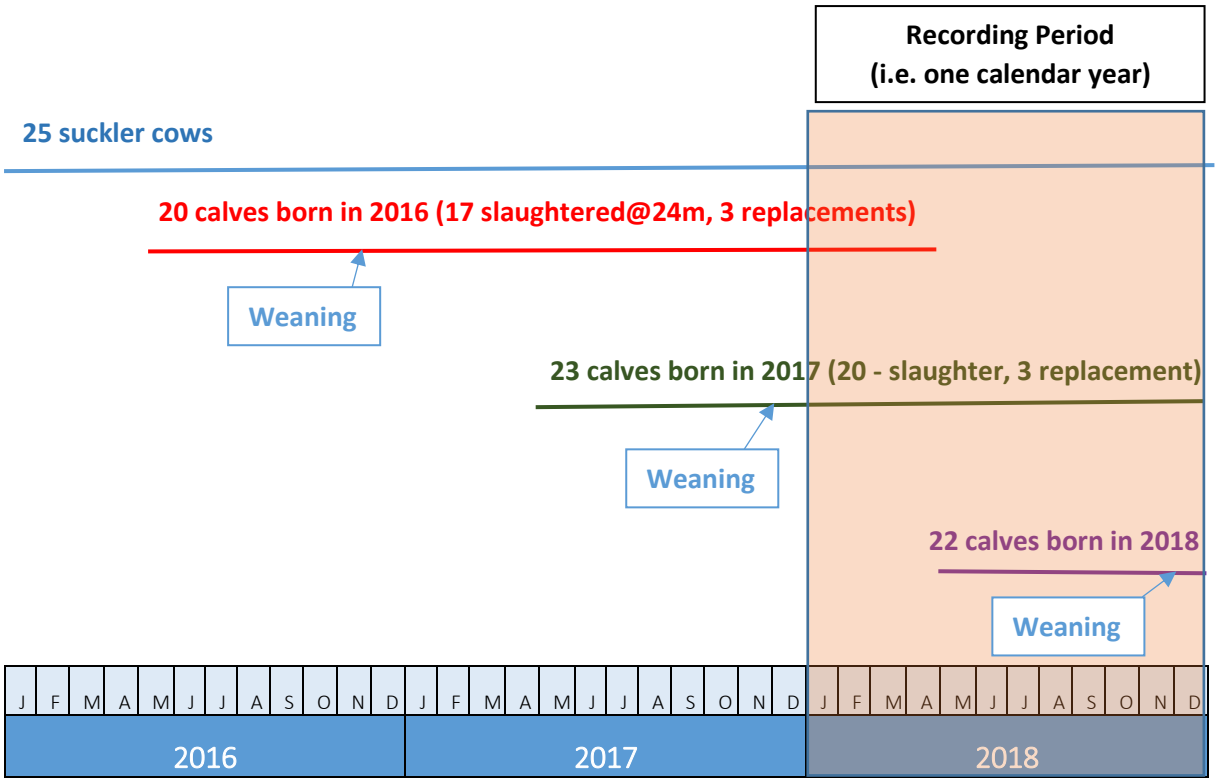
3.1.2. Calculation of mg/kg$^{beef\ farm}$:

Based on the information provided, an estimate of the average live-weight of animals on the farm can be calculated, using standardised live-weights:

- For cows put to the bull in the suckler herd, a live-weight of 762kg will be applied. This weight represents the liveweight of the Suckler cows, but also takes into account the live-weight of the pre-weaned dairy calves (0-7 months of age) and mature bulls on the farm (on the assumption that 88 calves are weaned per 100 suckler cows put to the bull and 4 stock bulls are run per 100 suckler cows put to the bull). For further details on how this live-weight has been derived, please see Appendix One

- For other cattle, the numbers provided are multiplied by a standard live-weight, which takes into account the assumed average live-weight within the category and time on the farm (using national averages, as described in Appendix One)

If we use an example of spring calving suckler herd that put 25 cows to the bull in 2018 and had 20 calves born in 2016, 23 calves born in 2017 and 22 calves born in 2018. Every year, 3 calves were kept as replacements (put to the bull at 19 months) and the rest were sent for slaughter (at 24 months). This can be mapped out as follows:



In this case the farmer completes the "Suckler Herd" part of the metric and records as follows:

- In the recording period, how many cows and heifers did you put to the bull*? 25
  *Please also include the number of any purchased in-calf heifers

- In the recording period, how many home-bred beef cattle were sold for slaughter?

Age when leaving farm (for slaughter)	Number
<1 yr	___
1-1.5 yrs	___
>1.5 years	17

- Of the calves born in the recording period, how many do you expect to be retained for breeding? 3

The kg^{beef} figure is then calculated by multiplying these numbers with the standardised live-weights (included in Appendix One) as below (note orange refers to the information that the farmer provides, whereas the rest relates to the underlying calculation):

	Number (N)	Standard average live-weight assigned per animal in kg	Average farm live-weight in kg (N x AL)
Cows and heifers put to the bull	25	762	19050
Home-bred cattle sold for slaughter >1.5 years	17	655	11135
Home-bred cattle retained for breeding	3	367	1101
Total average farm live-weight – $kg^{beef\ farm}$			31286

If we assume the antibiotic usage data is as described in section 4a then we get the following:

$$mg/kg^{beef\ farm} = \frac{440400mg}{31286kg} = 14.1$$

For further examples, please see Appendix Two.

How do you account for the live-weight of animals that do not leave the farm, e.g. those retained for feeding?

This is an important question, as $kg^{beef\ farm}$ represents the average liveweight of all animals on the farm during the recording period, not just those which leave the farm. For this reason, the standard average live-weights assigned to each animal leaving the farm are adjusted to help take into consideration the live-weight of the animals that remain on the farm.

For example, if we look we look at "home-bred suckler beef cattle leaving the farm for slaughter >18months" from the earlier example:

- Based on national averages, it is assumed that calves are weaned at 7 months (at a live-weight of 274kg), reared conventionally (as otherwise they would not be slaughtered at >18months) and slaughtered at 24 months of age (at a liveweight of 650kg). The average live-weight during the animal's lifetime is therefore assumed to be 462kg
- The cattle that left the farm for slaughter in 2018 (which were born and weaned in 2016) were on the farm for 17 months in total, but only for 4 months during the recording period before leaving. However, other weaned beef cattle remained on the farm and didn't leave in 2018, i.e.
    - The batch born in 2017 were on the farm as weaned beef cattle in 2018 for 12 months
    - The batch born in 2018 were on the farm as weaned beef cattle in 2018 for 1 month

- To help take this into consideration, the live-weight assigned per animal leaving is adjusted according to the *overall* time that they spent on the farm (not just how long they were on the farm during the recording period). For example:

    - The cattle that left the farm for slaughter in 2018 (which were born in 2016) were on the farm as weaned cattle for a total of 17 months
    - As described earlier, the average live-weight during these animals' lifetime is assumed to be 462kg
    - However, in this case, the average live-weight assigned per animal (462kg) is adjusted by multiplying this weight with the total number of years on farm (i.e. 17/12) to get 655kg
    - The number of cattle in this category that left for slaughter is then multiplied by 655kg to get an estimate of the average farm live-weight for this category of animals
    - This "additional weight" assigned per animal slaughtered therefore helps to take into account the weight of animals within this category that remain on the farm, although this is under the assumption that the farm follows a similar pattern (in terms of farming systems and numbers) year on year

For a full explanation of how the standard average live-weights are calculated, please see Appendix One.

Why has a weight-based metric been chosen?

CHAWG AMU consider that metrics which assess the weight of active ingredient are valuable as:

- They are used for national monitoring and for benchmarking in other sectors, including pigs and dairy
- They can be calculated using both supply/prescription data (e.g. from veterinary practice records) and farm-derived data
- There is often good correlation with dose-based metrics. For example, in a study looking at a convenience sample of 207 commercial sheep only farms in England, Wales and Scotland from 8 veterinary practices, an 84% correlation between a mg/kg-based metric and daily dose metric was found[7]

However, CHAWG AMU accept that disadvantages include:

- The amount of active ingredient per course can be lower for some antibiotics than others. This is particularly the case for HP-CIAs such as fluoroquinolones, colistin and 3rd and 4th generation cephalosporins. This has led to a concern that a mg/kg-based metric may drive farmers towards using these antibiotics. However, in the beef sector the use of HP-CIAs is relatively low (1% active ingredient administered in a 2018 sample[8]) and, to avoid driving inappropriate behaviour, it is recommended that a $mg/kg^{beef\ farm}$ for HP-CIA's is calculated and monitored separately alongside a total figure
- Some non-HP-CIA products (e.g. trimethoprim-sulphonamides, which have two active ingredients) can have a higher amount of active ingredient than others, but may be the responsible choice in a particular case
- Weight-based metrics don't always reflect the number of animals treated. For example, the weight of antibiotic given to a calf will usually be less than the weight given to an adult cow. However, when considering risk of selection or transmission of Antimicrobial Resistance (AMR), it is unknown if the mass of antibiotics used or the number of animals treated is more important

4) Additional Metrics

Because of the limitations of weight-based metrics, where more detailed farm level data is available CHAWG AMU also recommend that animal based metrics are considered as these have a number of additional advantages as follows:

- Each animal is treated the same (e.g. calves and adults) so animal-based metrics more accurately reflect the number of animals exposed
- There is no need to apply standardised animal weights
- They can be more easily be applied to non-antibiotics e.g. Non-Steroidal Anti-Inflammatory Drugs
- The figure may be more tangible and easier for the vet and farmer to understand and monitor progress

In particular, CHAWG AMU consider the following animal-based metrics to be of value:

4.1. Percentage of animals treated

4.1.1. Information provided by the farmer:

For this metric, the farmer needs to record the number of animals treated with an antibiotic over the 12 month recording period. This could be provided directly by the farmer or calculated using, for example, an electronic farm medicines book. Treated animals refer to any animal that has received one or more doses of antibiotic at any point in the recording period. There is no distinction made between an animal that has received one treatment dose and one that has received multiple treatment doses.

The farmer also needs to record the total number of animals on the farm, which is calculated as follows:

- All cattle born on the farm during the recording period
- All cattle bought on to the farm during the recording period
- All cattle already on the farm at the start of the recording period

Cattle that die on farm should not be excluded and it should be noted that (unlike the $mg/kg^{beef\ farm}$ figure) how long each animal spends on the farm is not taken into account.

4.1.2. Calculation of % animals treated:

The number of treated animals during the recording period is then compared with the number of animals on the farm at any point during the year.

$$\%\ animals\ treated = \frac{\text{number of animals treated with antibiotics}}{\text{total number of animals which have been on the farm}}$$

If we consider the same example included earlier, the following would be calculated:

	Total number of animals on the farm (N)	Number treated (T)	% animals treated T/N x 100
Suckler cows	25	2	8%
Suckler calves born in 2016	20	3	15%
Suckler calves born in 2017	23	2	9%
Suckler calves born in 2018	22	4	18%
Bull	1	0	0%
TOTALS	91	11	12%

Therefore, in this case:

$$\%\ animals\ treated = \frac{11}{91} * 100 = 12$$

This means that 12% of the animals on the farm have been treated with an antibiotic in the recording period (2018).

4.2) Treatment days per animal

4.2.1. Information provided by the farmer:

This calculation requires farmers to record the total number of days that animals have received an antibiotic over the 12 month recording period. If an animal is treated with a long-acting antibiotic, then the number of days treatment will need to be multiplied by the length of activity for that product. A duration factor of 3 could be used as a rough estimate, although product specific information on duration of action could be incorporated into an electronic farm medicine book and this would increase the accuracy of the result obtained. The farmer also needs to record the total number of animals on the farm, as described in 4.1.1.

4.2.2. Calculation of treatment days per animal:

The total number of days treated with antibiotics is then compared with the total number of animals on the farm during the recording period, to create a figure that represents the average number of days that each animal has received a day of antibiotic treatment:

$$\text{Treatment days per animal} = \frac{\text{number of days animals were treated with antibiotics}}{\text{total number of animals which have been on the farm}}$$

If we consider the example farm discussed, the following would be calculated:

	Number on the farm (N)	Number of treatment days (T)	Treatment days per animal T/N
Suckler cows	25	6	0.2
Suckler calves born in 2016	20	6	0.3
Suckler calves born in 2017	23	4	0.2
Suckler calves born in 2018	22	12	0.5
Bull	1	0	0.0
TOTALS	91	28	0.3

Therefore, in this case:

$$Treatment\ days\ per\ animal = \frac{28}{91} = 0.3$$

This means that, on average, each animal received 0.3 days of antibiotic treatment.

5) Questions and answers

What about beef farms that also rear other livestock, particularly sheep?

CHAWG AMU recognizes that many beef farms also rear other livestock, particularly sheep. Where possible, it is advisable that farmers and veterinary practices separate beef and sheep usage, for example by having different sub-accounts. If this is not done, antibiotic usage on these farms may appear high when compared with beef farms that do not rear sheep. The Sheep Health & Welfare Antibiotics Working Group have produced metrics for benchmarking antibiotic use on sheep farms, and these can be found here - http://beefandlamb.ahdb.org.uk/returns/health-and-welfare/sheep-health-and-welfare-group-shawg/.

Why are topical products excluded?

Topical products (such as antibiotic sprays and eye drops) account for a small proportion of antibiotic active ingredient used in beef farms and removing them is in line with ESVAC methodology.

Are products used topically under the cascade (e.g. products licensed for oral use in another species but used topically within an antibiotic footbath) included in any of the analyses?

Yes, the amount of active ingredient in oral and injectable products used under the cascade will be captured in the all calculations.

Why do we need to measure total use and HP-CIA use?

Because of the risks of cross-resistance and co-resistance (i.e. the use of one antibiotic class can induce resistance to another antibiotic class), reducing overall use of antibiotics is important to minimise the risk of the development of AMR.

However, there is particular scrutiny on reducing antibiotics that are considered highest priority for human medicine (as defined by the European Medicines Agency[1]), so categorised if they are used as a last resort antibiotic for serious infections in people and the risk of resistance transfer is considered high.

Why is it recommended to have a 12-month (rather than a 3- or 6-month) benchmarking period?

A 12-month period (either based on calendar year or rolling year to date figure) is recommended as it takes into account seasonal fluctuations, for example due to climate as well as management systems (e.g. for spring and autumn calving herds).

References

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3 – Dairy benchmarking report - http://beefandlamb.ahdb.org.uk/returns/health-and-welfare/cattle-health-and-welfare-group-chawg/

4 - Understanding the mg/PCU calculation used for antibiotic monitoring in food producing animals, https://www.gov.uk/government/publications/understanding-the-mgpcu-calculation-used-for-antibiotic-monitoring-in-food-producing-animals

5 – VMD product list - https://www.vmd.defra.gov.uk/ProductInformationDatabase/

6 – European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) - https://www.ema.europa.eu/en/veterinary-regulatory/overview/antimicrobial-resistance/european-surveillance-veterinary-antimicrobial-consumption-esvac

7 – Davies, Peers and Remnant, John G. and Green, Martin J. and Gascoigne, Emily and Gibbon, Nick and Hyde, Robert and Porteous, Jack R. and Schubert, Kiera and Lovatt, Fiona and Corbishley, Alexander (2017) *Quantitative analysis of antibiotic usage in British sheep flocks.* Veterinary Record. ISSN 2042-7670, http://eprints.nottingham.ac.uk/47659/

8 – UK-VARSS Report 2018 - https://www.gov.uk/government/publications/veterinary-antimicrobial-resistance-and-sales-surveillance-2018

Appendix One – Assumptions used for standard average live-weights in the mg/kg$^{beef\ farm}$ metric

The following assumptions are use when calculating the average category live-weight in kg:

- *Suckler cows:*

  The average live-weight assigned to suckler cows has been adjusted to include the live-weight of the calves at foot and stock bulls running with the herd. It is assumed that:

  - 88 calves are weaned per 100 suckler cows put to the bull
  - 4 stock bulls are run per 100 suckler cows put to the bull

Cattle group	Days in category	Average live-weight (kg)	Number in herd per cow	Pro-rated live-weight in kg
Cows put to the bull	365	650		650
Pre-weaned calves (0-7 months of age)	210	157	0.88	79
Mature bulls	365	813	0.04	33
Standard average live-weight assigned per animal in kg				762

The standard average live-weight assigned per suckler cow is therefore 762 kg. It is assumed that suckler cows are present throughout the year on the farm.

- *Other cattle:*

  When calculating the standard average live-weight (in kg) assigned to each animal category leaving the farm, assumptions are made in line with the following slaughter ages and live-weights at slaughter (based on national averages):

	Slaughter age category (assigned name)	Assumed slaughter age (months)	Assumed live-weight at slaughter (kg)
Home bred suckler beef cattle	Under 1 year (rare but may occur) (a)	12	560
	1 – 1.5 years (b)	16	640
	Over 1.5 years (c)	24	650
Dairy origin calves born on farm or purchased on milk	Under 1 year (veal production) (d)	7.5	250
	1 – 1.5 years (e)	16	580
	Over 1.5 years (f)	24	640
Grower and finisher	Under 1 year (same as d)	7.5	250
	1-1.5 years (average of b and e)	16	610
	Over 1.5 years (average of c and f)	24	645

For grower and finishers, the standard live-weights used represents an average between the assumed slaughter ages and live-weights for suckler bred beef cattle and dairy origin calves, except for those slaughtered under 1 year - when it is assumed this relates to dairy origin cattle (which are the most likely cattle type in this slaughter age category)

The following tables show the full list of average live-weights assigned per animal category, which used to calculate the average total average live-weight of animal population on the farm ($kg^{beef\ farm}$):

- Suckler Herd:

	Assumed age and live-weight at beginning of category	Assumed age and live-weight at sale	Estimated months in category (T)	Average category live-weight in kg (L)	Standard average live-weight assigned per animal in kg (AL = T/12 x L)
Cows and heifers put to the bull	N/A	N/A	12	762	762
Category	Home-bred beef cattle sold for further feeding or breeding (not for slaughter)				
Sold at <1 year	7 months 274kg	7 months 274kg	0	274	0
Sold between 1-1.5 years	7 months 274kg	15 months 525kg	8	400	266
Sold at >1.5 years	7 months 274kg	20 months 562kg	13	418	453
Category	Home-bred beef cattle sold for slaughter				
Sold at <1 year	7 months 274kg	12 months 560kg	5	417	174
Sold at 1-1.5 years	7 months 274kg	16 months 640kg	9	457	343
Sold at >1.5 years	7 months 274kg	24 months 650kg	17	462	655
Home bred beef cattle (<1yr at end of reporting period) retained for breeding	7 months 274kg	19 months 460kg	12	367	367

- Calf Rearing:

	Assumed age and live-weight at beginning of category	Assumed age and live-weight at sale	Estimated months in category (T)	Average category live-weight in kg (L)	Standard average live-weight assigned per animal in kg (AL = T/12 x L)
Category	Dairy origin calves (born on farm or purchased to rear on milk) sold for further feeding or breeding (not for slaughter)				
Sold at <1 year	0 months 40kg	4 months 130kg	4	85	28
Sold at 1-1.5years	0 months 40kg	15 months 477kg	15	258	323
Sold at >1.5 years	0 months 40kg	20 months 538kg	20	289	482
Category	Dairy origin calves (born on farm or purchased to rear on milk) sold for slaughter				
Sold at <1 year	0 months 40 kg	7.5 months 250kg	7.5	145	91
Sold at 1-1.5 years	0 months 40kg	16 months 580kg	16	310	413
Sold at > 1.5 years	0 months 40kg	24 months 640kg	24	340	680

- Growing and Finishing (1- Sold for further feeding or breeding):

		Assumed age and live-weight at beginning of category	Assumed age and live-weight at sale	Estimated months in category (T)	Average category live-weight in kg (L)	Standard average live-weight assigned per animal in kg (AL = T/12 x L)
Category		Bought-in growing/ finishing cattle sold for further feeding or breeding (not for slaughter)				
Entered at <1 year	Sold at <1 year	7 months 249kg	11 months 375kg	4	312	104
	Sold at 1-1.5 years	7 months 249kg	15 months 501kg	8	375	250
	Sold at >1.5 years	7 months 240kg	20 months 550kg	13	395	428
Entered at 1-1.5 years	Sold at 1-1.5 years	13 months 383kg	17 months 478kg	4	431	144
	Sold at >1.5 years	15 months 431kg	20 months 550kg	5	490	204
Entered at >1.5 years	Sold at >1.5 years	20 months 550kg	23 months 621kg	3	585	146

- Growing and Finishing (2- Sold for slaughter):

		Assumed age and live-weight at beginning of category	Assumed age and live-weight at sale	Estimated months in category (T)	Average category live-weight in kg (L)	Standard average live-weight assigned per animal in kg (AL = T/12 x L)
Category		Bought-in growing/ finishing cattle sold for slaughter				
Entered at <1 year	Sold at <1 year	4 months 130kg	7.5 months 250kg	3.5	190	48
	Sold at 1-1.5 years	7 months 258kg	16 months 610kg	9	434	326
	Sold at >1.5 years	7 months 240kg	24 months 645kg	17	443	627
Entered at 1-1.5 years	Sold at 1-1.5 years	12 months 454kg	16 months 610kg	4	532	177
	Sold at >1.5 years	15 431kg	24 645kg	9	538	403
Entered at >1.5 years	Sold at >1.5 years	20 months 550kg	24 months 645kg	4	597	199

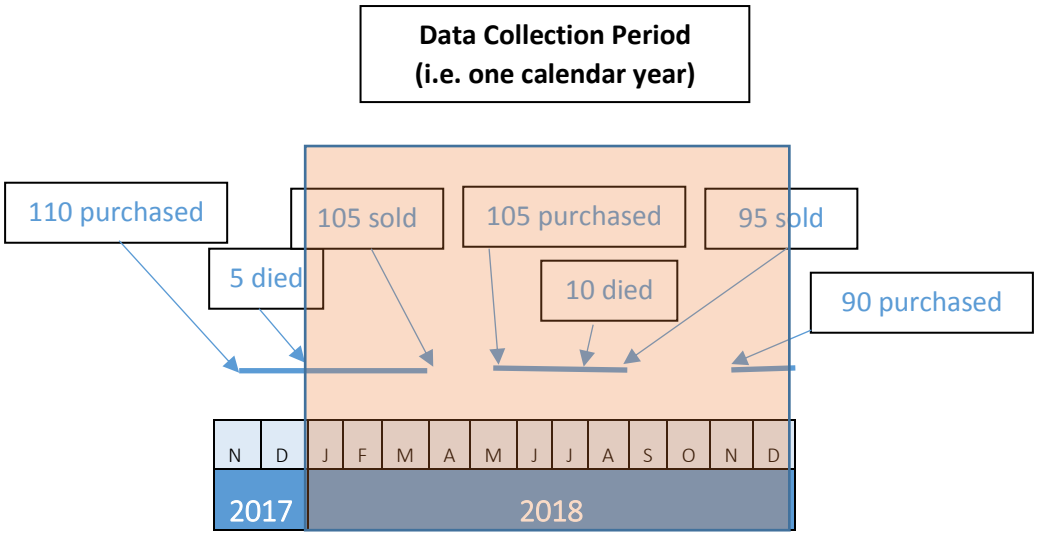
Appendix Two – Further case examples for the mg/kg$^{beef\ farm}$ core metric

Calf Rearer Case Study:

A calf rearing enterprise uses 250,000mg antibiotics in 2018

The calf rearer buys in pre-weaned dairy cattle at 2 weeks of age as follows:

- **Batch One** – 110 pre-weaned dairy calves purchased mid-November 2017, 5 animals died at 2 months of age and 105 were sold at the end of March at 5 months of age
- **Batch Two** – 105 pre-weaned dairy calves purchased mid-May, 10 died at 3 months of age and 95 were sold at the end of August at 4 months of age
- **Batch Three** – 90 pre-weaned dairy calves purchased in mid-November, due to be sold in 2019



The farmer records the numbers sold in the "Calf Rearing" section i.e. 105 in batch one and 95 in batch two – therefore 200 in total:

- In the recording period, how many dairy-origin calves* (born on farm or purchased to rear on milk) were sold for further feeding or breeding (not for slaughter)?

Age when leaving farm (not for slaughter)	Number
<1 year	200
1-1.5 years	___
>1.5 years	___

* Dairy or beef sired calves from the dairy herd for beef production

These animals are then assigned a standard adjusted live-weight in kg:

	Number (N)	Standard average live-weight assigned per animal in kg	Average farm live-weight in kg (N x AL)
Dairy origin calves (born on farm or purchased to rear on milk) sold for further breeding or feeding (not for slaughter) at < 1yr	200	28	5600
Total average farm live-weight in kg – $kg^{beef\ farm}$			5600

In this example, there is only one animal category and the total average live-weight of animal population on the farm ($kg^{beef\ farm}$) = 5600kg. Therefore:

$$mg/kg^{beef\ farm} = \frac{250000mg}{5600kg} = 44.6$$

Mixed Enterprise Case Study

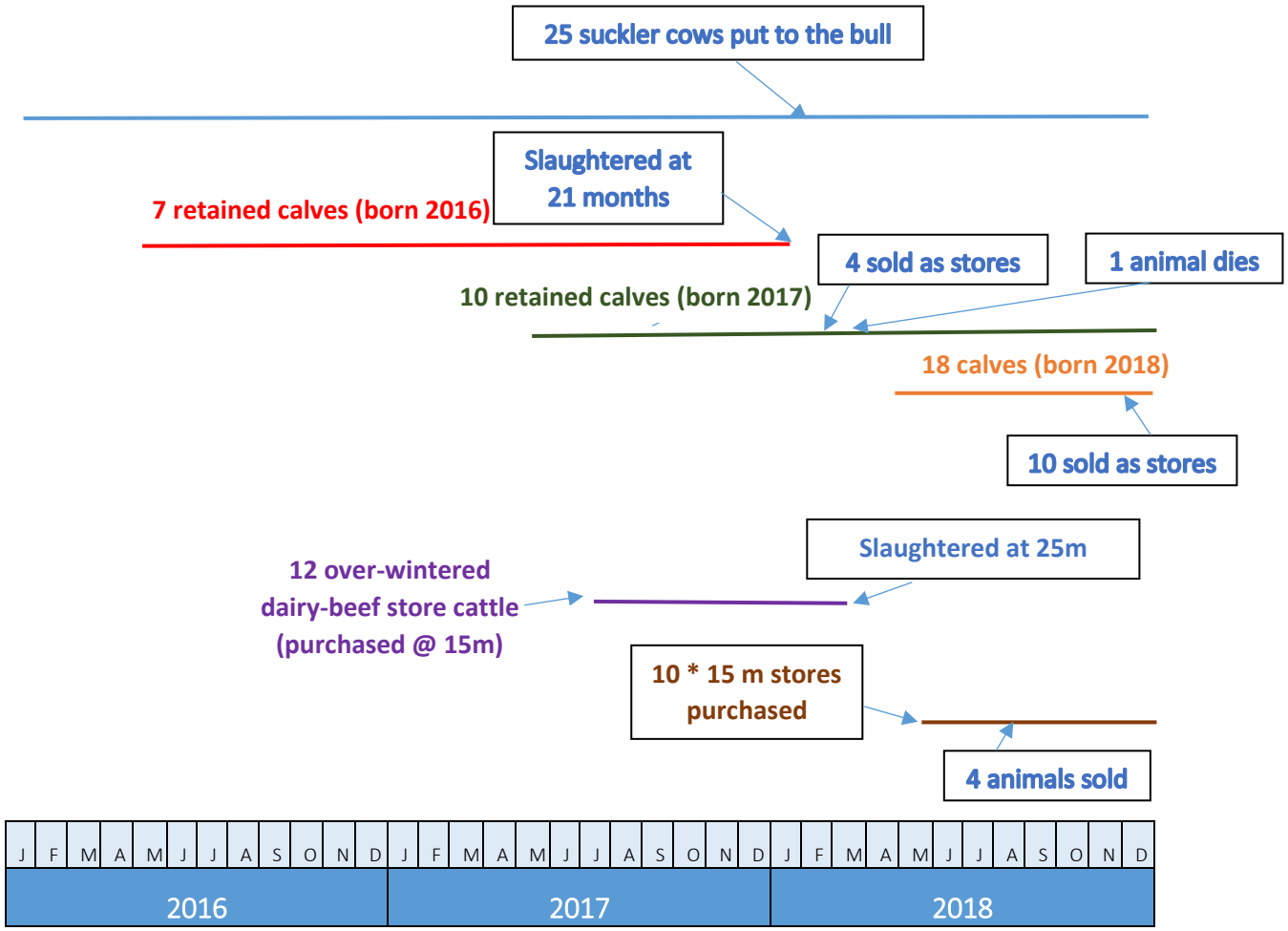
This case study has been included to illustrate an enterprise that has Suckler cows and is also a grower-finisher, with animals being purchased and sold at different times and ages. This is in order to demonstrate the complexity involved in applying these metrics to such an enterprise:

In the recording period (2018), a mixed enterprise farm used 140125mg of antibiotic active ingredient.

- The farm started the year with 25 spring calving suckler cows and put 25 suckler cows to the bull in 2018
- In 2018:
    - 7 calves (which had been retained since they were born on the farm in 2016) were sent to slaughter in January at 21 months of age
    - Of the 10 calves (which have been retained since they were born on the farm in 2017), 4 were sold as stores in January (at 9 months of age) and the remaining 6 were kept (and reared in a conventional manner). Unfortunately, one dies from pneumonia in March
    - 18 calves were weaned in November. 10 of these were sold immediately after weaning and the remaining 8 were kept for finishing
    - The farm had 12 overwintered dairy–beef stores (purchased at around 15 months of age in May last year). These went for slaughter in March at 25 months of age

- The farm had great grass in May and purchased 10 stores in May but not sure if they were suckler derived or dairy-beef cross or what age they were – probably 15 months. Then the drought came and 4 of them were sold in August at 18 months of age as stores, but the rest were kept

This can be mapped this out in the following way:



In this example, it is necessary to complete both the Suckler and the Grower/ Finisher sections as follows:

- Suckler Herd:

  - In the recording period, how many cows and heifers did you put to the bull*? 25
    *Please also include the number of any purchased in-calf heifers

  - In the recording period, how many home-bred beef cattle were sold for further feeding or breeding (not for slaughter)?

Age when leaving farm (not for slaughter)	Number
<1 year	14
1-1.5 years	___
>1.5 years	___

  - In the recording period, how many home-bred beef cattle were sold for slaughter?

Age when leaving farm (for slaughter)	Number
<1 year	___
1-1.5 years	___
>1.5 years	7

- Growing and finishing (of purchased weaned cattle):

  - Please provide the number of bought-in growing/ finishing cattle that were sold in the recording period for further feeding or breeding (not for slaughter) and their age at purchase/ arrival on the farm?

Age when leaving farm (not for slaughter)	Number (a)	Age at purchase/ arrival on farm (For those animals identified in (a))	Number (These numbers should add up to match the number provided in (a))
<1year	___	(<1 year)	(same as (a))
1-1.5years	4	<1 year 1-1.5 years	___ 4
>1.5 years	----	<1 year 1-1.5 years >1.5 years	___ ___ ___

- Please provide the number of bought-in growing/ finishing cattle that were sold in the recording period for slaughter and their age at purchase/ arrival on the farm?

Age when leaving farm (not for slaughter)	Number (b)	Age at purchase/ arrival on farm (For those animals identified in (b))	Number (These numbers should add up to match the number provided in (b))
<1year	___	(<1 year)	(same as (b))
1-1.5years	___	<1 year 1-1.5 years	___ ___
>1.5 years	12	<1 year 1-1.5 years >1.5 years	___ 12 ___

The $kg^{beef\ farm}$ is then calculated as follows:

Suckler Part:

	Number (N)	Standard average live-weight assigned per animal in kg (AL)	Average farm live-weight in kg (N x AL)
In the last year, how many cows and heifers did you put to the bull?	25	762	19050
In the last year, how many home-bred beef cattle were sold for further feeding or breeding (not for slaughter)?			
Average age at sale:			
< 1 year	14	0	0
In the last year, how many home-bred beef cattle were sold for slaughter?			
Average age at sale:			
> 1.5 years	7	655	4585
Total average farm live-weight for category in kg			23635

Grower and finisher part:

Average age when entering the farm	Average age when leaving the farm	Number (N)	Standard average live-weight assigned per animal in kg (AL)	Average farm live-weight in kg (N x AL)
In the last year, how many brought-in growing/ finishing cattle were sold for further feeding or breeding (not for slaughter)?				
Age when entering the farm	Age when leaving the farm			
1 – 1.5 years	1-1.5 years	4	144	576
In the last year, how many brought-in growing/ finishing cattle were sold for slaughter?				
Age when entering the farm	Age when leaving the farm			
1-1.5 years	>1.5 years	12	403	4836
Total average farm live-weight for category in kg				5412

In this example, the total average live-weight of animal population on the farm ($kg^{beef\ farm}$) = (23635kg + 5412kg) = 29047kg. Therefore:

$mg/kg^{beef\ farm} = \frac{140125mg}{29047kg} = 4.8$