The Epidemiology of Bovine Salmonellosis in Cork and Kerry

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SECTION 1. Tasks

Task Titles

Status

1. Salmonella database.	extended/completed
1. Spatial and temporal epidemiology.	extended/completed
1. Characterisation of salmonella isolates.	completed
1. Epidemiological studies.	modified/completed
1. Population sero-prevalence and longitudinal study of infected farms.	incorporated into task 4
1. Modelling the epidemiology of bovine salmonellosis and identifying practical control measures.	completed

SECTION 2: Results

Task 1: Salmonella Database.

From contemporaneous workbooks in the Cork Regional Veterinary Laboratory, it was possible to identify all submissions since 1981 from which salmonella spp. had been isolated. The initial ***animal salmonella database*** was compiled by retrieving the appropriate records from the RVL archive (1987-2003) and extracting the relevant data in a standardized format. While this database allowed a general overview of salmonella infection in livestock in the catchment area of the Cork RVL, it was not possible to calculate prevalence rates as no denominator data (number of submissions examined for salmonellae) were available. As the laboratory protocol for investigating bovine stillbirths and abortions included a routine bacteriological culture for salmonella, it was decided to compile a second ***bovine abortion***

database comprising data from all cases of bovine stillbirths and abortions. In the absence of any indexing system to identify abortion/stillbirth submissions, this required a manual review of each of the 90,000 records in the archive. To maximise the benefit of such a laborious exercise, all occurrences of a range of diseases of economic or public health significance were also recorded thereby creating a third ***regional animal pathogen database***.

Deliverables:

Databases from submissions to Cork RVL of:

1. Salmonella isolates in livestock, 1981 – 2003
2. Bovine abortions/stillbirths, 1989 – 2003
3. Animal pathogens, 1989 – 2003.

A functional prototype animal surveillance system has been established for the catchment area of the Cork RVL, a region containing approximately one quarter of the national cattle population and 20 per cent of the sheep population. The system could be extended i) to cover a wider range of diseases, ii) to include other regional veterinary laboratories, iii) to capture disease related data from other sources within the Cork RVL area. It has the potential to act as a resource for future epidemiological research and to provide routine and timely advice to farmers on appropriate biosecurity and control measures for specific diseases. An active surveillance system for birth defects in the cattle population of Cork would be a useful addition to environmental monitoring for the county.

Task 2: Temporal and spatial epidemiology.

i) Temporal Distribution

a) Secular trends

Temporal patters in disease prevalence were investigated using a 12-point moving average of monthly aggregated data. (These were not true prevalence rates as the population at risk was not defined. Factors such as year to year variation in the sampling intensity and the decline in the number of active herds over the study period would have been sources of bias.) Time series for the number of outbreaks of Salmonella Dublin and Salmonella typhimurium in cattle from 1981 to 2003 showed the former to be endemic with a complex periodicity while the latter showed two self-limiting epidemic cycles, the first associated with definitive type 204 complex and the second with definitive type 104 complex (Figure 1).

S. Dublin outbreaks were categorised into those characterized by abortion/stillbirth and those where the clinical manifestation was enteric or septicaemic in nature. Abortion associated outbreaks accounted for 70 per cent (1141/1619) of incidents of S. Dublin recorded between Oct. 1989 and Dec. 2003. Time series for the two types of outbreak indicated that the complex periodicity pattern was primarily a feature of S. Dublin abortions (Figure 2). Outbreaks of systemic disease tended to mirror changes in the prevalence of S. Dublin abortions but in a less predictable fashion. Allowing for the cyclic nature of S. Dublin abortions, there appeared to be a decrease in the prevalence of this clinical manifestation, particularly from 1996 onwards. In contrast, numbers of enteric/septicaemic cases showed a progressive increase over the study period.

A number of bovine diseases from the regional animal pathogen database were also subjected to time series analysis for the period Oct. 1989 and Dec. 2003. The results are shown here. Numbers of outbreaks refer only to submissions to the Cork RVL and should not be considered definitive. In the case of notifiable diseases such as brucellosis, BSE or Johne's disease, samples may have been sent directly to the Central Veterinary Laboratory in Abbotstown and would not therefore appear on the Cork RVL database. Private veterinary laboratories would also have examined a proportion of clinical samples from the catchment area and again these data would not be captured. The use of laboratory data to evaluate temporal trends in disease surveillance can also be compromised by changes over time in diagnostic methodology or the performance characteristics of the tests used. Prevalence rates based on bacteriological culture are less susceptible to this form of bias than those based on immunological criteria.

Findings on the main infectious causes of bovine abortion were also expressed in time series format as were rates of vaccination against salmonellosis, leptospirosis and BVD. The results can be found here. As the abortion database contained all cases submitted to Cork RVL, it was possible to calculate true prevalence rates for each pathogen based as the proportion of submissions examined for a given organism that were positive.

b) Seasonality

Another aspect of temporal epidemiology is seasonality or the distribution of cases throughout the year. This could best be assessed using the true prevalence rates available from the abortion database. The proportion of abortion/stillbirth submissions culture positive for S. Dublin, Arcanobacter pyogenes and Listeria monocytogenesby month of submission is shown in tabular form here. Each pathogen showed a slightly different seasonality relative to the predominantly spring calving pattern of the region. S. Dublin tended to occur earliest in the calving season, starting in September and peaking at over 20 per cent of submissions in October/November. Isolates of A. pyogenes and L. monocytogenes both increased from November onwards with the prevalence of A.pyogenes remaining high throughout the winter while L. monocytogenes declined from January onwards.

A comparison of the temporal distribution of Cork RVL abortion/stillbirth submissions relative to the calving and drying off patterns of Cork dairy herds is given here. Two aspects of these data are of particular interest in understanding the pathogenesis of S. Dublin abortions in the cattle population. Firstly the seasonality of S. Dublin positive cases indicates that infection had already been established by late summer/autumn when the animals were still at grass. The second, related observation is that the epidemic did not continue after housing in the remaining population of susceptible pregnant animals despite factors such as intensive stocking rates and increased levels of environmental contamination which could have been expected to increase the probability of disease transmission. These observations, together with the strong temporal association between drying off and the occurrence of S. Dublin abortions, suggest that the act of drying off cows is an important predisposing factor in the activation of latent S.Dublin infection which precipitates an abortion.

The timing of vaccinations against salmonella and leptospira based data from abortion submissions to Cork RVL is shown here. Allowing for the fact that a proportion of Salmonella vaccinations would have been administered following confirmation of S. Dublin infection in a herd, most salmonella vaccinations were given too late in the year to provide protection at the time of greatest challenge.

ii) Spatial Distribution

The spatial distribution of diseases was examined using two separate systems, a) district electoral division (DED) and b) national grid co-ordinates.

a) DED

The use of DEDs enables herds to be grouped into locally contiguous clusters of approximately 40 to 50 herds. The availability of denominator data (number of herds, number of cattle) at DED level makes this system suitable for computing summary statistics. However, the absence of any logical structure to herds within a DED or DEDs within a county renders the system unsuitable for more complex spatial analysis. The distribution of S. Dublin abortions by DED for county Cork is shown here.

b) National Grid Co-ordinates

In recent years, the functionality of the Bovine Tuberculosis Eradication Scheme has been enhanced by the addition of a database containing geographical co-ordinates for each farm, together with a list of all contiguous holdings. While the system is not comprehensive, national grid co-ordinates are available for approximately 90 per cent of the active herds in Cork and Kerry. Using trigonometric functions, simple spatial analysis could be carried out on the basis of national grid co-ordinates. The system is also suitable for more complex methodologies such as the salmonella outbreak detection algorithms used by CDC and PHLS or spatial epidemiological techniques developed at Massey University. An examination of the spatial distribution of birth defects in abortion/stillbirth submissions to Cork RVL is given here.

Deliverables:

1. Spatial distribution maps of any parameter of interest based on DED or National Grid Co-ordinates.
2. Presentation of data in a format suitable for advanced spatial analytical methodologies.

Task 3: Characterisation of salmonella isolates.

The value of any typing system can be judged on a range of criteria including typeability, reproducibility, stability, discriminatory power and epidemiological concordance (Struelens, M.J., 1998) as well as practical considerations such as cost, speed and ease of interpretation. In practice, no single technique meets all these requirements and it is best to use a combination of systems depending on the particular question to be answered. Typing systems such as antimicrobial susceptibility testing (R-typing) and definitive (phage) typing have traditionally been used to identify phenotypic diversity among bacterial isolates. Such systems are used both in outbreak investigations to identify epidemic clones and in disease surveillance to monitor long-term changes in a pathogen as a result of mutation or the introduction of a new variant. Often these techniques provide insufficient definition to monitor specific strains, delineate outbreaks and compare salmonella isolates from livestock and humans. In recent years, a range of new molecular typing systems have been developed which greatly enhance the ability to discriminate between isolates by allowing direct analysis of genetic polymorphism rather than being limited by phenotypic expression.

In association with Cork Institute of Technology (CIT), isolates of S. typhimurium and S. Dublin from Cork RVL were investigated using a number of typing systems. Characterisation of S. typhimurium and S. Dublin isolates from Cork RVL based on these studies together with the results of routine typing carried out by the regional laboratory on salmonella isolates is discussed below. The S. typhimurium study also included human and food isolates. However insufficient information was available on the origins of these samples to effectively evaluate the typing systems in terms of reproducablity or epidemiological concordance.

i) Salmonella Typhimurium

a) Definitive Typing

Definitive typing is normally the first method of classifying S. Typhimurium and isolates from Cork RVL are routinely typed by the UK Central Public Health Laboratory, Colindale or more recently by the Salmonella Reference Laboratory, University College Hospital, Galway.

A total of 20 definitive types of S. typhimurium were identified from the 286 animal isolates made between 1992 and 2003 of which 188 (66 per cent) were DT104 or the closely related strains DT104b, U302 and multiresistant DT12 and DT120. These variants are believed to arise due to changes (instability) in phage susceptibility of DT104 rather than horizontal transfer of resistance genes. A breakdown by host species of the definitive types of S. typhimurium isolates from Cork RVL is shown here. While the majority of DT104 complex isolates were from cattle, a wide range of other host species were also affected. Apart from DT104 complex, the only other definitive types to be found in significant numbers were DT193 and DT208 which were both prevalent in pigs.

The temporal distribution of S. typhimurium definitive types from 1992 to 2003 is shown in tabular form here. While the prevalence of DT104 has declined dramatically in cattle since the peak of the epidemic in 1998, isolates of DT104b and other variants continue, particularly in the pig population. The failure of S. typhimurium to persist in cattle was also a feature of the outbreak of DT204 in the late 1980s as was the emergence of definitive type variants during the course of the epidemic (DT204a and DT204c). However type 204 did not become established in the pig population as now appears to be happening with DT104 complex. If a reservoir of infection becomes established in pigs, this has implications for the future course of the epidemic in both humans and animals. Anecdotal evidence suggests a number of outbreaks of DT104 complex in cattle in Munster have been associated with the presence of a pig enterprise on the farm or the spreading of pig slurry.

b) Antimicrobial Susceptibility (R-Typing)

For many years, Cork RVL has routinely carried out antimicrobial sensitivity testing of salmonella isolates other than those from abortion/stillbirth cases. However, this information was used as an adjunct to clinical treatment rather than as a typing system, the latter requiring a standardised methodology and defined antibiotic levels and breakpoints. Since 2000, salmonella isolates of all serovars other than S. dublin have routinely been sent to the National Salmonella Reference Laboratory in Galway where they have been screened for antimicrobial resistance using NCCLS standard protocol. A number of S. typhimurium isolates from the RVL/CIT study collected between 1996 and 1998 were similarly tested. A breakdown of the antimicrobial resistance patterns observed in these isolates is recorded here.

The results indicate increased levels of antimicrobial resistance in variants of S. typhimurium DT104 compared to the epidemic clone, particularly in isolates of porcine origin. Resistance levels in serovars other than typhimurium also tended to be high in isolates from pigs while those of avian origin were generally low. Apart from two isolates, there was little evidence of possible dissemination of the gene cluster responsible for penta-resistance (R-type ACSSuT) among serovars other than typhimurium.

c) Integron-mediated PCR and DAF Fingerprinting of Salmonella typhimurium

In the joint studt with CIT, two molecular typing systems, integron-mediated PCR and DNA amplification profile analysis (DAF fingerprinting), in addition to definitive typing and antimicrobial resistance profiles, were used to characterise a 68 S. typhimurium isolates from Cork RVL. Data on definitive typing and R-typing have been included in the relevant sections above while the results of the DAF and PCR analyses are considered here. The results did not indicate that either method offers any benefit over currently available typing systems that would justify their inclusion in routine Salmonella typhimurium surveillance.

ii) Salmonella Dublin

In a second study carried out jointly with Cork Institute of Technology (CIT) and not previously reported, three typing systems, namely pulsed-field gel electrophoresis (PFGE), DAF fingerprinting and plasmid profiling, were used investigate diversity among S. Dublin isolates from Cork RVL. The results are discussed here. In summary, both PFGE and plasmid profiling were capable of discriminating between Salmonella dublin isolates while DAF fingerprinting appeared unreliable. However the lack of diversity in both PFGE and plasmid profiles would limit the practical application of either typing system.

Deliverables:

Task 4: Epidemiolgical studies.

A number of desktop studies were carried out in order to quantify epidemiological characteristics of *S*. typhimurium and *S*. dublin outbreaks as they presented in cattle herds in the Munster region. The initial objectives of conducting a full case-control study and longitudinal studies of infected herds were not pursued given the logistical and budgetary constraints of the project.

Observational study of Salmonella typhimurium DT104 outbreaks

A total of 51 farmers with confirmed *S*. typhimurium DT104 cases were interviewed about the clinical course of the outbreak in their herd. These farms accounted for 40 percent of the total of 123 bovine outbreaks of DT104 identified by Cork RVL between 1995 and 2001 and 90 percent of those outbreaks occurring in north Cork and adjacent counties. The results of the survey are given here.

Performance Characteristics of Salmonella Dublin Blood Test.

Performance characteristics of the maternal serology test for Salmonella Dublin were evaluated on a subset of 335 submissions for which culture, serology and vaccination data were available. Test parameters were estimated at cut-off titres of 1:80 for ‘O’ antigens and at

1:160 and 1:320 for ‘H’ antigens. The higher cut-off point for ‘H’ antigens is the one currently used by Cork Regional Veterinary Laboratory with ‘H’ titres of 1:160 being considered inconclusive. Where the dam had been vaccinated against salmonellosis, the sensitivity of the maternal blood test at a cut-off of 1:80 and 1:160 was 42.3% rising to 47.0% where no vaccination had occurred. Test specificity was 90.9% in vaccinated and 98.3% in unvaccinated dams. The proportion of test positives that were truly positive was 73.3% where the dam had been vaccinated and 97.5% where the dam was not vaccinated. The reliability of a negative blood test result was 72.7% and 57.1% in vaccinated and unvaccinated dams respectively.

Where the more conservative cut-off point of 1:80 for ‘O’ antigens and 1:320 for ‘H’ antigens was used, the test sensitivities in vaccinates and non-vaccinates were 23.1 and 20.5% respectively while the corresponding test specificities were 95.5% and 100%. Predictive values of a positive test result increased to 75% and 100% at the higher cut-off point in vaccinates and non-vaccinates respectively while the predictive value of a negative test result fell to 67.7% and 47.4% respectively.

Field Efficacy of Vaccination in the Control of Bovine Abortion

The effects of vaccination against salmonella, leptospira and BVD on bovine abortions were investigated and the results written up as a research report (see here). It is proposed to use this work as the basis of a peer reviewed paper.

Deliverables:

Epidemiological studies on Salmonella dublin and Salmonella typhimurium.

Task 5: Population sero-prevalence and longitudinal study of infected farms.

Modified and incorporated into task 4.

Task 6: The epidemiology of bovine salmonellosis in relation to practical control measures.

Public Health Implications of Bovine Salmonellosis

Most salmonella infection in Irish cattle is caused by one of two serotypes, Salmonella typhimurium and Salmonella dublin, accounting for 11 percent and 85 percent respectively of salmonella isolates by Cork RVL over the last 10 years. Salmonella typhimurium affects a wide range of host species including birds and mammals and is the second most common causes of the disease in humans. In the 1990s, a clone of Salmonella typhimurium, DT104, with a wide spectrum of antibiotic resistance caused a worldwide epidemic in humans and animals. For reasons that remain unclear, cases of Salmonella typhimurium have since fallen dramatically with 135 human cases recorded in Ireland in 2003 compared to 578 in 1998. The decline in the number of cases in livestock is even more dramatic with only 3 outbreaks of DT104 confirmed by Cork RVL in 2003 compared to 63 in 1998.

Salmonella dublin, in contrast, is host specific to cattle with an average of only 10 human cases reported each year in Ireland. However, when people do contract Salmonella dublin, the

consequences can be particularly serious. The case fatality rate for the septicaemic form of the disease in the elderly is 15 per cent, one of the highest for any salmonella serotype. Apart from its pathogenicity, two other characteristics of Salmonella dublin make it particularly important from a public health viewpoint. Firstly, it is very prevalent on Irish farms and secondly, in evolutionary terms, it is only one step away from Salmonella enteritidis, a common salmonella serotype in poultry and the main cause of clinical salmonellosis in humans.

Unlike the self-limiting epidemic of Salmonella typhimurium, Salmonella dublin is endemic in the cattle population in Munster. Approximately one thousand abortion/stillbirth submissions are made annually to Cork RVL of which between 6 and 14 percent are culture positive for Salmonella dublin in any given year. Salmonella dublin related scour or septicaemia, usually in calves, account for a further 20 to 60 confirmed outbreaks per year. Together, these figures suggest an annual prevalence rate of clinical disease of around 14 percent of herds. This high level of infection in the cattle population is not reflected in more human cases due to the host specificity of Salmonella dublin.

One reason for fears that Salmonella dublin could develop into a major human pathogen is its close similarity to Salmonella enteritidis. In genetic terms, differences between strains of Salmonella dublin and Salmonella enteritidis are no greater than those found within each serotype. This indicates that in the recent past, Salmonella dublin and Salmonella enteritidis shared a common ancestor. One branch evolved into a poultry-adapted serotype capable of causing disease in humans, the other into a host-specific cattle pathogen. However there are numerous examples of bacteria suddenly changing their host range or virulence. These include the emergence of E. coli O157:H7 as a major human pathogen in the 1980s and pandemic of Salmonella typhimurium DT104 in the 1990s. Salmonella enteritidis itself emerged as a major human pathogen in the 1970s when it replaced the avian adapted serotype Salmonella gallinarum in domestic poultry flocks. Prior to then, Salmonella enteritidis had been endemic in the rodent population and a sporadic cause of human disease.

Virulence genes have been identified in various salmonella serotypes, including Salmonella dublin and enteritidis, which play a role in determining the host range and pathogenicity of the organisms. Like some genes which code for antimicrobial resistance, these are located on plasmids rather than on the bacterial chromosome. Plasmids are a favourite tool of genetic modification research as they function and replicate independently and provide a simple mechanism for transferring DNA between serotypes and even across bacterial species. They make the acquisition by Salmonella dublin of a plasmid coding for human virulence a distinct possibility.

Awareness of the public health risk posed by bovine salmonellosis is higher in other countries with correspondingly greater effort being put into its control and eventual eradication. As with pigs and poultry, the Scandinavians have taken the lead with Denmark operating a national surveillance programme for Salmonella dublin since 2002. Swedish attitudes to salmonella and food production are particularly uncompromising as the result of an outbreak of Salmonella typhimurium in the market town of Alvesta in southern Sweden in 1953 which left 100 people dead. Farms infected with salmonella, regardless of serotype, are subjected to restrictions which include a total ban on movement of animals except for slaughter. The restrictions remain in place until all animals are declared free from salmonella following bacteriological examination. Furthermore, meat products from any food producing animals contaminated by any serotype of salmonella are deemed unfit for human consumption. For

comparison, a recent Teagasc study found salmonella contamination, predominantly Salmonella dublin and Salmonella typhimurium, on 7.6 percent of carcases in a commercial Irish abattoir. While the Swedish approach might seem somewhat authoritarian to Irish free-marketeers, consumer pressure on quality assurance and fear of lawsuits will drive legislation inexorably in that direction over the coming decade.

Control of Bovine Salmonellosis

Salmonella dublin is one of the easiest diseases to introduce into a herd and one of the most difficult to eradicate once it is present. Herds are also readily infected with Salmonella typhimurium but the disease rarely persists for more than a few months. For herds that are free of salmonella, the priority is to prevent its introduction, which essentially means attention to biosecurity measures. For those that are infected, the objective is to minimise the effects of the disease, which means good management, hygiene and vaccination. To identify the appropriate strategy, it is therefore necessary to know the disease status of the herd. Routine investigation of cases of abortions, stillbirths or cattle deaths will confirm if salmonella is present in a herd as the organism is easily isolated from infected material. In the case of scour, clinical diagnosis of salmonella is usually straightforward but suspected outbreaks should always be confirmed by submitting appropriate samples to the Regional Veterinary Laboratory. If a herd has been reasonably diligent in monitoring its disease status and no evidence of salmonella has been found in the last 5 years, it can be assumed to be clear of infection. Conversely, if Salmonella dublin has been confirmed in a breeding herd, there is a significant risk of persistent infection in carrier cows for as long as animals which were present at the time of the outbreak remain in the herd. The larger the herd, the greater is the risk. Such herds typically experience repeated clinical outbreaks at 5 to 6 year intervals as turnover in the herd produces a new population of susceptible animals.

Status: Susceptible

The main risk factors for introducing Salmonella dublin into a susceptible herd are shown here.

For each potential source of infection, there are appropriate control measures. For example purchasing directly from herds of known disease status and quarantining recently introduced stock will reduce the risk of buying-in disease. Where a number of cattle are being bought from a single source of unknown health status, blood testing is an option, particularly if tests for other high risk diseases such as Johne's, neospora and BVD are included. While the current blood test for salmonella has relatively poor sensitivity and interpretation is complicated by prior vaccination, a significant proportion of animals with positive titres would be highly suspicious.

Salmonella dublin outbreaks tends to occur on an area basis, suggesting local spread from infected herds either by direct contact or via people, vehicles or equipment. Contact between farm visitors and livestock should be kept to a minimum. Where it is unavoidable, such as vets and AI technicians, strict hygiene measures including the use of disinfectant footbaths and clean protective clothing is essential. The spreading of pig slurry and contamination of feed and water by birds have both been implicated in outbreaks of Salmonella typhimurium but are not significant in the case of Salmonella dublin. However the potential of infected

cattle slurry to spread Salmonella dublin between farms either in aerosols or by contaminating waterways has probably been underestimated.

Status: Infected

In infected herds, a different set of risk factors are present (shown here), each again with specific control measures. The most immediate concern in an actively infected herd is to limit the spread of disease. The priority is to segregate and treat clinical cases for which requires an effective isolation unit on the farm. The longer an outbreak goes on before it is diagnosed and control measures are put in place, the greater will be the number of cases and the ultimate cost. If possible faeces of scouring animals should be kept out of the slurry tank as Salmonella dublin can survive for a month in the tank and up to 300 days in the soil after spreading.

Another concern at this stage is the risk to humans, usually children or old people, particularly where Salmonella typhimurium is implicated. High risk activities include nursing sick animals and drinking raw milk. A study of 230 Irish dairy farms by local authority vets found that 83 percent of farm families regularly consumed unpastuerised milk, including herds restricted for TB and brucellosis. The authors recommended the use of home pasteuriser kits or else pasteurised milk should be purchased from normal retail channels. In Northern Ireland, bulk milk tankers leave pasteurised milk on the farm when they make milk collections which is a sensible alternative.

Vaccination

If salmonellosis is confirmed in a herd, a decision has to be taken on whether or not to vaccinate. Vaccination in the face of an outbreak can have an immediate and dramatic effect and should be considered despite the relatively high cost. Vaccination at this stage can also reduce the risk of animals becoming carriers. Routine vaccination of chronically infected herds is again probably justified as these herds tend to have repeated clinical outbreaks every few years due to the presence of carrier cows. At present, there is no effective method to identify and remove such animals from the herd. Herds with no history of salmonella, particularly closed herds with secure boundaries in a clean area, are less likely to recoup the costs of vaccination but may be at risk of serious losses due to the low levels of herd immunity if their biosecurity fails. The decision on whether or not to vaccinate is even trickier in herds that regularly buy in cattle or where neighbouring herds are known to be infected.

There is currently only one bovine salmonella vaccine on the Irish market, Bovivac S, from Intervet. It is licensed for use against the enteric form of salmonella with the manufacturers making no claim that it will prevent abortions, the more common manifestation of Salmonella dublin infection in Ireland. However, the proportion of Salmonella dublin positives in abortion submissions to Cork RVL from herds which are using salmonella vaccine is significantly lower than in herds which are not vaccinating. It appears that vaccination more than halves the risk of a Salmonella dublin abortion. Salmonella abortions tend to occur very early in the calving season, usually between September and November and the precipitating factor in many cases may be stress associated with drying off. Protection afforded by the vaccine does not last a full 12 months and many apparent vaccine breakdowns in the autumn occur where cow abort which were last vaccinated at drying off the previous year. Although

the manufacturers advise that an annual booster be given 3 to 4 weeks pre-calving, it would be better to give the booster 3 to 4 weeks before drying off in order to reduce the risk of a Salmonella dublin abortion.

Deliverables:

Dissemination of research findings on bovine salmonellosis through:

Articles in farming press.

Farmer meetings.

Veterinary clinical society meetings.

Local radio.

Peer reviewed paper on efficacy of vaccination (pending).

SECTION 3:

References:

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