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Risk factors associated with the presence of *Campylobacter*-positive broiler flocks in Sweden

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ABSTRACT

Approximately 40% of Swedish broiler producers deliver *Campylobacter*-negative broilers in 90–100% of their flocks, showing that it is possible to produce *Campylobacter*-free broilers in Sweden. This study investigated risk factors associated with the presence of *Campylobacter*-positive flocks at Swedish broiler producers. A total of 37 producers, with 90 broiler houses including 144 compartments, participated in the study. An on-farm interview was performed to collect information on potential risk factors for *Campylobacter* infection in broilers, with questions about farmcharacteristics such as the environment around the farm and broiler houses, design of the broiler houses and on-farm management practices. Negative binomial regression models were used to assess the statistical significance of risk factors associated with the within-farm number of *Campylobacter*-positive flocks (the outcome).

Campylobacter is transmitted in broiler flocks due to multiple factors and several potential sources, illustrating the complexity of *Campylobacter* epidemiology in broilers. Factors significantly associated with increased proportion of *Campylobacter*-positive flocks were the presence of other livestock on the farm, or the presence of cattle, swine, poultry or fur animals within 1 km of the farm. Poor or average general tidiness were associated with increased proportion of *Campylobacter*-positive flocks, but decreased if split slaughter was seldom or never applied or if farm workers changed footwear twice or three times instead of once before entering the broiler house.

1. Introduction

Campylobacter jejuni is frequently found in the intestinal tract of a wide variety of wild and domesticated animals, especially birds (Blaser et al., 1983; Skirrow, 1994). Poultry are an important reservoir of *C. jejuni* and the consumption and handling of broilers presents a risk of human campylobacteriosis (Blaser et al., 1983; Deming et al., 1987; Altekruse et al., 1999). As *C. jejuni* has a wide host range, there may be many potential sources of infection for broilers (Evans, 1992; Newell and Fearnley, 2003), and although *Campylobacter* can be isolated from nearby animals and the surrounding environment, the transmission routes to a broiler flock are not completely understood.

Under normal commercial broiler production conditions, broilers are rarely colonised by *Campylobacter* spp. before two weeks of age (Jacobs-Reitsma et al., 1995; Berndtson et al., 1996; Newell and Wagenaar, 2000; Bull et al., 2006; Hansson et al., 2007). Vertical transmission from infected breeder flocks has not been demonstrated and hence horizontal transmission from the environment is more likely (Shanker et al., 1986; van de Giessen et al., 1992; Humphrey et al., 1993; Jacobs-Reitsma, 1997; Callicott et al., 2006). According to studies performed in the early 1990s by Mead et al. (1995), improvements in hygiene at slaughter to reduce *Campylobacter* in broilers

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have little impact on the risk to consumers. Changes at farm level might therefore be more cost-effective in producing *Campylobacter*-free broilers, although Wagenaar et al. (2006) believe that preventive measures in primary production have a limited and unpredictable effect.

A number of studies have been performed to explain some of the transmission routes of *Campylobacter* spp. into broiler flocks. Risk factors identified by these studies include higher age of broilers at slaughter (Bouwknegt et al., 2004; McDowell et al., 2008), the presence of other livestock within 1 km (Bouwknegt et al., 2004; Cardinale et al., 2004; Ellis-Iversen et al., 2009), broiler houses with static air distribution (Refregier-Petton et al., 2001), higher number of persons taking care of the house (Refregier-Petton et al., 2001), season (summer) (Kapperud et al., 1993; Refregier-Petton et al., 2001; Bouwknegt et al., 2004; Ellis-Iversen et al., 2009) and flock depletion (Hald et al., 2001). In the first year of the revised Swedish *Campylobacter* programme (1 July 2001 to 30 June 2002), about half of the producers included delivered 90% of the *Campylobacter*-positive slaughter batches. Furthermore, one-quarter of producers did not deliver any *Campylobacter*-positive slaughter batches at all (Hansson et al., 2004), and thus it appears possible to consistently produce *Campylobacter*-free broilers in Sweden.

The aim of this study was to identify risk factors for *Campylobacter* spp. in Swedish broiler flocks, particularly with regard to broiler house environment, design of buildings and farm management practices.

2. Materials and methods

2.1. Study population

In Sweden, a broiler farms is a holding with one or several broiler houses, each house consisting of one to four compartments and each compartment producing up to eight flocks per year. A flock means all broilers kept in the same compartment sharing the same airspace. One flock can be divided into one to three slaughter batches, often referred to as split slaughter or flock depletion. Members of the Swedish Poultry Meat Association (SPMA) produce about 98% of the broilers in Sweden. The production schedule is tight, with pre-planned hatching, rearing and slaughter. During 2008, 73.6 million broilers were delivered to slaughter from 122 broiler farms with 462 compartments, all members of SPMA. All broiler producers and slaughter houses are situated in the southern quarter of Sweden.

2.2. Study design

Thirty-seven (30%) of the 122 SPMA producers, representing 90 broiler houses with 144 compartments, were randomly selected for the present study and all farmers contacted collaborated generously. The 37 broiler producers selected for study were visited once all over the year 2005 by the same visiting researcher, and all 37 participating farmers answered the on-farm interview. The interview included questions about a wide range of factors, such as the surroundings of the farm, including other animals on the farm and nearby, the design of buildings, the house environment, hygiene and working routines (Table 1). The questionnaire (in English or Swedish) is available from the corresponding author upon request. Some questions were answered either yes/no or countable, while in other questions a judgement was performed by the first author, for example the status of the general tidiness and hygiene barrier, which was classified into one of the three levels: poor, average or good. When judging the general tidiness, the farms were allocated in three different groups, those with the lowest level of tidiness were rated poor and those with the highest level were rated good. This resulted in three not uninformed groups of farms. The rating of the hygiene barrier was reduced e.g. if there was no solid wall at the bench at the hygiene barrier, if there was no proper barrier between the footwear used outside and the footwear used inside the broiler house and if the doors into the broilers could not be closed properly. In Sweden, broiler producers mostly use all in/all out systems, but sometimes a flock could be split in two or three slaughter batches. However, after the last depletion there is always an empty period, which is the time between slaughter of the previous flock and repopulation. The length of this empty period is dependent on the market demand for broiler meat, such that when the demand is high, the empty period is brief. During this study the empty period varied between one and four weeks.

Table 1
Risk factors, divided into three subject-orientated groups, used to find associations with number of *Campylobacter*-positive flocks on 37 broiler farms in Sweden.

Variables	Total number of variables
Environment Surroundings on the farm and nearby, water source, livestock on the farm and nearby, storage of manure, distance to slaughterhouse	10
Housing No. of houses and compartments, no. of broilers, broiler density, building material, age of building, building characteristics especially concerning floor, doors, windows, feeding, water and ventilation system, type of bedding, handling of manure, cleaning routines for the broiler house, hygiene barrier, rodent control, sprinkler, empty period	30
Management Experience of broiler production, production of livestock other than broilers, number and type of farm workers, hygiene practices, slaughter, handling of dead broilers	19
Total	59

2.3. Data collection

All farms were visited between January 2004 and May 2005. The cumulative incidence of *Campylobacter*-positive flocks per herd was calculated using data from the Swedish monitoring programme during the previous three-year