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Salmonella Dublin infection in young dairy calves: Transmission parameters estimated from field data and an SIR-model

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Abstract

In this study we used field data collected from October 2001 to January 2002 to estimate number of days of faecal excretion of *Salmonella* Dublin bacteria and time to seroconversion in infected calves below the age of 180 days. Based on these estimates all calves in four endemically infected dairy herds were grouped into the following infection states: susceptible (*S*), infectious (*I*) and resistant/recovered (*R*). Resistant calves had either acquired maternal antibodies through colostrum or they have recovered from previous infection and had a high level of antibodies directed against *Salmonella* Dublin possibly protecting them from becoming infected again until the level of antibodies had decreased to sufficiently low levels. Using the antibody measurements and faecal excretion periods, it was possible to assign the most likely infection state to each calf per week of the study period.

Estimates of transmission parameter, β, were obtained from a generalised linear model relating the number of new infections to the proportion of susceptible and infectious calves per week. From β, the reproduction ratio R at steady state and the basic reproduction ratio R_0 were estimated for each herd and across herds. The R_0 denotes the average number of new infections caused by one infectious individual that is introduced to a fully susceptible population. The point estimates for R_0 ranged from 1.1 to 2.7 in the study herds. However, the confidence intervals were wide. Data were too limited to show possible significant differences in the parameters between the study herds. However, the tendency in the data suggested that there may be important differences. Across herds the R_0 was close to two suggesting that on average one infectious calf will produce two new infectious calves when introduced into a fully susceptible population under typical Danish dairy production systems. Further,

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the analyses indicated that environmental contamination from infectious calves plays an important role in transmitting *Salmonella* Dublin between calves.

Keywords: *Salmonella* Dublin; Transmission; SIR; Calves

1. Introduction

Salmonella Dublin is a cause of concern in the cattle industry, because it is a zoonosis causing severe invasive infections in humans and because it causes economic and welfare losses in infected herds (Peters, 1985; Helms et al., 2003). The infection has a tendency to become endemic in many cattle herds in Denmark. When attempting to control *Salmonella* Dublin infections in such dairy herds it is critical to intervene in the calf barn where the infection spreads readily. However, not much is known about the infection dynamics of *Salmonella* Dublin in calf barns of endemically infected herds, because most information comes from outbreak situations and clinical cases (Richardson and Watson, 1971; Wray et al., 1989). Knowledge about the basic reproduction number, R_0, is useful for modelling the infection and the effect of potential intervention strategies. The net reproduction number, R, at steady state is one, meaning that on average every individual that becomes infected succeeds in transmitting the infection to one other individual during its infectious period (Anderson and May, 1991, p. 17). However, R_0 must be above one for any endemically stable disease, meaning that when one infectious animal is introduced into a fully susceptible population on average more than one animal will become infected and thus outbreaks may also occur. In endemically infected herds, the proportion of susceptible animals varies over time. Thus, the infection may die out, or a new outbreak may occur. The size of the outbreak is mainly related to the number of susceptible individuals in the herd (Anderson and May, 1991, pp. 68–69). This is supported by varying clinical signs over time and fluctuating seroprevalence of *Salmonella* Dublin in infected herds that makes it reasonable to assume that even in endemically infected herds, smaller outbreaks are occurring intermittently over time.

The aims of the study were to (1) estimate length of the infectious periods and serological response to infection in calves below 180 days of age from field data, (2) illustrate fluctuations in size of the infection states S (susceptible), I (infectious) and R (recovered/resistant) over time and (3) to estimate the transmission parameters, β, R and R_0 for *Salmonella* Dublin among young calves (<180 days old) in four Danish dairy herds with long-term infection on the premises.

2. Materials and methods

2.1. Study herds and sampling

The estimates were obtained by the use of field data collected in Denmark in 2001–2002 and a generalised linear model relating the number of new infections to the proportion of