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The effects of building design on hazard of first service in Norwegian dairy cows

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ABSTRACT

Reproductive inefficiency is one of the major production and economic constraints on modern dairy farms. The environment affects onset of ovarian activity in a cow postcalving and influences estrus behavior, which in turn affects a stockperson's ability to inseminate her at the correct time. This study used survival analysis to investigate effects of building design and animal factors on the postpartum hazard of first service (HFS) in freestall-housed Norwegian Red cows. The study was performed on 232 Norwegian dairy farms between 2004 and 2007. Data were obtained through on farm measurements and by accessing the Norwegian Dairy Herd Recording System. The final data set contained data on 38,436 calvings and 27,127 services. Univariate Cox proportional hazard analyses showed that herd size and milk yield were positively associated with HFS. Total free accessible area and free accessible area available per cow year were positively associated with the HFS, as was the number of freestalls available per cow. Cows housed on slatted floors had a lower HFS than those housed on solid floors. Conversely, cows housed on rubber floors had a higher HFS than cows on concrete floors. Dead-ending alleyways reduced the hazard of AI after calving. A multivariable Cox proportional hazards model, accounting for herd management by including a frailty term for herd, showed relationships between hazard of postpartum service and explanatory variables. Animals in herds with more than 50 cows had a higher HFS [hazard ratio (HR) = 3.0] compared with those in smaller herds. The HFS was also higher (HR = 4.3) if more than 8.8 m^2 of space was available per cow year compared with herds in which animals had less space. The HFS after calving increased with parity (parity 2 HR = 0.5, parity ≥3 HR = 1.7), and was reduced if a lactation began with dystocia (HR = 0.82) or was a breed other than Norwegian Red (HR = 0.2). The frailty term, herd, was large and highly significant indicating a significant proportion of the variation resides at herd level. The hazard of first insemination decreased with time for all predictive variables, except dystocia. This study shows that providing adequate environmental conditions for estrus behavior is imperative for reproductive efficiency and after herd management factors and time from calving have been accounted for. Thus, optimizing building design for reproductive efficiency is of significant importance when constructing new cattle housing.

Key words: reproduction, dairy cow, freestall, housing

INTRODUCTION

Reproductive efficiency is one of the most important factors affecting the productivity, profitability, and also the environmental impact of dairy farming (De Vries, 2006; Lucy, 2007; Garnsworthy, 2011). Despite its key role in milk production and pressure to improve productivity, dairy cow reproductive performance has declined over the past half century (Royal et al., 2000; Lucy, 2007). Although recently reproductive performance appears to have stabilized in many populations throughout the world (Philipsson, 2011). A wide array of factors have been implicated in this fertility decline; genetics, feeding, metabolic stress, concurrent disease, reduced estrus expression, and reduced identification of estrus behaviors have all been reported to cause reduced reproductive performance (Lucy, 2007; Dobson et al., 2008). However, on a worldwide basis, it is most probable that a combination of these factors have brought about the decline in dairy cow fertility (Lucy, 2007).

Norway is one of the few countries in the world in which phenotypic dairy cow reproductive performance has remained constant (Refsdal, 2007). The Norwegian Red breed accounts for approximately 95% of the Norwegian dairy population. Nonreturn to service rates have been included in the breeding index of the Norwegian Red with a relative weight of between 8 and 15% since 1972 (Andersen-Ranberg et al., 2005b). More recently, the interval from calving to first service (**CFS**) has been included in the breed's total merit index (Andersen-Ranberg et al., 2005a; Geno, 2014).

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In large part, the stable reproductive performance of the Norwegian Red has been attributed to the breeding program (Andersen-Ranberg et al., 2005b; Garmo et al., 2009b). However, phenotypic performance is the result of a combination of genotype, environment, and genotype by environment interaction. Little attention has been given to the moderate yield of Norwegian cows (average yield in 2005 = 6,541 kg), the relatively small herds they are kept in (average herd size in 2005 = 16.7 cow years), the low levels of endemic infectious disease in Norway, or absence of routine use of timed AI breeding programs, all of which affect reproductive performance (Østerås et al., 2007; Refsdal, 2007). The absence of routine estrus synchronization and low levels of infectious disease (Østerås et al., 2007) make the study of environmental factors affecting reproduction less likely to be confounded by veterinary interventions in Norway than in other parts of the world.

Environmental influences are known to affect estrus behavior, the identification of which is a prerequisite for AI to be performed in the absence of timed AI programs (VanVliet and VanEerdenburg, 1996; Orihuela, 2000; Platz et al., 2008). Despite this, little work has been published on the effect of building design on traditional fertility measures. Although the importance of social interactions for reproduction has been discussed by several authors (Roelofs et al., 2005; Dobson et al., 2008; Sveberg et al., 2013), relatively few studies have been carried out to identify optimal herd size or space required per cow for displaying estrus behavior in freestall systems. Although the effect of herd size on reproductive performance is likely to be complex, one recent Norwegian study modeled 20 versus 50 cow herds and found the latter to have slightly improved reproductive performance (Simensen et al., 2010). In 2010, traditional tiestall housing was still the most common way to house Norwegian dairy cattle. However, legislation passed in Norway bans the use of cattle tiestalls from 2024 (Lovdata, 2013). Dairy producers with these facilities must build cubicle sheds or cease cattle production by 2024. Therefore, information about how building design influences cattle health and production is needed so that building designs can be optimized and returns from capital investments maximized. Our study aimed to investigate the effect of specific environmental factors, such as herd size, stocking density, floor type, and building layout, on CFS in Norwegian dairy cattle.

MATERIALS AND METHODS

Farm Selection

This study was part of a larger descriptive and cross-sectional project on freestall housing in Norwegian dairy herds (Kielland et al., 2009; Naess and Boe, 2010). The Norwegian Dairy Herd Recording System (**NDHRS**, Ås, Norway), which in 2005 held records from 11,600 dairy farms, provided a list of 2,400 herds that were believed to have cattle housed in freestalls. A preliminary questionnaire was sent to these farms to gather background herd information and determine their willingness to participate in the study. Inclusion criteria for the study were farmers' willingness to participate, herd size >20 standardized cow years (based on the year 2005), barns built between 1995 and 2005, and the presence of freestalls. One cow-year was defined as the sum of the total of individual feed days for all cows in a herd over the course of a calendar year divided by 365. All farms that fulfilled the inclusion criteria were included in the study.

Data Collection

The herds were visited once during the indoor housing period between September 2006 and June 2007 by trained technicians; their training has previously been described (Naess and Boe, 2010). The technicians recorded type of flooring (in the alleys and feeding area), free accessible area (**FAA**; alleyways, freestalls, feeding areas), number of alleyways, number of dead-ending alleyways, and the total number of freestalls present on the farm for the adult cows (Naess and Boe, 2010). Herd level data were gathered from NDHRS database, including average herd milk yield per cow year (total milk delivered from the farm annually per cow years) and herd size (in cow years). Lactation level data were also extracted from this database (i.e., parity, breed, calving and service dates, as well as occurrence of dystocia).

Statistical Analysis

All available data concerning the lactations that occurred on the study farms in the period 2004 to 2007 were gathered in one database. The statistical program Stata 11 (Stata Corp., College Station, TX) was used for all analyses. This study was performed at the lactation level and cows could contribute more than one lactation to the study. The clustering effect of repeated lactations in individual cows was not accounted for in the statistical analyses. Cox regression analyses were performed and the outcome variable was CFS. The start day was the day of calving (DIM 1). The time to event was set as the time to first service after calving. Lactations which did not have any services were censored when an animal was culled or left the farm. On DIM 285, lactations were right censored if no record of service or AI had been recorded. The term stop day was used to describe right censoring.