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Survival and dispersal of a defined cohort of Irish cattle

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ABSTRACT

An understanding of livestock movement is critical to effective disease prevention, control and prediction. However, livestock movement in Ireland has not yet been quantified. This study has sought to define the survival and dispersal of a defined cohort of cattle born in Co. Kerry during 2000. The cohort was observed for a maximum of four years, from January 1, 2000 to December 31, 2004. Beef and dairy animals moved an average 1.31 and 0.83 times, respectively. At study end, 18.8% of the beef animals remained alive on Irish farms, including 6.7% at the farm-of-birth, compared with 48.6% and 27.7% for dairy animals respectively. Beef animals were dispersed to all Irish counties, but mainly to Cork, Limerick, Tipperary and Galway. Dairy animals mainly moved to Cork, Limerick, and Tipperary, with less animals going to Galway, Meath and Kilkenny. The four-year survival probability was 0.07 (male beef animals), 0.25 (male dairy), 0.38 (female beef), and 0.72 (female dairy). Although there was considerable dispersal, the number of moves per animal was less than expected.

KEYWORDS: cattle, dispersal, Kaplan-Meier, livestock, movement, survival

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INTRODUCTION

The movement of animals is often implicated in the spread of disease; for example, foot-and-mouth disease (Anderson 2002; Carrique-Mas et al. 2005), scrapie (Gubbins 2005) in Great Britain and Johne’s disease in the Netherlands (Weber et al. 2004). Logically, effective disease prevention, control and prediction depend in part on a sound understanding of movements in relevant animal populations. For a range of diseases, studies have been conducted to define the importance of animal movement and the potential of movement in disease transmission (Sanson et al. 1993; Sanson 1994; Forde et al. 1998; Rojas et al. 2002; Webb and Sauter-Louis 2002; Velthuis 2004). Modelling studies have also been conducted to quantify the role of animal movement in disease spread (Sanson et al. 1993; Nielen et al. 1996; Mangen et al. 2002; Mourits et al. 2002; Bachmann et al. 2005; Chowell et al. 2005; Gubbins, 2005; Kitching et al. 2005) Such is the importance of disease transmission due to animal movements, new methodologies have been adapted from other areas of science, such as network analysis, in a further attempt to describe and predict disease spread (Webb and Sauter-Louis 2002; Bigras-Poulin et al. 2004; Christley et al. 2005).

To-date, no studies have been conducted to quantify the dispersal, movement and survival of Irish cattle. As a result, there is no knowledge on the potential for disease transmission as a result of these movements. The objectives of this study were to describe the movement of cattle born in Co. Kerry in 2000 in terms of dispersal, distance travelled and frequency of moves, as well as the survival of this cohort over a four-year period.

MATERIALS AND METHODS

Cattle production

There are approximately seven million cattle in the Republic of Ireland, including 2.2 million Friesian cows. The latter animals are used in the production of dairy products, the remainder are beef breeds producing beef for export and local consumption. The dairy herd produces five billion litres of milk per year. Counties Cork, Tipperary, Limerick and Kerry hold the largest numbers of dairy cattle, whereas counties Cork, Galway, Tipperary and Mayo have the largest numbers of beef cattle. Approximately 150,000 live cattle are exported from Ireland each year, the majority of which are beef animals. Each year, 1.6 million beef carcasses are exported and 106,000 are slaughtered for domestic consumption.

The data

In Ireland, a central database is used to record the origin, identity and life history of cattle prior to death or slaughter. The database manages calf birth registrations and the Cattle Movement Monitoring System (CMMS). All cattle are uniquely identified, and farmers are obliged to maintain an on-farm herd register, which provides a record of all cattle in the holding, and to register the full details of births, (incoming and outgoing) movements and on-farm deaths. Animal movement data are also captured electronically at livestock marts, meat plants and export points. Components of the database have been operating since the 1950s, with the system being fully-operational since January 1, 2000 (Anon. 2003).

The central database was accessed to identify all registered animals born on farms in Co. Kerry (one of Ireland's 26 counties) during 2000 and to access relevant data including animal identification, date of birth, sex, breed of sire, breed of dam and identification of the birth herd. In addition, we extracted data on all recorded movements prior to January 1, 2004, including date and type of movement, identification of the premises (and county) of origin and destination, and – if relevant – date of death on-farm. We considered each animal movement (farm directly to farm, farm to mart, mart to farm) as a separate event. Therefore, an animal movement between farms via a mart (Farm A to mart, mart to Farm B) was considered two separate events. Animals were considered a dairy breed if both sire and dam were Friesians, and beef otherwise.

Data analyses

The data were managed using Microsoft Access and graphs were produced using Microsoft Excel (Microsoft Corporation, Seattle, WA, USA). To create a spatial representation of dispersal, files were first prepared of each relevant livestock movement. These files included animal identification, the herd (and county) of origin, and the herd (and county) of destination. The Microsoft Access file was then converted to text format using a programme written in Microsoft Visual Basic, stored in ArcInfo and graphed using ArcView (ESRI GIS and Mapping Software, Redlands, CA, USA). The cumulative probability of animals surviving to defined ages was determined using Kaplan-Meier survival curves, based on an analysis of time from birth to death. Data were right-censored if animals were either exported from Ireland on or prior to December 31, 2003, or were still alive on Irish farms on January 1, 2004. The survival curves were produced using Stata version 8 (StataCorp, College Station, TX, USA) following data transfer from

Microsoft Access using Stat/Transfer (Circle Systems, Seattle, WA, USA). Survival curves were created for the birth cohort, in total and by breed (dairy versus beef) and sex.

RESULTS

Survival

A total of 145,211 cattle were born in Co. Kerry during 2000, including 40,068 (27.6%; 19,650 female and 20,418 male) dairy animals and 105,143 (72.4%; 51,223 female, 53,920 male) beef animals (**Figure 1**). The beef animals made 138,186 (average 1.3, median 1, 25th and 75th percentiles one and two, range 0-12) movements during the four-year study period. The dairy animals moved on 33,176 occasions during this period (average of 0.8 moves per animal, median one, 25th and 75th percentiles 0 and one, range zero to seven). At the end of the study period, 19,815 (18.8%) beef animals were alive on Irish farms, including 7,000 (6.7%) animals that had never moved from their premises of birth. Of these latter animals, 5,845 (83.5%) were female. A further 64,155 (61%) beef animals were slaughtered prior to study end, 3,696 (3.5%) died on-farm and 17,477 (16.7%) were exported. During the study period, 14,068 (35.1%) of the dairy cohort were slaughtered, 1,577 (3.2%) died on-farm and 4,963 (13.2%) were exported. A total of 19,460 (48.6%) of the dairy animals survived on Irish farms until the end of the study, including 11,235 (27.7%) of all dairy animals which never moved from their premises of birth. A total of 10,755 (95.7% of these latter) animals were female. The cumulative probability of survival is presented in **Table 1**, and **Figures 2-4**. **Figure 2** shows the changes in the cumulative probability of survival of the study group

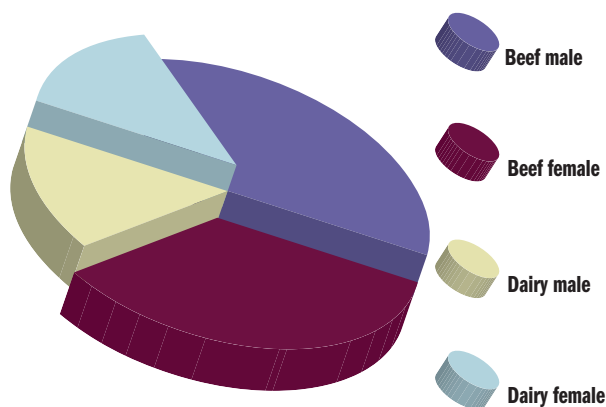


Figure 1: The relative proportion of cattle born in Co. Kerry during 2000, by production type and sex.

Table 1: The probability of survival of the Kerry cohort to 1-4 years of age, including 95% confidence intervals, by production type and sex

Survival to:	Survival probability								
	Production type			Sex		Beef		Dairy	
	Total	Beef	Dairy	Male	Female	Male	Female	Male	Female
1 year	0.97(0.96-0.97)	0.96(0.96-0.96)	0.98(0.97-0.98)	0.97(0.97-0.97)	0.96(0.96-0.96)	0.97(0.97-0.97)	0.95(0.95-0.95)	0.98(0.98-0.98)	0.97(0.97-0.98)
2 years	0.77(0.77-0.78)	0.72(0.72-0.73)	0.89(0.89-0.90)	0.81(0.81-0.81)	0.73(0.73-0.73)	0.80(0.80-0.80)	0.62(0.62-0.63)	0.83(0.83-0.84)	0.94(0.94-0.94)
3 years	0.36(0.36-0.36)	0.26(0.26-0.26)	0.60(0.60-0.61)	0.17(0.17-0.18)	0.57(0.57-0.58)	0.13(0.13-0.14)	0.43(0.42-0.43)	0.3(0.29-0.31)	0.85(0.85-0.86)
4 years	0.29(0.29-0.30)	0.20(0.20-0.21)	0.52(0.51-0.52)	0.11(0.11-0.12)	0.50(0.49-0.50)	0.07(0.07-0.08)	0.38(0.37-0.38)	0.25(0.24-0.26)	0.72(0.72-0.74)

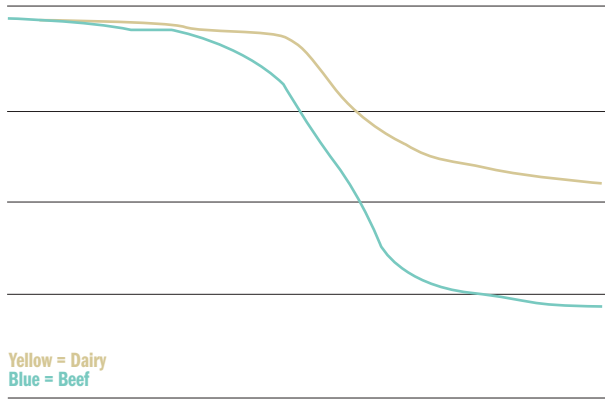


Figure 2: The cumulative probability of survival of cattle born in Co. Kerry during 2000, by production type.

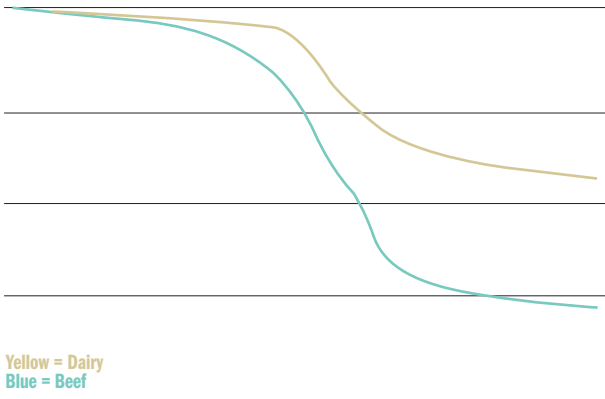


Figure 3: The cumulative survival probability of dairy cattle born in Co. Kerry during 2000, by sex.

by production type over the study period, **Figure 3** the survival of dairy cattle by sex and **Figure 4**, the survival of beef cattle by sex. Survival is longest in female dairy cattle (cumulative probability of surviving to four years of age, 0.72) and shortest in male beef cattle (0.07). There is a steep decline in probability of survival for male cattle between two and two-and-a-half years of age. In contrast, dairy females show a very gradual decrease in their probability of survival throughout the study period. The survival probability of dairy (**Figure 3**) and beef (**Figure 4**) male animals was similar, declining sharply between two and two-and-a-half years of age, in agreement with known industry slaughtering practices. The survival probability of female dairy (0.72) and beef (0.38) animals to four years of age was similar, declining sharply between two and two-and-a-half years of age, in agreement with known industry slaughtering practices. The survival probability of female dairy (**Figure 3**) and beef (**Figure 4**) male animals was similar, declining sharply between two and two-and-a-half years of age, in agreement with known industry slaughtering practices. The survival probability of female dairy (0.72) and beef (0.38) animals to four years of age was similar, declining sharply between two and two-and-a-half years of age, in agreement with known industry slaughtering practices.

Dispersal

The dispersal of beef animals during the study period is presented in **Figures 5** and **6**. Beef cattle moved an average of 49.4 kilometres per farm-to-farm move (median 20 km, min. <1 km, 25th and 75th percentiles 7 and 49 km, max. 321 km). Dairy cattle moved an average of 44.6 kilometres per farm-to-farm move (median 19 km, min. <1 km, 25th and 75th percentiles 6 and 50 km, max. 326 km).

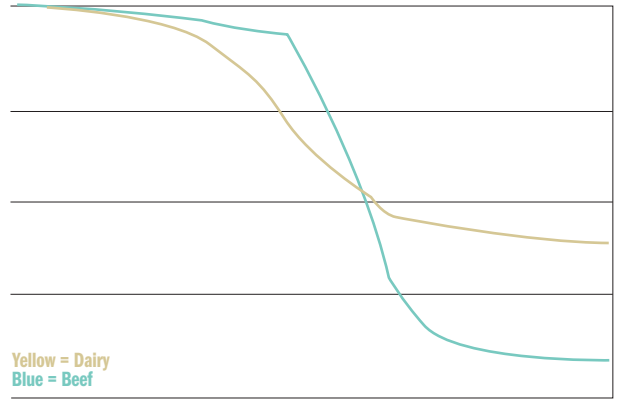


Figure 4: The cumulative survival probability of beef cattle born in Co. Kerry during 2000, by sex.

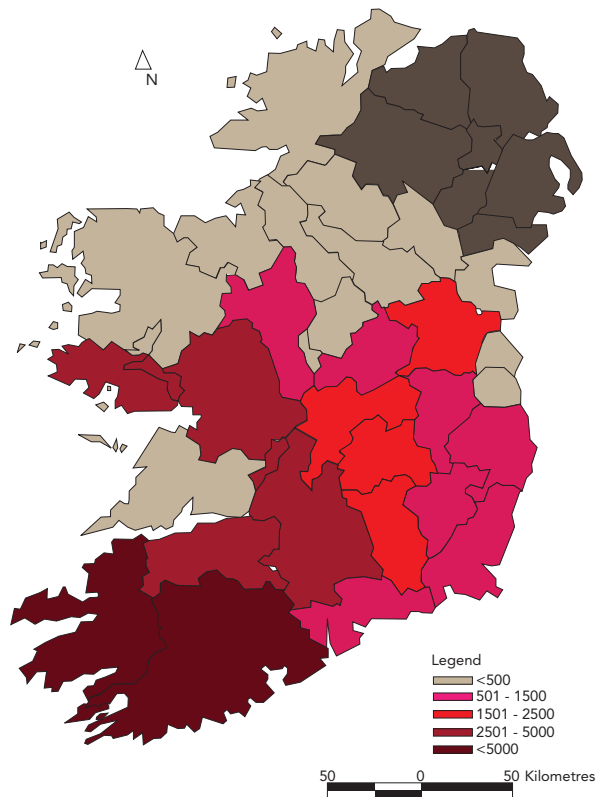


Figure 5: The location, on January 1, 2002, of beef cattle born in Co. Kerry during 2000.

DISCUSSION

Dispersal

There was substantial dispersal of cattle throughout Ireland, with dairy and beef animals from this Kerry birth cohort moving to every other county by the beginning of January 2002 (for beef animals, see **Figures 5** and **Figure 6**). As expected, dispersal was affected by distance, with counties closer to Kerry receiving more animals than counties that were more-distant. For example, on January 1, 2002, there were 4,706 beef animals from the birth cohort in Limerick and 6,371 in Cork, in comparison to 72 and seven beef animals in the more distant counties of Monaghan and Cavan, respectively. Although no account is taken of county size (or cattle population), the general trend is clear. However, more than distance

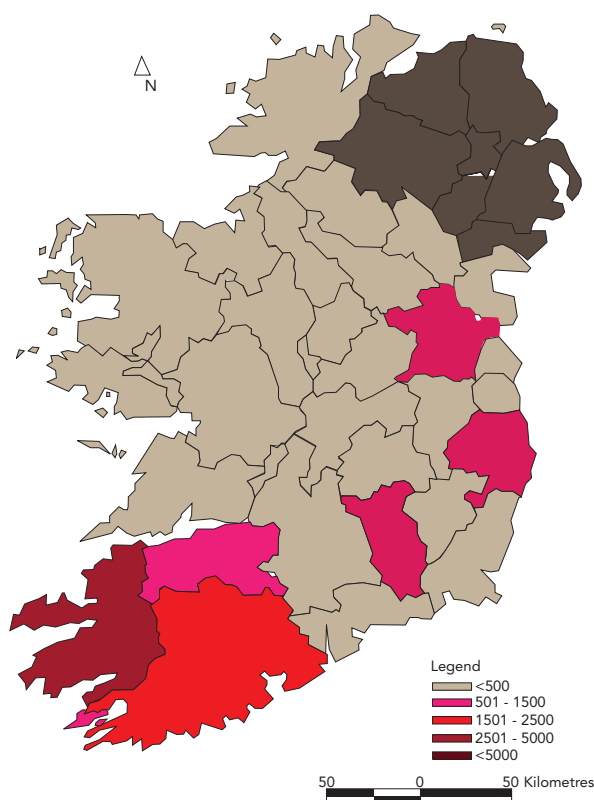


Figure 6: The location, on January 1, 2004, of beef cattle born in Co. Kerry during 2000.

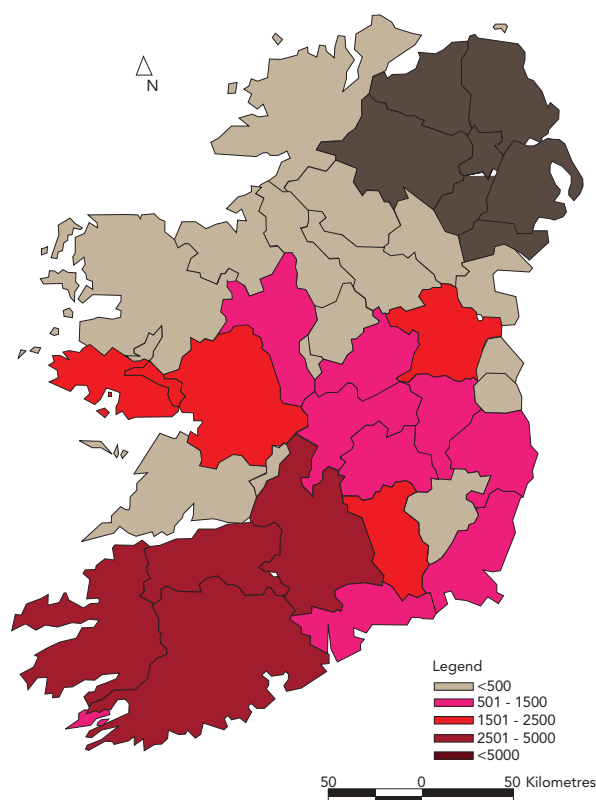


Figure 7: The location, on January 1, 2002, of dairy cattle born in Co. Kerry during 2000.

alone affects the dispersal of animals. To illustrate, fewer animals moved to Co. Clare (immediately north of Kerry across the River Shannon) than might be expected. On January 1, 2002 there were 334 beef animals from the birth cohort in Clare, and 3,016 in Galway (which is more distant). These results add weight to a widely held view of Clare as a net exporter of cattle. Conversely, Meath, a traditional cattle-fattening county in the north east of Ireland, received more cattle than any of its neighbours. The dispersal of animals throughout the country has major implications for the spread of disease (Anderson, 2002; Weber *et al.* 2004; Carrique-Mas *et al.* 2005; Gubbins, 2005). In particular, as a result of rapid movement and widespread dispersal, there is the potential for rapid dissemination of infection prior to the development of clinical signs. Further work is needed to investigate the implications of movement on disease control in an Irish context. Mathematical modelling may be of particular benefit, specifically with the aim to predict the spread of infection following introduction. Other methodologies, such as network analysis (Webb and Sauter-Louis, 2002; Bigras-Poulin *et al.* 2004; Christley *et al.* 2005) may also contribute to our understanding of livestock movements and the potential for disease spread.

Survival

Survival analysis has been used previously in Austria (Eszl 1998), Italy (Samore *et al.* 2003) and Kenya (Ojango *et al.* 2005) to describe the changes in probability of survival

of livestock. To this point, the survival experience of Irish cattle has not been quantified. The results from this work are essentially as expected, based on our knowledge of routine practices within the Irish cattle industry. The difference in survival due to production type (Figure 2) is due to the actual use of beef versus dairy cattle. Among the study population, there was a very gradual decline in survival probability among dairy cows with age, indicating their use for production purposes over a number of years (Figure 3). Dairy males on the other hand are not so long lived. Beef females, however, are less likely to be retained in the herd when compared to their dairy counterparts (Figure 4).

Extrapolation of results

Kerry has one of the largest cattle populations of any Irish county (145,211 births registered in Kerry compared with 2.1 million nationally in 2000); it was chosen as a starting point for the study of cattle movements because of this relatively large, yet manageable, number of cattle and moves, from a viewpoint of data management and manipulation. However, there are substantial regional differences in cattle management throughout Ireland, as reflected in objective measures such as the proportion of agricultural land, the density of stock, the type of land and of farms. Furthermore, severe restrictions were placed on livestock movements throughout Ireland during 2001, at the time of the foot and mouth disease outbreak. This prevented all livestock from moving for a period of time, and may have altered animal movement

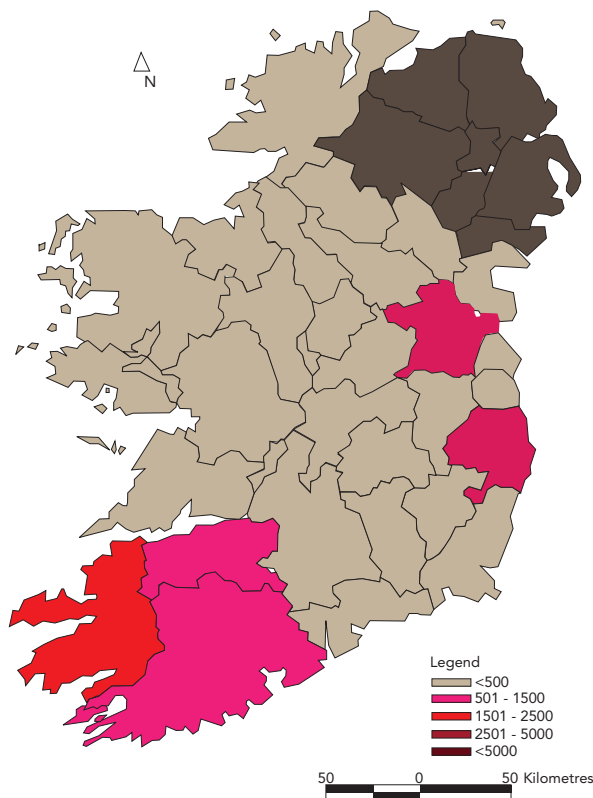


Figure 8: The location, on January 1, 2004, of dairy cattle born in Co. Kerry during 2000.

patterns subsequently. Since the end of the study period, there have also been substantial changes to the Common Agricultural Policy of the European Union. Although there remains an incomplete understanding of the effect of these changes, these reforms are certain to effect the numbers of stock kept. As a consequence of each of these issues, the Kerry results should only be extrapolated to other regions with care.

Farm to fork

This study was only possible as a consequence of the national animal identification and tracing system, managed by the Department of Agriculture, Fisheries and Food. The main components of the system include calf birth registration and the cattle movement and monitoring system. The resulting database is robust, as a result of tagging and registration of all calves at birth, as well as an extensive national mechanism to trace livestock from birth to slaughter. Nonetheless, some degree of error is likely, for example data absence (animals dying before being registered) or invalidity (illegal alteration of identity as a result of ear tag swapping). These issues were not considered in the current study, and will only have a substantial effect if these errors are common.

CONCLUSION

The dispersal and survival of cattle in Ireland have been quantified for the first time. This data could now be used to model the spread or prevalence, and the impact of control measures, of various diseases such as brucellosis or BSE and reinforces the importance of the Cattle

Movement and Monitoring System (CMMS) in ensuring both public and animal health.

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