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Papers and Articles

Risk of BSE from the import of cattle from the United Kingdom into countries of the European Union

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Veterinary Record (1997) **141,** 187-190

This study assesses quantitatively the risk that other countries, in particular those within the European Union, have incurred by importing cattle from the United Kingdom during the period before or shortly after the ban on the import of live breeding stock was introduced in 1989. It does this by assessing the probability that animals imported from the UK in a certain year would have become a detected BSE case, had they not been exported. Using the annual incidence rates available for separate birth cohorts and a given culling rate, a cumulative incidence for each birth cohort was calculated. These figures were then combined with the numbers of live breeding cattle imported from the UK into the other countries of the EU, to give an import-related risk index for each country, assuming that their culling rates were similar to that in Great Britain. The countries could thus be categorised in terms of the number of cases of BSE they might have expected.

AS a major epidemic, bovine spongiform encephalopathy (BSE) has been confined largely to the United Kingdom (UK) and principally to Great Britain. Apparently it was only here that all the risk factors required for a large scale epidemic were present simultaneously (Wilesmith and Wells 1991). Among the risk factors for BSE to occur in countries outside the UK, the import of meat and bone meal (MBM) and the import of live cattle from the UK are the most obvious and important ones. In July 1989 the European Commission restricted the import of live animals from the UK into other member states, initially by an import ban on cattle born before July 18, 1988 (the date of the feed ban in Great Britain) (Commission Decision 89/469/EEC). In February 1990 the import ban was extended to a ban on all live cattle except for those under six months of age which would be slaughtered before they reached that age (Decision 90/59/EEC).

The importance of the import of live cattle has been demonstrated by the cases of BSE in Oman, the Falkland Islands, Denmark, Canada, Germany, Portugal, Italy, and the Republic of Ireland, where one or more cattle originating from the UK have succumbed to the disease (Table 1).

The authors have been investigating the risk of BSE occurring in cattle imported from the UK for the European Union (EU) as a whole (Schreuder and Straub 1996). This paper describes the results of a study to assess quantitatively the risk that individual countries which were members of the European Community in 1989 have incurred by the import of cattle from the UK during the period before or shortly after the introduction of the ban on the import of live breeding stock. It assesses the chances that animals imported from the UK in a certain year might have been infected with BSE in the UK, by calculating the chance of their having become a detected BSE case had they not been exported.

The study did not consider the risk from MBM imported from the UK, although epidemiological evidence, for example from Switzerland, suggests that this route could also be important.

Materials and methods

The first section discusses data from Great Britain only, whereas the next section, which deals with export statistics, relates to the UK as a whole.

Incidence of BSE

The numbers of cases of BSE which occurred in Great Britain in each year from 1987 to 1996, by their year of birth, were obtained from the main BSE epidemiological database (Wilesmith and others 1992), which covers Great Britain only. From these numbers, the annual incidence of BSE in dairy and beef suckler herds combined was calculated for each 12-month birth cohort (July to June inclusive) from July 1974 to June 1995, using the total adult cattle population in Great Britain, divided into birth cohorts on the basis of the age distribution in affected herds, as the denominator. For the total adult population, the year 1992, which was the mid-point of the epidemic, was considered to be representative of the period of interest because the total adult cattle population number (in 1992 slightly over four million) did not change substantially between 1989 and 1994.

The annual incidence data were subsequently regrouped by cross-tabulation (Table 2). The cumulative incidences of BSE during the commercial lifespan of the animals for each 12-month birth cohort were calculated by summing the individual annual incidences from 1987 to 1996 inclusive.

For the purpose of the study, the following assumptions, which entail certain simplifications, had to be made. First, it was assumed that the various incidence rates, as calculated for Great Britain, were representative of the UK as a whole. Secondly, it was assumed that the culling rates in the UK as a whole and in the other member states of the EU were similar to the culling rate in Great Britain. Thirdly, it was assumed that all BSE-infected cattle became infected in the first one-and-half to two years of their life, that is, before they were exported; this may look like a simplification, but modelling studies have indicated that most BSE cases will

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TABLE 1: Numbers of confirmed BSE cases worldwide up to January 1997

Country	Total number of cases
Great Britain	165,323
Guernsey	600*
Jersey	120*
Northern Ireland	1733*
Isle of Man	408*
Republic of Ireland	188
Switzerland	228*
Portugal	61
France	28
Germany	5
Italy	2
Oman	2
Canada	1
Denmark	1
Falkland Islands	1

* Cases up to October 1996
The cases in Germany, Italy, Denmark, Oman, Canada and the Falkland Islands were in imported animals only, with one doubtful case in Germany
After the completion of this study two cases were reported in the Netherlands in the spring of 1997
Source: OIE; MAFF UK

have been infected within the first two years of their life (Wilesmith and others 1988, Anderson and others 1996). Finally, it was assumed that the exported cattle represented, with regard to BSE, a random sample of the UK cattle population: no distinction was made on the basis of herds of origin, but separate calculations were made for dairy and beef breeds.

Imports

The numbers of cattle imported annually from the UK into the individual member states of the EU were extracted from reports by EUROSTAT, the Statistical Department of the EU, for the years 1985 through 1992. The EU Statistical Department distinguishes four categories of live domestic cattle:

1) Purebred animals for breeding;
2) Animals weighing less than 220 kg (excluding purebred animals for breeding);
3) Live heifers, cows and bulls, all weighing over 220 kg and excluding purebred animals for breeding;
4) Live steers weighing over 220 kg.

The present data relate to animals that were not exported with the apparent intention of being slaughtered, and therefore include only category 1 'purebred animals for breeding purposes' and category 3 'live heifers, cows and bulls, all weighing over 220 kg'. Calves, steers (oxen) and all other categories were thus excluded. The average age of these two categories of animals at the time of their export from Great Britain was assumed to be one-and-half to two years, because the majority would have been bulling heifers or in-calf heifers.

The EU data were checked against data provided by the UK MAFF statistical department (Animal Health, International Trade) and the mean of both datasets was used to calculate the number of animals imported into each country (Table 3). Only the years 1985 to 1989 inclusive were used for the subsequent calculations, because from March 1990 onwards breeding animals were no longer permitted to be exported (or permitted to live beyond six months of age).

Risk index

By combining the numbers of animals imported with the intrinsic risk of each import group to become a detected BSE case had they remained in Great Britain or the UK, a risk index for each country was obtained.

This risk index, indicating the cumulative risk involved in the imports of cattle for the individual countries during the years 1985 through 1989, was calculated from the following formula.

Risk index = sum (n x CI), in which:

n = number of animals imported in a certain year;
CI = cumulative incidence in animals born in the calving season previous to the year of import (that is, one birth cohort earlier).

Subject to the given assumptions, the resulting index equals the potential number of BSE cases imported.

Results

The cumulative incidences for the individual birth cohorts of all the cattle herds are presented in Table 2 and Fig 1. The cumulative incidence for each successive birth cohort increased until that for the 1987/88 cohort, with a peak of 5·4 per cent. This was the calving season just before the feed ban for MBM was introduced.

This means that, for example, an animal born in the calving season 1987/88 had a 5·4 per cent chance of becoming a detected, recognised and confirmed BSE case (which is not the same as 'being infected'), given the culling pattern and detection level in Great Britain.

For dairy herds and beef herds considered separately (calculations not presented), the cumulative incidence peaks were 7·1 and 0·8 per cent, respectively, both in the same calving season as the peak for all herds.

An import risk index for the EU countries was calculated as described above, by combining the numbers of imports given in Table 3 with the cumulative incidence figures in Table 2, using the cumulative incidence in the birth cohort before the year of import. The results are presented in Table 4. This risk index indicates the number of BSE cases that would have been expected to have been detected in the group of cattle imported into a certain country, had these animals remained in the UK and had the culling rate been the same as the culling rate in Great Britain.

For example, Denmark has a risk index of 29. This indicates that Denmark had imported, among the 889 animals imported from the UK in the years 1985 to 1989, 29 animals that would have become detected and confirmed cases of BSE had these animals remained in the UK, taking into account the various assumptions.

The results vary from zero (Greece) to 911 (Republic of Ireland), with the other EU countries in between. The countries are listed in ranking order, starting from 'zero or low risk' to 'high

TABLE 2: Annual and cumulative incidence of BSE in different birth cohorts of cattle in Great Britain

Year of diagnosis	Year of birth 75/76	76/77	77/78	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94
1987	0·0000	0·0000	0·0007	0·0000	0·0029	0·0028	0·0130	0·0229	0·0095	0·0010	0·0000	0·0000	0·0000	0·0000	0·0000	0·0000	0·0000	0·0000	0·0000
1988	0·0000	0·0041	0·0045	0·0033	0·0085	0·0132	0·0432	0·1328	0·1584	0·0446	0·0034	0·0000	0·0000	0·0000	0·0000	0·0000	0·0000	0·0000	0·0000
1989	0·0000	0·0025	0·0062	0·0023	0·0060	0·0166	0·0420	0·1622	0·3530	0·3308	0·0847	0·0071	0·0000	0·0000	0·0000	0·0000	0·0000	0·0000	0·0000
1990	0·0000	0·0000	0·0050	0·0083	0·0113	0·0139	0·0290	0·1127	0·2930	0·4941	0·5689	0·2027	0·0124	0·0000	0·0000	0·0000	0·0000	0·0000	0·0000
1991	0·0000	0·0000	0·0000	0·0099	0·0186	0·0158	0·0398	0·0704	0·1849	0·3774	0·7647	1·1275	0·3940	0·0063	0·0000	0·0000	0·0000	0·0000	0·0000
1992	0·0000	0·0000	0·0000	0·0000	0·0223	0·0186	0·0225	0·0722	0·1352	0·2321	0·6247	1·4873	1·5774	0·1534	0·0061	0·0000	0·0000	0·0000	0·0000
1993	0·0000	0·0000	0·0000	0·0000	0·0000	0·0124	0·0372	0·0709	0·0948	0·1573	0·3479	1·0693	1·7535	0·7230	0·1042	0·0034	0·0000	0·0000	0·0000
1994	0·0000	0·0000	0·0000	0·0000	0·0000	0·0000	0·0223	0·0621	0·0867	0·1133	0·1966	0·5121	1·0177	0·7746	0·3927	0·0458	0·0019	0·0000	0·0000
1995	0·0000	0·0000	0·0000	0·0000	0·0000	0·0000	0·0000	0·0520	0·0600	0·0810	0·1239	0·2605	0·4769	0·5241	0·4671	0·2111	0·0449	0·0007	0·0000
1996	0·0000	0·0000	0·0000	0·0000	0·0000	0·0000	0·0000	0·0000	0·0322	0·0331	0·0507	0·0928	0·1548	0·1770	0·2069	0·1630	0·1207	0·0185	0·0000
Cumulative incidence	0·0000	0·0066	0·0164	0·0238	0·0696	0·0933	0·2490	0·7582	1·4077	1·8647	2·7655	4·7593	5·3867	2·3584	1·1770	0·4233	0·1675	0·0192	0·0000

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TABLE 3: Numbers of animals imported from the UK into other countries of the EU

Year	EU	B/L	Denmark	Germany	Greece	Spain	France	Ireland	Italy	NL	Portugal
1985	16,309	110	112	498	–	1092	243	10,917	115	110	3840
1986	9565	189	222	789	7	795	124	4742	357	86	2253
1987	10,537	80	212	1403	–	252	132	4365	305	955	2831
1988	10,937	95	213	2265	–	277	158	6459	244	117	1108
1989	8128	98	130	1388	–	353	271	4666	400	166	656
1990	(2424)	(41)	(18)	(715)	–	–	(178)	(1293)	(179)	(1906)	–
1991	(335)	–	–	(3)	–	–	(1155)	(261)	(71)	–	–
1992	(178)	(99)	–	(11)	–	(63)	(2623)	(820)	–	(5)	–

In the calculations only the figures for the years 1985 through 1989 are used; figures in brackets are for information only
The figures are the average of data provided by EUROSTAT and MAFF statistical department
B/L Belgium and Luxembourg, NL Netherlands

risk', using the combined dairy and beef incidence rate, the 'average' column in Table 4.

Certain countries may have incurred an actual risk different from the 'average'; for example, Germany, with most of its imports being beef breeds, probably incurred a lower risk, whereas Portugal, with its imports being predominantly dairy cattle, would probably have had a higher risk than the average. In this respect, it is salient to note that Portugal used its British imports mainly to replenish the stock that was culled as a result of the control of contagious bovine pleuropneumonia.

Discussion

The import figures

The data on imports had been extracted from reports by EUROSTAT, the Statistical Department of the EU and MAFF STATS, Department of Animal Health/International Trade. A comparison of the two data sets revealed a number of discrepancies, but both sets were generally speaking congruent: for the years 1985 through 1992, 34 of the 72 data entries were similar, 14 showed a discrepancy of <10 per cent, and 24 showed a discrepancy of >10 per cent. The fact that the two data sets used different categories of livestock was a complicating factor.

Certain categories of animals provided difficulties of interpretation, for example the category 'live heifers, cows and bulls, all weighing over 220 kg and excluding purebred animals for breeding', distinguished in the EUROSTAT data. Have these animals actually been excluded for breeding? For the purpose of this study it was assumed not, and they were therefore included. The data from MAFF STATS, on the other hand, distinguish a category 'cows other than for breeding or dairy purposes'. These animals were not included in the numbers given in Table 2.

Another category that caused some difficulties with interpretation was 'live bovine purebred breeding animals' (MAFF STATS), that continued to be imported even after the ban on livestock imports from the UK. For example, France imported several thousands of this category in 1992, in addition to 192,000 of the category 'live bovine animals of a weight less than 220 kg'. On the basis of their calculated weight, it was nevertheless concluded that the animals from the former category were calves that fell under the directive that demanded slaughter before the age of six months. These animals were therefore not included in the calculations (although some 'leakage' into the local cattle population is likely to have occurred as has been shown by the most recent case in Germany).

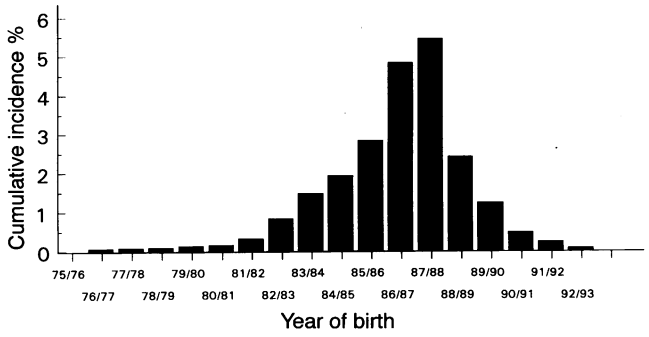

FIG 1: Cumulative incidence of BSE in different birth cohorts of cattle in Great Britain

Only in the case of the Netherlands have the import data been verified with locally available data, from the Produktschap voor Vee en Vlees (PVV), a body comparable to a Commodity Board in the UK. The PVV data were very much in line with the EU statistical data.

It would have been interesting to include other countries, for example new member states like Austria, and countries outside the EU, but not all the relevant data on the import of cattle were readily available, at least not from EUROSTAT. From the MAFF data over the years 1985 through 1988, it is evident that countries like Austria, the former Soviet Union, Egypt, the Gulf States, Pakistan and certain South American countries imported cattle from the UK during the period when the risks were considerable.

The incidence rate

As suggested by the preliminary findings of this study, more cases of BSE were expected in animals exported from the UK into the other member states of the EU than have been identified (Schreuder and Straub 1996). The present results also indicate that cases of BSE in these imported animals would have been expected to have been reported from more member states than was the case at the time of the analysis.

TABLE 4: Numbers of potential BSE cases imported into EU countries in the years 1985 through 1989

Country	Average	Number if imports were: Beef only	Dairy only
Greece	0	0	0
Belgium/Luxembourg	17	2	24
Denmark	29	3	40
France	32	4	43
Netherlands	44	5	62
Italy	50	6	68
Spain	54	6	74
Germany	243	30	334
Portugal	262	26	370
Ireland	911	103	1263
Total	1642		

Confidence interval calculated for the Netherlands for average import only: 32<44<57
Certain countries may have imported a preponderance of dairy cattle (for example Portugal), and others a preponderance of beef breeds (for example Germany). For these situations, differing from the average, the figures in the columns 'beef only' and 'dairy only' can be used. However, the incidence in the exported beef cattle is likely to have been higher than in beef cattle which remained in the UK (see discussion).
The estimates of potential cases in Ireland were based on the incidence of BSE in Great Britain, not Northern Ireland, which has a lower incidence and the figures for Ireland may be overestimates as most Irish imports came from Northern Ireland
Certain recent EU member states are not included owing to the unavailability or incompleteness of EUROSTAT data for the study period

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Although the estimated numbers of cases for several countries were relatively small, it is evident that even these countries have incurred a real risk of importing animals which would develop BSE. The analysis did not involve estimating the probability that a country would not have imported an animal which would develop BSE, except in the case of the Netherlands, where this probability was less than 1×10^{-20}. This calculation would have required a statistical analysis for each birth cohort imported by examining the minimum sample size needed to detect the disease, given the proportion of animals becoming affected. If this approach had been used there is no evidence that the results would have been different because of the numbers of animals imported. For example, assuming that the 213 animals imported into Denmark in 1988 represented a random sample, then this number would already have been sufficient to detect a cumulative incidence of 2 per cent with a 95 per cent confidence (Cannon and Roe 1982). The expected incidence in this particular cohort was in fact much higher than 2 per cent, namely 4·7 per cent.

Although the results in terms of the ranking of the countries by their risk indices is in close agreement with the observed incidence, the precision of the estimates of the number of BSE cases is naturally affected by a number of potential biases.

First, as indicated above, it was not always possible to determine from the import statistics the use, and therefore the ultimate age at death, of some animals. There were, therefore, some categories of animals for which there was a possibility that they were retained for breeding, although the original reason for their importation would have resulted in them being slaughtered at an age before BSE was likely to occur.

Secondly, the average expected numbers are based on the incidence of BSE in both dairy herds and beef suckler herds. As the incidence in beef suckler herds is considerably less than in dairy herds, the average expected numbers are likely to be underestimates as exports in general were of dairy type. Furthermore, there is some evidence that the imported beef-breed animals carried a greater risk than their parent population in Great Britain. This is evident from the cases occurring in Germany and the case in Denmark for which not all of the natal herds have experienced BSE. The supposition is that animals identified for export receive supplementary feeding with concentrate rations and as a result their risk of infection is increased. There is likely to be a similarly increased risk for dairy breeds because the imported animals have been predominantly from pedigree herds which have had a higher risk of BSE occurring than commercial dairy herds, again because of the level of concentrate feeding (J. W. Wilesmith and J. B. M. Ryan, unpublished observations). It was impossible to identify the natal herds for the imported animals from the available data, but it seems likely that all of the estimates of the expected numbers of cases would be conservative.

A third factor which would have had an effect on the observed numbers of cases is the age-specific culling rate. The estimates were produced with no correction for age-specific culling, presuming that the age-specific culling rates in the other member states would be similar to that in Great Britain. Therefore, if the mean age to survival of the imported animals was greater than the mean for cows in Great Britain, for example because of their high value or the husbandry system used, then the expected numbers of cases would again be underestimates.

Conversely, countries with an effective identification and registration system in place could have used this in the early 1990s to their benefit, by carrying out selective culling of this group of high risk animals. A country like the Netherlands, which has an identification and registration system and keeps track of all imported animals (among other reasons in connection with its enzootic bovine leukosis-free status) was in this respect in an advantageous position.

The detection rate

The degree of surveillance in the importing member states is important in comparing the expected number of BSE cases with the number observed. There is no uniform method of surveillance for BSE throughout the EU member states, and it would be difficult to achieve practically. However, more important is the general awareness of BSE which would undoubtedly have been lower outside the UK, in the absence of a significant epidemic of BSE, at least before March 1996 when general awareness increased all over Europe. The identification of cases is hindered by the low within-herd incidence, resulting in singleton cases, and by the lack of knowledge and perception of the clinical signs of BSE. These signs are probably more subtle, particularly in the early stages, than is generally appreciated and confusion with metabolic diseases is undoubtedly a problem.

However, the objective of these analyses was not to expose the potential under-reporting of BSE or to criticise the degree of surveillance in member states of the EU. Rather, it was to highlight the evidence that BSE cases are likely to have occurred in the importing member states. This is important because the epidemiological evidence from the epidemic in Great Britain is that, whatever their origin, the majority of cases have occurred as a result of recycling infected cattle tissues via MBM (Wilesmith and others 1991, Wilesmith and Wells 1991). The future risk of secondary cases occurring will not be the same in all EU countries. There are variations in feeding practices, the efficacy of rendering processes and the year when legislation was enacted to eliminate the feed-borne risk (some countries in the EU imposed a feed ban for meat and bone meal only as late as 1994).

The results of this study should therefore be of assistance in assessing past risks from the importation of live animals into the member states concerned. They also provide information which is of value for the epidemiological study of Creutzfeldt-Jakob disease (CJD), particularly the new variant CJD, in member states of the EU in relation to the incidence of BSE.

Acknowledgements. – The authors wish to thank Mart de Jong and Jaap van Bekkum for critical reading of this manuscript, Bert Kroese for his statistical contributions and Aline de Koeijer for assisting in the calculations. This study was commissioned by the CEC subgroup on TSE surveillance and by the Dutch Ministry of Agriculture, Nature Management and Fisheries, which also provided the financial means for it.

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Veterinary Record 1997 141: 187-190
doi: 10.1136/vr.141.8.187

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