Animal & Plant Health Agency

Report on the epidemiological investigation of a single BSE case in Somerset, England

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

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Executive summary

On 17 September 2021, the UK Chief Veterinary Officer (CVO) confirmed a case of classical bovine spongiform encephalopathy (BSE) in Somerset, England. This was the first case of classical BSE to be confirmed in the UK since 2018, and in England and Wales since 2015.

This report summarises the epidemiological investigations that have been carried out in order to describe and understand this single case of BSE.

The index case was a homebred dairy cow born in February 2015. She had calved 4 times in her natal herd. Clinical signs were first noted on 1 September 2021. Milk fever (hypocalcaemia) was suspected, but she was unresponsive to treatment and was euthanised on farm the following day.

As a result of her age, and because she was fallen stock, the carcase was tested for BSE as per the UK's statutory BSE surveillance procedures. An initial positive result was received on 8 September 2021. A final positive result was confirmed on 17 September 2021. The UK CVO confirmed a case of classical BSE in this animal, on the same day.

Her first 2 offspring (twins) were slaughtered for human consumption at approximately 30 months of age, and consequently were not tested for Transmissible Spongiform Encephalopathy (TSE), at the date of writing this report, the third calf is still in the natal dairy herd.

The youngest 2 offspring were sold as calves to another Somerset herd. TSE[1] legislation requires the culling and testing of the progeny born within a period of 2 years prior to, or after the clinical onset of the disease. Therefore, only the latter 2 offspring were placed under official restrictions and have been culled, sampled, and tested for BSE, both with negative result.

[1] Annex VII Chapter B paragraphs 1(a) first indent and 2.1 of retained Regulation (EC) No 999/2001 of the European Parliament and of the Council of 22 May 2001 laying down rules for the prevention, control and eradication of certain transmissible spongiform encephalopathies (as amended). This Regulation has been retained in UK domestic legislation as it was on 31 December 2020, following the exit of the UK from the EU. This is also a requirement in The Transmissible Spongiform Encephalopathies (England) 2018 (S.I. 2018/731)

Investigations also identified a total of 68 cohort animals that were still alive and that were born or reared with the index case during the relevant risk period of 12 months either side of the date of birth of this case. All these cohort animals were placed under official restrictions and have been culled, sampled, and tested for BSE, all with negative results.

The affected farm had previous confirmed BSE cases, all of which were born before the reinforced feed ban. From the information on historic farm management practices gathered at interview with the owner of the farm it seems likely that these cases were fed feed stored on-farm in silos.

One of the silos has been in continuous use since the early 1980s to store purchased cattle feed and was used to store cattle rearing pellets at the time of birth and rearing of this case.

A number of potential source risk pathways have been identified and thoroughly investigated. The most likely source is assessed to be residual material remaining in this silo, contaminating the cattle rearer ration that was fed to the index case during the first year of its life.

This has been assessed as a very low likelihood event, with medium uncertainty. This silo has been decommissioned and the farmer will dispose of it once APHA has sampled it for future testing.

There is no evidence that any TSE regulations have been breached in this case, and there is every reason to believe that current mitigations will contain any further potential exposure to cattle. Controls in place have negated any risk to the human food chain.

Introduction

On 17 September 2021, the UK CVO confirmed a case of classical bovine spongiform encephalopathy (BSE) in Somerset, England. This was the first case of classical BSE to be confirmed in the UK since 2018, and in England and Wales since 2015.

This report summarises the epidemiological investigations that have been carried out in order to describe and understand this single case of BSE.

Background

The index case was a homebred dairy cow born in 2015 in a herd located in Somerset, England.

She remained at her farm of origin for the whole of her life until her death in September 2021, and calved 4 times in that period.

Clinical signs indicative of metabolic disease was first noted on the day prior to its death. Milk fever (hypocalcaemia) was suspected, and calcium was administered. There was no response to treatment, and she was euthanised on-farm the following day.

As a result of her age, and because she was fallen stock, the carcase was tested for BSE as per as per the UK’s statutory BSE surveillance procedures. The carcase was taken to a local TSE testing site, where it was tested for BSE as fallen stock. The UK CVO confirmed a case of classical BSE in this animal, on 17 September 2021 following statutory tests.

Description of the herd of origin

The farm is in Somerset. The herd is a small-medium mixed dairy and beef unit.

Breeding is principally by artificial insemination (AI) with bulls being used as sweepers, for heifers. The herd calves in autumn. No embryo transfer has been used on this farm. The private veterinary surgeon currently visits the farm every 3 weeks for a routine visit and has always visited at approximately this frequency.

The farm is in a single block, with the farm buildings grouped together centrally; no other land is used except for one contiguous field which has been rented for over twenty years.

The farm management is typical for the area, and traditional in that up until 3 years ago (2018), the herd calved all year round, and all cattle were housed for the winter months between approximately November and April, depending on the weather. By 2018, the farm changed to a mainly autumn block-calving system.

Other than this change, there have not been any other major changes in management style, buildings, or land usage since the 1980s.

The main output from the farm is milk, with the majority sold under contract.

The local area is made up of small villages and livestock farms, with small patches of woodland interspersed. A wildlife park was situated near to the farm but closed permanently in 2009.

No nose-to-nose contact with neighbouring stock is possible now, nor around the time of birth of the index case.

This investigation has not identified any current or former Animal by Products (ABP) plants, abattoirs, or feed mills within 3km of this premises.

Epidemiological investigation of the premises

The epidemiological investigation and analyses have been conducted using the following information sources:

- Farm visits, interviews, with detailed inspection of the premises and of farm records
- British Cattle Movement System (BCMS) data
- Historical BSE data and investigations
- National Feed Audit (NFA) information related to the feed suppliers

The description of the farming practices provided below can be assumed to apply for this particular animal, as well as all other cattle within the relevant time period.

The records kept on-farm (such as, feed, cattle movements and medicine) appeared satisfactory and complete. The recollection and account of the historical farming practices is also consistent with the type of farming system in this area, nevertheless, given the passage of time since the birth of this case, the possibility of some recall bias cannot be ruled out.

Investigations identified a total of 68 cohort animals still alive, that were born or reared with the index case during the relevant risk period of twelve months either side of the date of birth of this case. All these cohort animals were placed under official restrictions and have been culled, sampled, and tested for BSE, all with negative results.

The offspring of the index case are listed in table 1. The first 2 (twins) were slaughtered for human consumption at approximately thirty months of age, and hence were not TSE tested under routine active TSE surveillance. The third calf is currently within the natal dairy herd. The youngest 2 offspring were sold as calves to another Somerset herd.

The youngest 2 offspring met the regulatory definition of ‘offspring’, which refers to the progeny of the index case born within a period of 2 years prior to, or after, the clinical onset of the disease where the disease was confirmed in a female animal. These 2 were placed under official restrictions and have been culled and tested for BSE, with negative results.

Table 1: Details of the offspring.

Age	Breed and sex	Current location	Restricted?	BSE test results
30 months	Beef female	Dead	Not applicable	Not applicable
30 months	Beef female	Dead	Not applicable	Not applicable
35 months	Dairy female	In natal herd	No	Not applicable
23 months	Beef female	Sold to farm in Somerset	Yes, and was euthanised on farm on 30 September 2021	Negative

Age	Breed and sex	Current location	Restricted?	BSE test results
12 months	Beef male	Sold to farm in Somerset	Yes, and was euthanised on farm on 30 September 2021	Negative

Source investigation

Vertical transmission

Dam to offspring

The dam was homebred, born in 2011. She was slaughtered as a healthy cow in an abattoir in April 2018, as result of which she was not eligible for, nor subject to, active BSE surveillance testing.

She had 3 other calves in her lifetime, one died on farm at 2 and a half months old, and the other 2 calves were slaughtered at 27 months old, so none of these would have been eligible for active BSE surveillance testing.

Table 2: Details of the offspring of the dam of the index case.

Year of birth	Comments
2014	Died on farm as a 2 and half months old calf, not BSE tested
2015	BSE positive index case, euthanised on farm on 2 September 2021

Year of birth	Comments
2016	Sold as a 6 week old calf and slaughtered at an abattoir at 27 months old, not BSE tested
2017	Sold as a 4 week old calf and slaughtered at an abattoir at 27 months old, not BSE tested

Sire to offspring

The sire of the index case was an AI bull. He was purchased by an AI company in October 2005 and sent to slaughter in March 2016. He was not eligible for, nor subject to, active BSE surveillance testing.

There is no evidence in the literature for transmission of BSE via semen.

Horizontal transmission

As previously stated, there have been previous confirmed cases of BSE on this farm. However, the last case was 19 years before the birth of the index case and hence horizontal transmission would not have been possible from prior cases.

Since active surveillance was established in 2001, from this holding and excluding the current BSE case, 252 cattle have been TSE tested. Of the 252, 85 were tested as fallen stock, and only the current case proved to be positive.

All the samples were reported as being of good quality, and none were unsuitable, which suggests the farmer was reporting the fallen stock animals on time and following the legal requirements and guidelines.

Feed

In 1988, the cause of BSE was first epidemiologically linked to feed containing meat and bone meal. In that same year, BSE was made notifiable and feed controls were introduced in the UK, prohibiting the consumption of ruminant material by ruminant species.

On the 1 August 1996, mammalian meat and bone meal were banned from all farm animal feed, and this is considered as the date of the effective Reinforced Feed Ban.

The affected farm had BSE cases confirmed, all of which were born between 1980 and 1990, before the reinforced feed ban, and most likely were themselves fed contaminated feed. This was stored on-farm in one of the 2 silos on farm.

One silo was installed 10 years ago, and the other silo was installed in 1981 or 1982 and has never been thoroughly cleaned out, as there is no suitable access to the inside of the silo.

The older silo has been used continuously since the early 1980s to store purchased cattle feed and was always used to store cattle rearing pellets. The index case would therefore have been fed from this silo from weaning age, for approximately 2 years.

Table 3 lists all feed stuffs that the index case received since birth in February 2015.

Table 3: All feed stuffs provided to the index case.

Age in months	Feed type	Supplier	Bulk in Silo	Bag	Purchase frequency	Storage and feeding method
0 to 2	Whole Milk (unpasteurised)	Home produced	None	No	Nil	Moved from parlour to calf pens in buckets
0 to 3	Calf starter Pellets	Devon	None	Yes	Approx. monthly	Delivered and stored in plastic 25 kg feed bags, stored on pallets in storage building and then individual bags taken to calf pens for feeding
0 to 3	Straw (and used for youngstock bedding)	Home produced and various	None	No	Rarely	Mostly home produced straw, stored in buildings. Some straw purchased from East of England

Age in months	Feed type	Supplier	Bulk in Silo	Bag	Purchase frequency	Storage and feeding method
3 to 26	Calf rearer Pellets	Devon	Yes	No	Approx. monthly	Delivered and blown into older silo from the feed lorry via connection pipe. Old 25kg feed bags are then filled up and taken to the troughs in fields and buildings
26 to 78	Dairy cake	Devon	Yes	No	Approx. monthly	Delivered and blown into newer silo from the feed lorry via connection pipe. Pipes from silo connected to feeders in the milking parlour
26(1st Calving) to 78 (Death)	'Liquid Feed' molasses	Devon	None	No	As required	Liquid molasses delivered in bulk containers and fed on top of silage in feed passageways for milking cows only

Age in months	Feed type	Supplier	Bulk in Silo	Bag	Purchase frequency	Storage and feeding method
3 (approx. weaning) to 78 (Death)	Silage (grass and maize in clamp, grass silage bales)	Home produced	None	No	Nil	Home produced

One feed silo has been on farm for approximately 10 years and has been used exclusively for dairy cattle cake during this period.

The other feed silo has been on farm since 1981 or 1982 and has been used for the cattle rearing pellets during this time. It has never been thoroughly cleaned out or the inside inspected as the lid of the silo cannot be opened to allow sufficient access due to its proximity to the roof of the building.

Since the 1970s, commercial pellet feed has been purchased first from a company based in Somerset and then Devon.

Over the past 10 years, the same feed mill has supplied both adult and calf rations. The mill has consistently tested negative for feed controls, including presence of Processed Animal Protein, every 6 months, as part of the official United Kingdom National Feed Audit throughout this time.

The positive case would have received growing rations from the older Silo from the ages of 4 to 12 months and beyond.

Prior to that, she would have received calf starter pellets from the same mill, but these were supplied in bags (See table 3).

All other feed is restricted to molasses, silage and straw and were not explored as credible risk pathways for BSE exposure.

Environmental contamination

The index case was born in February 2015, inside a loose straw shed, or possibly in an individual pen if assistance was required. Hydrated lime was occasionally used as a disinfectant between calving cows, but pens were not routinely cleansed or disinfected between each cow, or placentas removed.

These same sheds would have been used for calving in the 1990s at the time that the previous BSE positive cases were on farm.

Once calves were weaned, and during the summer months, they were run as a batch. The group grazed permanent calving paddocks and were able to run back into the youngstock housing for shelter if required. Some feeding with cattle rearer pellets occurred outside.

The positive case would have grazed in one of these paddocks in summer 2015, so if the soil had become contaminated in previous years with blood, amniotic fluids or placenta, then the positive case may have been exposed to them during the summer of 2015, when approximately 6 months old.

There have been no recorded burials on the farm and this premises were not subject to culling during the 2001 foot and mouth disease epidemic. There are no Animal by Products (ABP) plants, abattoirs or feed mills nearby, nor is there evidence of former plants or mills.

No slurry or farm-yard manure is moved off the premises, it is all spread on the premises' arable land. Commercial fertiliser is also purchased and spread. In the early 1990s pig slurry from a local pig farm was spread on the arable ground, but this practice ceased in the late 1990s. No other waste has been bought onto the premises since the 1990s. Meat and bone meal fertiliser has never been used.

Water supply to all the farm buildings and field troughs is from a natural spring located on the farm boundary. Spring water is then pumped to a water reservoir and supplies the fields and buildings.

Attaining enough water has always been an issue for the farm and the whole system was pressurised 4 years ago. The water is tested every 6 months for quality by Somerset District Council.

The source of the spring does flood occasionally but there have been no significant incidents in the past 10 years, and nothing of note in 2015 or 2016.

Veterinary treatment

The index case had not been subject to any veterinary surgical interventions (for example, caesarean section) during her life. She did receive routine worming, vaccinations, and other injections (for example, antibiotics and standard prostaglandin treatment) when required.

She was inseminated, but no embryo transfer or blood or serum products were administered. This information has been confirmed by both private vet and owner.

Other species

Some of the grazing fields have been rented out to a local farmer for winter keep for store lambs or ewes for the last 10 years but no lambing takes place at the farm. The sheep move onto the land at the beginning of November and are moved off by the beginning of January. There is no possibility of direct contact with the cattle, as the sheep graze the silage fields.

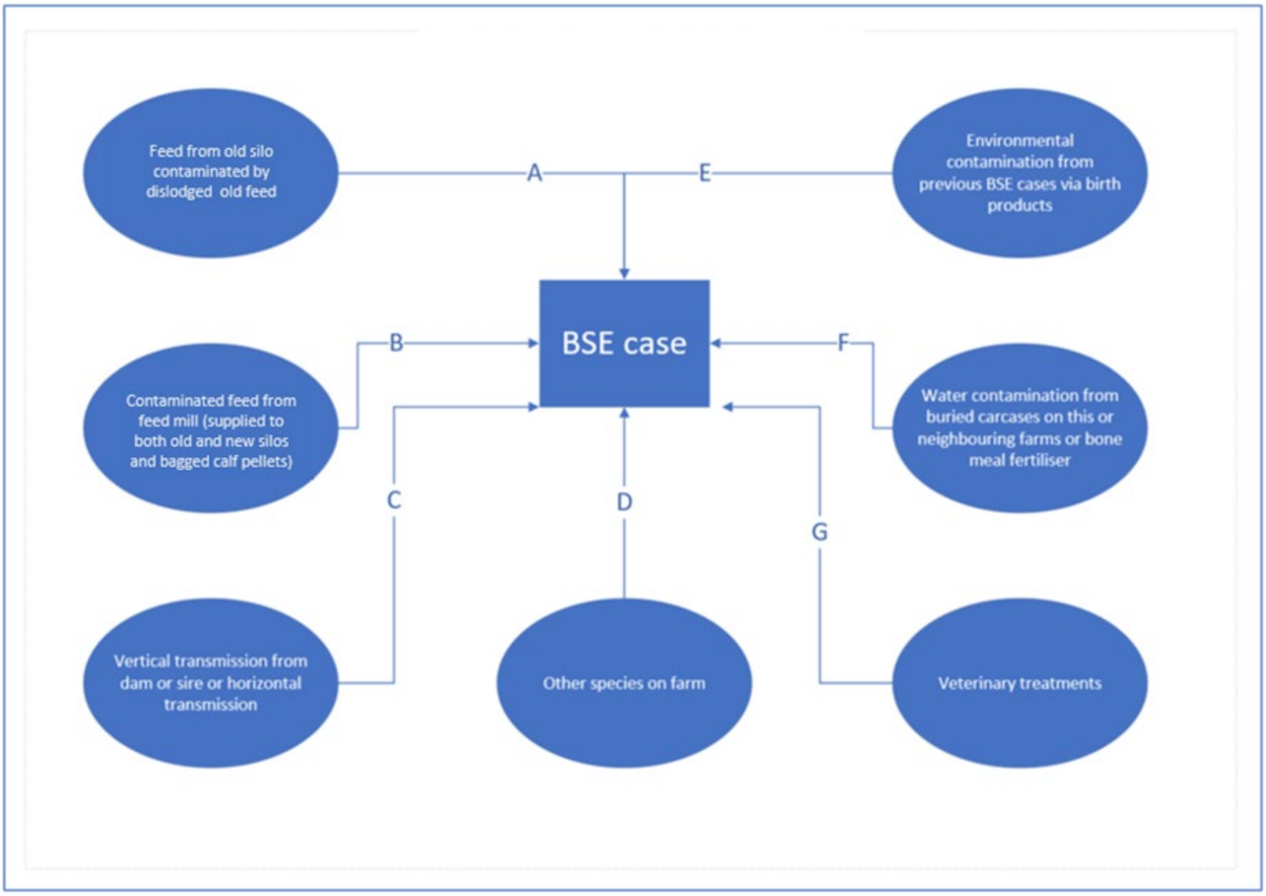
Initial investigations show there is no history of scrapie incidents in this flock. As far as is known, the sheep are not fed any concentrate feed whilst on the land.

There has been no farm dog for over 25 years, however, pet dogs are kept in the dwelling house and their food is stored there too. They are fed commercial feed purchased from supermarkets or agricultural feed merchants.

There have been multiple feral farm cats over the years, but only 2 farm cats remain. Their feed has always been commercial cat food purchased from supermarkets or agricultural feed merchants and is kept in a small, lidded container in the storage buildings at the farm, which makes it inaccessible to the cattle.

Assessment of potential sources of exposure

Figure 1: Risk pathway diagram showing potential sources.



A second quantitative assessment can be found at Appendix 2.

Table 4: Likelihood assessment of potential source and risk pathways.

Pathway	Risk factors	Mitigating factors	Uncertainties	Likelihood and uncertainty
A. Old feed from silo	Silo in constant use since 1981 or 1982 and never thoroughly cleaned. Previous BSE cases consumed potentially prion contaminated feed from this silo from its installation until the mid-1990s.	Last BSE case was born in 1990 and disclosed in 1996. Over 25 years ago. Constant throughput of feed for 25 years.	Internal structure of silo and the likelihood of feed retention. Presence of old feed from before 1996 in old silo until 2015 to 2016 when dislodged or fed to BSE case.	Very Low with medium uncertainty

Pathway	Risk factors	Mitigating factors	Uncertainties	Likelihood and uncertainty
B. Feed from mill since 2001	Same mill supplies feed to new silo (dairy ration), old silo (growing ration), and bagged feed (calf ration).	Statutory BSE and feed controls since 1996. Supplying feed mill has tested negative under National Feed Audit (NFA) for over 10 years. No BSE cases at other herds supplied by this mill.	Feed tested every 6 months - possibility of contamination between samples.	Negligible with low uncertainty

Pathway	Risk factors	Mitigating factors	Uncertainties	Likelihood and uncertainty
C. Vertical transmission from dam or sire, or horizontal transmission from other cases or cohorts	Dam not tested for BSE when slaughtered in 2018 as she was ineligible Sire was AI bull born in 2005. Slaughtered in abattoir in 2016. No BSE testing as he was ineligible.	Weak evidence of vertical or horizontal transmission. Dam was ‘big, fat cow’ when slaughtered. There were no clinical signs nor suspicion of BSE. No evidence of transmission by semen. Both dam and sire born after 1996 feed controls. No positive cases on natal farm since 1996. All cohorts have been culled and tested for BSE, all with negative results.	Any subsequent research or evidence of vertical and horizontal transmission.	Negligible with low uncertainty

Pathway	Risk factors	Mitigating factors	Uncertainties	Likelihood and uncertainty
D. Other species on farm	Sheep graze fields in winter while cattle are housed. Sheep are from another farm in the same county. Dog kept in dwelling house. Semi-feral cats kept on farm. Wildlife access to farm such as, foxes, badgers, rats, mice or wild birds	Sheep all from one flock or farm. No history of scrapie in the flock and no lambing on this farm. No concentrates fed to sheep whilst present. No contact between cattle and sheep. All proprietary dog and cat food purchased from supermarket or farmer's merchant and stored away from cattle. No cattle access possible. No evidence that wildlife spread BSE.	Sensitivity of scrapie surveillance. Any subsequent research or evidence of BSE transmission from other animals.	Negligible with low uncertainty

E. Environmental contamination from previous BSE cases	Previous confirmed cases recorded on this farm, all born and reared before introduction of reinforced feed ban. These animals would have calved on farm in pens, yards or at pasture. Placentas were not routinely removed by the farmer. Minimal cleansing and disinfection of calving pens and yards. Index case had access to pens and yards and pasture within the first 12 months of life, and subsequently.	Index case was born in February 2015 - this is 19 years after the last confirmed case. Poor evidence for vertical transmission via birth products. This level of contamination will exist on many other farms that have not experienced subsequent BSE cases to those in the 1990s.	Any subsequent research or evidence of transmission of BSE via birth products.	Negligible with medium uncertainty

Pathway	Risk factors	Mitigating factors	Uncertainties	Likelihood and uncertainty
F. Water contamination from carcases	Water sourced from local spring on farm. Flooding incidents have occurred in the past 10 years.	No evidence or records of carcase burial on this farm or neighbouring properties. No FMD burials in 2001. Water quality tested every 6 months. No flooding of note while the case was a calf.	Presence of illegal or unrecorded historic burials. Any subsequent research and evidence of transmission through contaminated water from burials. Reliability of owner's memory re. flood events.	Negligible with medium uncertainty

Pathway	Risk factors	Mitigating factors	Uncertainties	Likelihood and uncertainty
G. Veterinary treatments	CJD has been transmitted in humans through surgical procedures	Private vet and owner confirm that no surgical interventions were performed on the index case. All injections were routine products, wormers, antibiotics, prostaglandin only.	Veracity of vet's records and memory of owner.	No credible risk pathway with low uncertainty

Discussion of potential sources of exposure

As can be seen in table 4, all but one risk pathway has been assessed as a negligible likelihood. The only pathway that has been assessed with a likelihood other than negligible, is pathway A 'old feed from silo'.

This has been assessed as being very low likelihood with medium uncertainty. The definitions used for these terms are shown in Table 5 and Table 6 in Appendix 1.

The older silo could have contained small amounts of feed produced before the reinforced feed ban, caught up in the internal structure, which became dislodged in 2015 or 2016 and entered the cattle rearer ration, and was subsequently fed to the index case.

We know that the previous confirmed BSE cases on this farm would have been fed rearer ration from this same silo, which was most likely contaminated, although it is possible that they were infected from the bagged calf pellets or milk replacer powder that was fed in the late 1980s and 1990s.

The only other cattle that may have been exposed to the same contaminated feed are the cohorts to this case. The current BSE controls have identified all such animals that were still alive, and they have all been restricted, culled, and tested for BSE, all with negative results.

There is no evidence to suggest that there has been any further exposure beyond this group of cohort cattle.

Summary of relevant TSE control measures and dates

The Great Britain National Feed Audit

To confirm the effectiveness of the TSE Feed Ban controls in Great Britain, an inspection and sampling programme, the National Feed Audit (NFA), is undertaken throughout the animal feed chain.

This includes imported feeds, bulk storage, production at feed mills, blending plants, mobile mixers and on farm mixers using fishmeal in feed production and livestock farms including home compounders.

All incidents are rigorously investigated, and risk-based actions taken to prevent further marketing of contaminated feed into the feed chain and where necessary restriction of ruminant animals and removal of those animals from the food chain is carried out.

Summary statistics for the National Feed Audit programme are available prior to June 2017 on GOV.UK.

Summary statistics for April 2017 to 2020 are available in Appendix 4 and are awaiting publication at the above link.

The Feed ban

Feed controls were first introduced in the UK in 1988, when the cause of BSE was first epidemiologically linked to feed containing meat and bone meal. The 1st August 1996 is considered as the date of the effective Reinforced Feed Ban when mammalian meat and bone meal was banned from all farm animal feed.

A European Council Decision in 2000 (2000/76) extended the ban and provided harmonised BSE-related feed controls across all Member States. Current EU Feed Ban controls have been amended since then and are included in Regulation (EC) Number 999/2001.

Ban on on-farm burial of fallen stock

Since May 2003, it has been illegal to bury fallen stock (dead animals) on farms throughout the European Union (of which the UK was a member or continued to adhere to the specific regulations during ’the transition period’ until 31 December 2020) under the EU Animal By-Products Regulation.

A derogation exists within remote areas for burial to occur, however the farm concerned is out with any derogated areas. This prohibition has been retained in UK domestic legislation from 1 January 2021.

Concluding remarks

The most likely source of infection for this positive BSE case has been assessed as exposure to contaminated feed from the older silo, with a very low likelihood and medium uncertainty.

There is no evidence that any TSE regulations have been breached in this case, and there is every reason to believe that current mitigations will contain any further potential exposure to cattle. Controls in place have negated any risk to the human food chain.

It is recognised that even so many years after implementation of the total feed ban, detection of sporadic born after the reinforced ban (BARB) cases is not an entirely unprecedented event (for example, the 2015 cases in Wales and Ireland, 2016 case in France and 2018 case in Scotland) and continues to represent a significant epidemiological challenge in terms of investigation and being able to identify a definitive source of infection for each case.

This is due to the significant time delay between exposure to the agent and the subsequent development of clinical signs and post-mortem laboratory detection and the potential associated recall bias or loss of records consequent to elapsed time. (EFSA Scientific Opinion (2017))[2],[3]

A recently published modelling study considering BARB cases across the EU concluded that there is a 44.9% probability that a previous identified case in the UK in 2015 would be the final case, with a 55.1% probability remaining of additional cases occurring in 2016 or later, up to an extremely low (0.02%) but non-negligible probability of detecting a case up until 2026.[4]

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[2] EFSA Scientific Opinion (2017); Bovine Spongiform Encephalopathy (BSE) cases born after the total feed ban. EFSA Journal 2017;15(7):4885

[3] O'Connor, JT., Byrne, JP., More, SJ., Blake, M., McGrath, G., Tratalos, JA., Mcelroy, MC., Kiernan, P., Canty, MJ., O'Brien-Lynch, C., Griffin, JM. (2018) Using an epidemiological framework and bovine spongiform encephalopathy investigation questionnaire to investigate suspect bovine spongiform encephalopathy cases: an example from a bovine spongiform encephalopathy case in Ireland in 2015 Veterinary Record 182, 168.

[4] M. E. Arnold, R. R. L. Simons, J. Hope, N. Gibbens And A. L. Adkin. Is there a decline in bovine spongiform encephalopathy cases born after reinforced feed bans? A modelling study in EU member states. Epidemiol. Infect. (2017), 145, 2280–2286.

Recommendations and veterinary advice

Based on the conclusion that exposure to contaminated feed from the older silo, with a very low likelihood and medium uncertainty, has been assessed as the most likely source of infection for this positive BSE case, the recommendations and veterinary advice are as follows:

- For the older silo not to be used in connection with any activities related to livestock feeding. The farmer has already decommissioned this silo, which is no longer in use.
- For the older silo to be sampled by the APHA TSE team and the samples to be stored as part of a sample archive. The samples will be tested in the future when the current test under development is fully validated.
- For the older silo to be fully decommissioned and dismantled, and not used in connection with any other livestock activity or enterprise. The farmer has confirmed the silo will be sold for scrap once sampled by the APHA TSE team. The silo must be transported under a licence which will ensure compliance and verification of use of the silo destination.
- For Defra policy to undertake an assessment of pre-1996 silos in England.

References

- EFSA Scientific Opinion (2017); Bovine Spongiform Encephalopathy (BSE) cases born after the total feed ban. EFSA Journal 2017;15(7):4885
- O'Connor, JT., Byrne, JP., More, SJ., Blake, M., McGrath, G., Tratalos, JA., Mcelroy, MC., Kiernan, P., Canty, MJ., O'Brien-Lynch, C., Griffin, JM. (2018) Using an epidemiological framework and bovine spongiform encephalopathy investigation questionnaire to investigate suspect bovine spongiform encephalopathy cases: an example from a bovine spongiform encephalopathy case in Ireland in 2015,Veterinary Record 182, 168.
- M. E. Arnold, R. R. L. Simons, J. Hope, N. Gibbens and A. L. Adkin. Is there a decline in bovine spongiform encephalopathy cases born after reinforced feed bans? A modelling study in EU member states. Epidemiol. Infect. (2017), 145, 2280–2286.

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The NEEG is comprised of staff from APHA's Veterinary, Operations and Science Directorates.

NEEG 19 November 2021

Appendix 1: Definitions

Table 5: Definitions for the qualitative risk terms used in this assessment, based on EFSA (2006) and Office International Epizooties (OIE) (2012) with expanded descriptions adapted from Kahn et al. (1999) and FAO (2009)

Risk level	Definition	Expanded descriptions based on (Kahn et al. (1999) and FAO (2009))[5]
Negligible	Event is so rare, does not merit consideration	The chance of the event occurring is so small it does not merit consideration in practical terms, it is not expected to happen for many years, if at all.
Very low	Event is very rare, but cannot be excluded	The event is not expected to occur (very rare), but it is possible, it is not expected to occur within the next 5 years.
Low	Event is rare, but does occur	The event may occur occasionally (rare), it is unlikely to occur within the next 5 years.
Medium	Event occurs regularly	The event occurs regularly, it is possible within the next 5 years.
High	Event occurs very often	The event will happen more often than not, it is expected to occur within the next 5 years.
Very high	Event occurs almost certainly	The event will undoubtedly happen, it is expected to occur within the next 5 years and could happen more than once

Table 6: Qualitative categories for expressing uncertainty given the available evidence; based on definitions within the literature (EFSA (2006) and ECDC (2011) and Spiegelhalter and Riesch (2011))

Uncertainty category and definition	Type of information or evidence to support uncertainty category
Low **Further research is very unlikely to change our confidence in the assessed risk**	• Solid and complete data available (for example, long term monitoring results) • Peer reviewed published studies where design and analysis reduce bias (for example, systematic reviews, randomised control trials, outbreak reports using analytical epidemiology) • Complementary evidence provided in multiple references • Expert group risk assessments, specialised expert knowledge, consensus opinion of experts • Established surveillance systems by recognised authoritative institutions • Authors report similar conclusions

[5] The quantitative intervals for each qualitative measure are meant as a guide to assist in either translating quantitative data into a qualitative band for a single parameter or to aid in interpreting the overall qualitative result. It is not anticipated that qualitative measures for each parameter would be multiplied together using the quantitative intervals provided. Instead, this would be achieved using the matrix provided in Gale *et al*., (2009).

Uncertainty category and definition	Type of information or evidence to support uncertainty category
Medium **Further research is likely to have an important impact on our confidence in the risk estimate**	• Some but no complete data available • Non peer-reviewed published studies and reports • Observational studies, surveillance reports or outbreak reports • Individual (expert) opinion • Evidence provided in a small number of references • Authors report conclusions that vary from one another
High **Further research is very likely to have an important impact on our confidence in the risk estimate**	• Scarce or no data available • No published scientific studies available • Evidence is provided in grey literature (such as, unpublished reports, observations or personal communication) • Individual (non-expert) opinion • Authors report conclusions that vary considerably between them

Appendix 2: Quantitative assessment of potential sources of BSE in this case

The potential sources are set out in figure 1. These are now examined in detail to assess their likelihood. The most plausible risk pathway is via feed contaminated with 'old feed' from the 1980s inside a silo.

It is demonstrated here that it would not have to be very much 'old feed' to initiate infection of one cow in a herd with a significant risk. The key points are set out below:

The BSE agent is highly infectious to cattle

The oral ID_{50} is 0.15 g of bovine brain homogenate with confidence intervals of 0.03 minus 0.79 g (Konold et al. 2012).

Assuming bovine brain and spinal cord from a single bovine weigh 750g, then a single brain or spinal cord from a single bovine in late stages of clinical infection would contain 750 divided by 0.15 = 5,000 bovine oral ID_{50} units, which if dispersed orally across a large number of cows could infect 0.69 times 5000 = 3,450 cows (see Gale (2004) for derivation of 0.69 factor).

MBM from the 1980s was highly infectious to cattle

Epidemiological studies demonstrated Meat and Bone Meal (MBM) as the root cause of the BSE epizootic in the UK in the 1980s.

The levels of BSE infectivity in UK MBM produced prior to the ban on the use of brain, spinal cord and offal (Category III ABP) in the source material for MBM would have been high in terms of bovine oral ID_{50} units as evidenced by the large number of BSE cases in the UK during this period.

It should be stressed that the concentration of BSE infectivity in MBM depends entirely on the prevalence of BSE in the cattle offal that went into the rendering plant as source material and whether or not their brain and spinal cord were included.

Thus, there is little point looking for published data on BSE levels in MBM from other countries or for the UK in recent times. There appears to be little data for the UK from the 1980s. However, some estimate can be made from the efficiency of rendering in inactivating BSE infectivity.

TSE-agent strains differ in their heat inactivation properties, such as their thermostability (Somerville and Gentles 2011). The BSE agent has a particularly high thermostability compared to the scrapie agent for example. This enhances its survival in the rendering process by which cattle offal and other ABP including brain and spinal cord were converted to MBM.

Rendering has been shown to destroy at least 98% of BSE infectivity, such that the reduction is greater than 50-fold (Taylor et al. (1995)). Using data from Somerville and Gentles (2011)) some 1.5 $\log_{10}$ of BSE 301 infectivity remained at 100ºC (5 bar 10 min) compared to the 3.7 $\log_{10}$ at the lowest temperature studied of 80ºC (See figure 2d taken from Somerville and Gentles (2011)).

Thus, it is assumed here that rendering achieves a 3.7 minus 1.5 = 2.2 $\log_{10}$ reduction back in the 1980s, such as, a 160 fold reduction, which is consistent with the less than 50-fold achieved by Taylor et al. (1995).

Thus, one whole brain or spinal cord from a BSE-infected cow going into MBM feed would infect 3,450 divided by160 = 22 cows if all that MBM feed were ingested by the cattle herd.

BSE infectivity decays very slowly

Somerville et al (2019) demonstrated survival of BSE agent in cattle heads over a 5 year period. The remaining infectivity was assayed by mouse bio-assay.

After one year in clay (see figure 2 taken from Somerville et al. (2019)) only around 20% of the mice survived (with incubation periods of around 180 days), while after 5 years around 40% of the mice survived with incubation periods of round 200 days. This is consistent with very limited decay over the 4 year period.

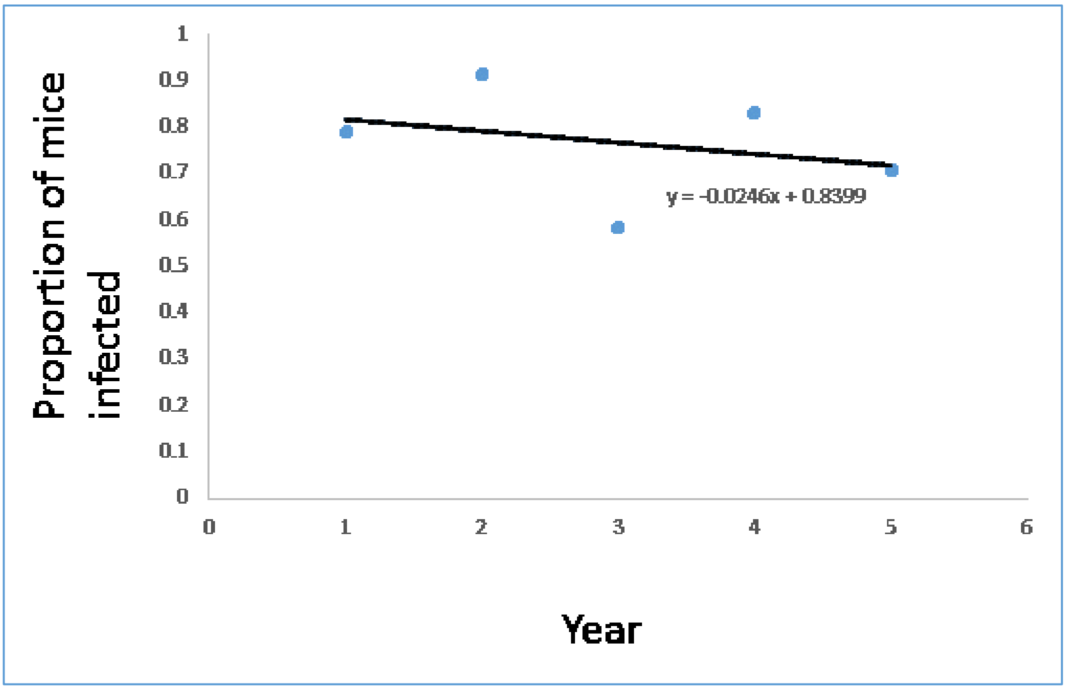
So, if 80% of the mice died at year 1 and 60% at year 5, then the risk is reduced by about 25% in 5 years. Thus, extrapolating this decay over a 40 year period (from 1980 to 2020), the risk may be reduced around 10-fold, although there is considerable uncertainty in this estimate.

Thus, the one whole brain or spinal cord form a BSE-infected cow going into MBM feed in the 1980s could infect 22 divided by 10 = 2.2 cows.

It should be noted that there is considerable variation between the 5 years in the data of Somerville et al. (2019) and this 10-fold reduction is perhaps optimistic and using data from Table 1 of Somerville the reduction over 5 years is only 15% (See figure 2) giving only a 3.5 fold reduction over the 40 years.

The key point is that BSE infectivity was recovered in similar amounts from the heads exhumed annually throughout the 5 year period of the experiment from both clay and sandy soils. Somerville et al. (2019) concluded that BSE infectivity is likely to survive burial for long periods of time. It is assumed here that that conclusion applies to BSE infectivity in MBM too.

Figure 21: Proportion of mice infected from 6 soil samples taken each year from BSE infectivity buried in a bovine skull. Data from Table 1 of Somerville et al. (2019)



There is no threshold dose for TSE infection (Fryer and McLean 2011)

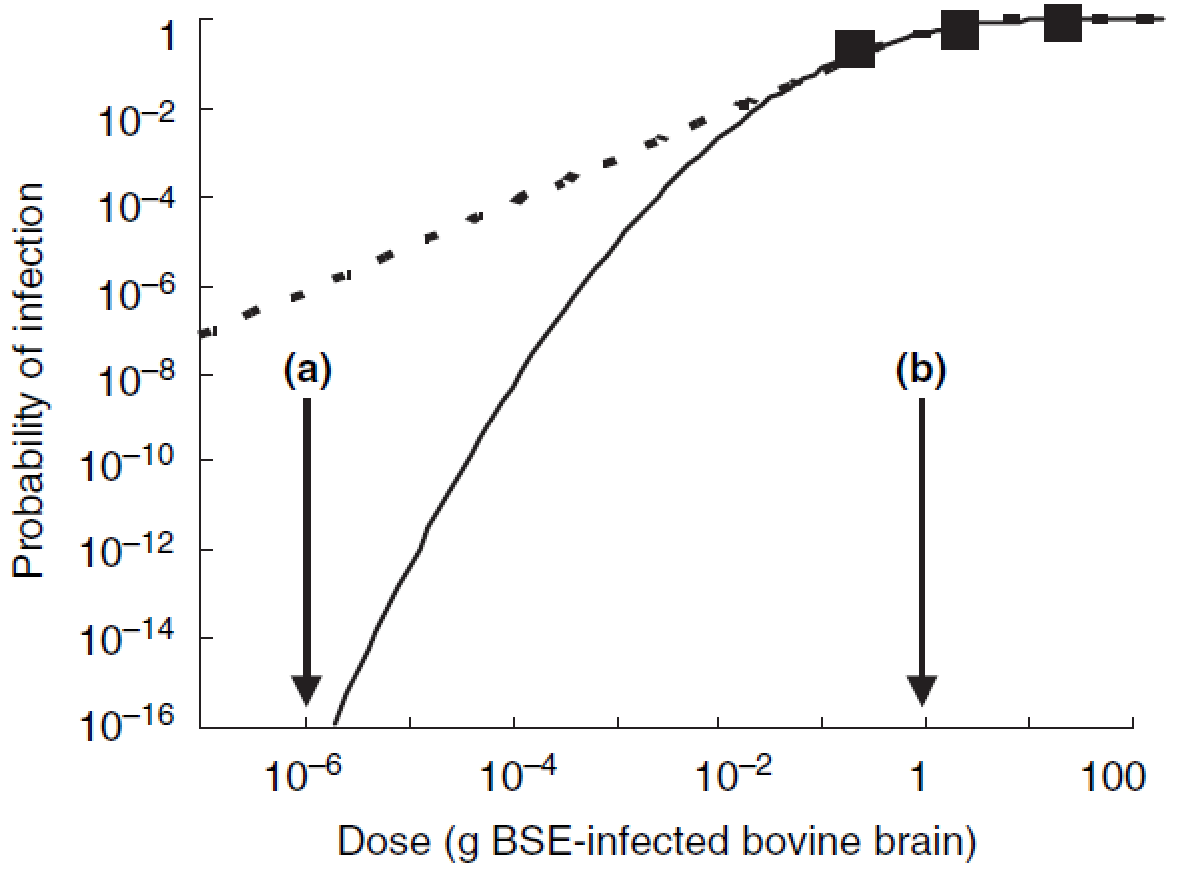
This is an important point because it means that dispersion of the 'old feed' by mixing in with new feed would not in any way diminish the risk particularly because all feed material (including any of the old feed) is eaten by one or more cattle.

Indeed, dispersion of highly infectious pathogens actually increases the group risk because more animals are exposed, albeit to lower doses. In the absence of a threshold dose, the risk of infection from less infectious pathogens decreases linearly with decreasing dose (see dashed line in figure 3), such that risks from the very small doses ingested by the one or more animals are additive and nothing is lost through dispersion.

In contrast the risks from low doses if there were a threshold (or cooperative effect, see solid line in figure 3) are greatly reduced so that adding them up across the exposed population gives a greatly diminished group risk.

Independent action (dashed line) and co-operative action (solid line) dose-response models fitted to BSE infectivity data in mice (Taylor et al 1995) and extrapolated to low doses: a) represents the individual exposures through environmental routes, b) through food sources. Adapted from Gale (2006).

Figure 2: Proposed BSE dose-response curves for oral exposure in humans.



Above it is estimated that one whole brain or spinal cord from a BSE-infected cow going into MBM feed in the 1980s could infect 2.2 cows in the herd. Much smaller volumes of MBM may have remained in the Silo to be redistributed into the current feed.

However, because the dose response is linear (with no threshold) these smaller exposures could still initiate infection in the cattle herd fed from the silo albeit with lower risks.

For example, just a 50th of a whole brain or spinal cord (that is,15g) from a clinical case going into the MBM would infect 0.04 cows in the exposed herd. This can be interpreted as a 4% probability of one cow becoming infected, which is a low or medium risk qualitatively.

Thus, even relatively small amounts of old MBM remaining carry a low to medium risk of one cow becoming infected.

Other routes

Environmental contamination from previous BSE cases via birth products

Unlike scrapie and chronic wasting disease the environmental transmission of BSE has not been documented. This could reflect the tissue distribution of BSE with most being found in the brain and spinal cord which don't generally contaminate pastureland. While birth products may be left on the pasture, there is no evidence of BSE infectivity in birth products.

This is consistent with the results of cohort studies to investigate vertical transmission of BSE being inconclusive (Wilesmith et al. (1997)).

A key difference between environmental routes and MBM feed routes is dilution in the soil which greatly decreases the exposure. Thus, while all the feed is destined to be consumed by cattle, only a small proportion of any infectivity in birth products would be ingested through cattle grazing on the field.

Water contamination from buried carcasses on this or neighbouring farms or bone meal fertiliser

This pathway can be ruled out because of the number of barriers between the buried carcase and the water supply.

First TSE burial experiments have shown very little leaching of infectivity (Brown and Gajdusek 1991 and Somerville et al 2019).

Second, BSE infectivity is amphipathic and sticks to particulates which aquifers and clay soils effectively filter out before they reach the water (Gale et al. (1997)). Treated drinking water is based on particle removal by coagulation or sand filtration and would present a negligible risk to cows.

Third, only a small fraction of drinking water is consumed by the cows, giving a massive dilution effect, and hugely reducing exposures.

Fourth, cattle carcasses would probably not be buried near to water supplies, even during the 2001 FMD outbreak.

While Somerville et al. (2019), reports some infectivity in samples of rainwater that had drained through the bolus of BSE-infected brain buried in the soil, the subsequent dilution and suspension of the particles in soil would greatly minimise the risk compared to direct consumption of MBM, Bone meal fertilisers would present a relatively higher risk than the drinking water route because the BSE infectivity would be associated with particulate matter and there would be less dilution than in water.

However, the fertilisers would be diluted into the soil (particularly if tilled in), and furthermore not all the topsoil would be ingested by grazing cattle anyway, such that only a fraction of the fertiliser would be ingested by cows, thus greatly minimising the risk compared to direct consumption of the bone meal as feed.

Sewage sludge on land can be ruled out because of the low levels of BSE agent that would have entered the sewage due to the 10mm screens across drains at abattoirs since 1996, together with dilution in the soil (Gale and Stanfield 2001). There is also evidence that anaerobic digestion inactivates scrapie prions. Compost catering waste would present very low risks again due to dilution and also the very low incidence of BSE in catering waste (Gale 2004).

Vertical transmission

Relatively low risk as results of BSE cohort study were inconclusive (Wilesmith et al 1997). Clearly this would have required an undetected BSE dam previously in the UK in the last 6 years, which is low probability given UK surveillance.

Conclusion

Feed contaminated with old MBM from the 1980s seems to be the most likely route of exposure. MBM produced in the 1980s was highly infectious to cattle and available evidence suggests that infectivity is unlikely to be reduced by much over forty years due to the stability of the BSE agent.

Calculations here show that even after 40 years, the residual BSE infectivity in MBM produced from the rendering of the brain or spinal cord (750 g) of just one BSE-infected cow with clinical signs from back in the 1980s could infect 2.2 cows if consumed in 2020 by a herd of cows.

Even small portions of MBM derived from just a 50th (such as 15 g) of an infected cow's brain or spinal cord would still give a low or medium probability of one cow in the herd becoming infected if ingested across the herd because there is no threshold dose.

It is not inconceivable that a few 100g of old MBM could have remained trapped in parts of the silo. Dispersing it into the new feed would not in any way reduce the risk to the cattle herd because there is no threshold.

The actual risk from the feed silo bin depends on the mass of old MBM which was left in from the 1980s. This mass is unknown as this study is retrospective.

Furthermore, the actual level of infectivity in that ‘old MBM’ would have depended on source and date of production reflecting the BSE incidence in the UK national herd prior to the ban on use of brain and spinal cord in the late 1980s and the efficiency of the rendering process used at that time.

The key point about feed is that there is no dilution effect because, unlike water and the environmental routes considered here, it is generally all eaten, including any ‘old feed residues’ remaining from the 1980s if disturbed and allowed to enter the current feed chain.

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Appendix 3: Timeline of events in the life of the index case

Table 7: Timeline of index case life events and fate of her offspring.

Date	Event
February 2015	Birth (normal delivery), Dam (Dairy Cow, 2nd calver)
At 2 days	Removed from Dam into individual pen in buildings
May 2015	Weaning and turned out into calving paddocks for summer grazing
November 2015	Winter housing in youngstock building
April 2016	Turned out for summer grazing in fields
November 2016	Winter housing in youngstock building
April 2017	Turned out for summer grazing in fields
Summer 2017	1st calving – twin heifer beef calves, normal delivery sold as a 23 day old calf and slaughtered by an abattoir at 30 months old sold as a 23 day old calf and slaughtered by an abattoir at 29 months old
Summer 2017	Entry into milking herd
Summer 2018	2nd calving – dairy heifer calf, normal delivery: still in the herd, reported as healthy, not restricted and not part of offspring cull
Autumn 2019	3rd calving – beef heifer calf, normal delivery, sold when 29 days old to Somerset holding. Restricted and was then culled on 30 September 2021, BSE sampled and tested negative.

Date	Event
Autumn 2020	4th calving – beef male calf, normal delivery, sold when 6 days old to Somerset holding. Restricted and was then culled on 30 September 2021, BSE sampled and tested negative.
1 September 2021	Farmer first noted clinical signs of abnormal behaviour and head carriage, unable to stand, dragging herself, knuckling fetlocks and excitable or nervous
2 September 2021	Euthanised on farm and carcase removed to sampling plant for TSE testing
8 September 2021	Preliminary positive result received for BSE
17 September 2021	Final positive result received of classical BSE. The UK CVO confirms the disease

Appendix 4: National feed audit data

Table 8: Inspection data from National Feed Audit sampling for feed supplier.

Year	2015	2016	2017	2018	2019	2020	2021	Total samples
Number of inspections	2	2	2	2	2	2	2	14
Number of samples	10	10	10	10	10	10	10	70
Number of non-compliance (positive) samples	0	0	0	0	0	0	0	0
Number of non-compliances recorded in comments on BSE16	0	0	0	0	0	0	0	0

Inspection data from National Feed Audit 1 April 2017 to 31 March 2021

Table 9: samples collected by Animal Health Officer (AHO) staff tested for processed animal proteins (1 April 2017 to 31 March 2018)

Premises	Feed materials	Compound feeding stuffs for ruminants	Compound feeding stuffs for non-ruminants
At import	114	3	0
Feed mills	864	1,158	393
Intermediaries or storage	144	45	8
Means of transport	0	0	0
Home mixers or mobile mixers	49	156	73
On farm	217	1,700	306
Fats and vegetable oils	2	0	0
Total	1,390	3,062	780
Total samples collected	5,232		
Total samples collected using Official Method	2,484		

Table 10: number of non-complaint samples tested for the presence of processed animal protein or animal protein from terrestrial animals (1 April 2017 to 31 March 2018)

Premises	Feed materials	Compound feeding stuffs for ruminants	Compound feeding stuffs for non-ruminants
At import	0	0	0
Feed mills	0	0	0
Intermediaries or storage	0	0	0
Means of transport	0	0	0
Home mixers or mobile mixers	0	0	0
On farm	0	0	0
Fats and vegetable oils	0	0	0
Total	0	0	0

Table 11: number of non-compliant samples tested for the presence of processed animal protein from fish (1 April 2017 to 31 March 2018)

Premises	Feed materials	Compound feeding stuffs for ruminants	Compound feeding stuffs for non-ruminants
At import	0	0	0
Feed mills	0	0	0
Intermediaries or storage	0	0	0
Means of transport	0	0	0
Home mixers or mobile mixers	0	0	0
On farm	0	0	0
Fats and vegetable oils	0	0	0
Total	0	0	0

Table 12: number of samples collected by AHO staff tested for processed animal proteins (1 April 2018 to 31 March 2019)

Premises	Feed materials	Compound feeding stuffs for ruminants	Compound feeding stuffs for non-ruminants
At import	100	7	0
Feed mills	966	1,155	405
Intermediaries and storage	149	53	0
Means of transport	0	0	0
Home mixers and mobile mixers	38	142	80
On farm	159	1,671	315
Fats and vegetable oils	0	0	0
Total	1,412	3,028	800
Total samples collected	5,240		
Total samples collected using Official Method	2,393		

Table 13: number of non-complaint samples tested for the presence of processed animal protein or animal protein from terrestrial animals (1 April 2018 to 31 March 2019)

Premises	Feed materials	Compound feeding stuffs for ruminants	Compound feeding stuffs for non-ruminants
At import	0	0	0
Feed mills	3	3	0
Intermediaries and storage	1	0	0
Means of transport	0	0	0
Home mixers or mobile mixers	1	0	0
On farm	1	52	1
Fats and vegetable oils	0	0	0
Total	6	55	1

Table 14: number of non-compliant samples tested for the presence of processed animal protein from fish (1 April 2018 to 31 March 2019)

Premises	Feed materials	Compound feeding stuffs for ruminants	Compound feeding stuffs for non-ruminants
At import	0	0	0
Feed mills	0	0	0
Intermediaries and storage	0	0	0
Means of transport	0	0	0
Home mixers or mobile mixers	0	0	0
On farm	0	0	0
Fats and vegetable oils	0	0	0
Total	0	0	0

Table 15: samples collected by AHO staff tested for processed animal proteins (1 April 2019 to 31 March 2020)

Premises	Feed materials	Compound feeding stuffs for ruminants	Compound feeding stuffs for non-ruminants
At import	82	25	0
Feed mills	738	1,116	336
Intermediaries and storage	127	39	4
Means of transport	0	0	0
Home mixers or mobile mixers	32	108	56
On farm	191	1,626	289
Fats and vegetable oils	15	0	0
Total	1,185	2,914	685
Total samples collected	4,784		
Total samples collected using Official Method	2,398		

Table 16: number of non-compliant samples tested for presence of processed animal protein or animal protein from terrestrial animal (1 April 2019 to 31 March 2020)

Premises	Feed materials	Compound feeding stuffs for ruminants	Compound feeding stuffs for non-ruminants
At import	0	0	0
Feed mills	0	0	0
Intermediaries and storage	0	0	0
Means of transport	0	0	0
Home mixers or mobile mixers	0	0	0
On farm	0	0	0
Fats and vegetable oils	0	0	0
Total	0	0	0

Table 17: number of non-compliant samples tested for the presence of processed animal protein from fish (1 April 2019 to 31 March 2020)

Premises	Feed materials	Compound feeding stuffs for ruminants	Compound feeding stuffs for non-ruminants
At import	0	0	0
Feed mills	0	0	0
Intermediaries and storage	0	0	0
Means of transport	0	0	0
Home mixers or mobile mixers	0	0	0
On farm	0	0	0
Fats and vegetable oils	0	0	0
Total	0	0	0

Table 18: number of samples collected by AHO staff tested for processed animal proteins (1 April 2020 to 31 March 2021)

Premises	Feed materials	Compound feeding stuffs for ruminants	Compound feeding stuffs for non-ruminants
At import	78	13	0
Feed mills	763	1,090	327
Intermediaries and storage	163	20	2
Means of transport	0	0	0
Home mixers or mobile mixers	24	91	54
On farm	188	1,522	219
Fats and vegetable oils	1	0	0
Total	1,217	2,736	602
Total samples collected	4,555		
Total samples collected using Official Method	2,221		

Table 19: number of non-compliant samples tested for presence of processed animal protein or animal protein from terrestrial animal (1 April 2020 to 31 March 2021)

Premises	Feed materials	Compound feeding stuffs for ruminants	Compound feeding stuffs for non-ruminants
At import	0	0	0
Feed mills	0	0	0
Intermediaries and storage	0	0	0
Means of transport	0	0	0
Home mixers or mobile mixers	0	0	0
On farm	0	0	0
Fats and vegetable oils	0	0	0
Total	0	0	0

Table 20: number of non-compliant samples tested for the presence of processed animal protein from fish (1 April 2020 to 31 March 2021)

Premises	Feed materials	Compound feeding stuffs for ruminants	Compound feeding stuffs for non-ruminants
At import	0	0	0
Feed mills	0	0	0
Intermediaries and storage	0	0	0
Means of transport	0	0	0
Home mixers or mobile mixers	0	0	0
On farm	0	0	0
Fats and vegetable oils	0	0	0
Total	0	0	0