J. Dairy Sci. 98:889–897
http://dx.doi.org/10.3168/jds.2014-8366

Variation in the interservice intervals of dairy cows in the United Kingdom

J. G. Remnant,[1] M. J. Green, J. N. Huxley, and C. D. Hudson
School of Veterinary Medicine and Science, University of Nottingham, Sutton Bonington Campus, Sutton Bonington, Leicestershire, LE12 5RD, United Kingdom

ABSTRACT

An understanding of the normal estrous-cycle length of the cow is important when managing and monitoring dairy-herd fertility. Although the normal interovulatory interval is widely considered to be 21 d, some studies have found alternative intervals to be more prevalent; previously, most of the variation in interval length was expected to be between cows. The aim of this study was to assess the time between inseminations (interservice interval, ISI) in a large number of dairy cows and to explore possible associations between cow factors and estrous-cycle length. The study used ISI data from 42,252 cows in 159 herds across England and Wales. Univariate analysis of the subset of 114,572 intervals between 15 and 30 d (a range covering the increased frequency of ISI occurring at the expected time of the first return to estrus) following an insemination revealed a modal ISI of 22 d. Primiparous heifers had a modal ISI of 21 d. Significant differences existed between the distribution of ISI for different yield groups, parity numbers, and the number of inseminations. Multilevel regression modeling was used to evaluate the associations between cow factors and ISI, while accounting for clustering at the herd and cow level. This revealed significant associations between predicted ISI and insemination number, days in milk, lactation 305-d milk yield, and month and year of insemination. Variance partition coefficients indicated that only 1% of variation in ISI was at the herd level, 12% at the animal level, and 87% at the insemination level, indicating that cycle length varies substantially more between cycles within a cow than between cows or herds. These findings suggest the normal range of ISI for modern UK dairy cows is longer than expected and cycle length has a large amount of unexplained variation within individual animals over time.

Key words: interservice interval, interovulatory interval, estrous cycle

INTRODUCTION

Good reproductive performance is an essential part of any successful dairy enterprise, and heat detection is an important part of this in herds using artificial insemination. It is commonly accepted that the estrous cycle of domestic cattle (*Bos taurus*) is approximately 21 d long, with a normal range of between 18 and 24 d (Hartigan, 2004; Forde et al., 2011). A more accurate knowledge of normal cycle length may contribute to improved heat detection. It has been demonstrated that variation in estrous-cycle length occurs primarily between cows rather than within cows (Olds and Seath, 1951). The number of follicular waves in the estrous cycle of a cow affects the interovulatory interval (**IOI**; Ginther et al., 1989), and the number of follicular waves in a cycle is also repeatable between cycles within a cow (Jaiswal et al., 2009). Some studies have shown improved fertility in cows following 2-wave cycles as opposed to 3-wave cycles (Townson et al., 2002). Explaining the between-cow variation in IOI may uncover mechanisms to improve fertility.

The expected normal range of IOI is used to calculate a variety of fertility parameters employed by veterinarians, farmers, and other professionals to monitor dairy-herd heat detection (Hudson et al., 2012b). These include first-service submission rate (the proportion of cows that are inseminated within 24 d of the end of the voluntary waiting period), return-to-service submission rate (the proportion of cows reinseminated 18 to 24 d after an unsuccessful insemination), and analysis of interservice interval (**ISI**) profiles. Expected cycle length could also affect the interpretation of commonly used indices for monitoring overall reproductive performance, such as the proportion of eligible cows becoming pregnant every 21 d (21-d pregnancy risk or fertility efficiency, common in year-round calving herds) or the proportion of cows pregnant within the first 21 or 42 d of the breeding season (in seasonally calving enterprises). As well as allowing useful monitoring of heat detection, awareness of the normal ISI can directly help improve heat detection by allowing more accurate prediction of the next heat. A reliable figure is also useful in research, for example for constructing

---

Received May 15, 2014.
Accepted November 8, 2014.
[1] Corresponding author: john.remnant@nottingham.ac.uk

simulation models of reproduction, with many authors using a fixed cycle length of 21 d in their models (Brun-Lafleur et al., 2013).

Globally, milk yield has been increasing over time, and until recently, dairy-herd fertility had been declining. Delayed return to normal ovarian cyclicity, reduced heat expression, and poor conception rates are commonly implicated in this trend (Dobson et al., 2007; Walsh et al., 2011). The effect of increased level of production in reducing the time and intensity of estrus expression has been well documented (Lopez et al., 2004); an association between increasing milk yield and an increase in the incidence of abnormal ovarian cycles (particularly prolonged luteal phases) has also been shown (Kafi et al., 2012). It is plausible that production may have an effect on ISI length.

The aim of this study was to assess the ISI in a large number of dairy cows, to explore the variability in estrous-cycle length and to identify associations between cow factors and cycle length. A more accurate understanding of the normal ISI of a cow would enable this knowledge to be used when interpreting herd production parameters. Understanding the variability of estrous-cycle length will allow identification of potential mechanisms regulating this process.

MATERIALS AND METHODS

Data Collection and Organization

Herd-management data were collected as part of a larger project (Hudson et al., 2010, 2012a). The commonly used ISI based measures of estrus-detection efficiency have been applied to this data set in a separate study (Remnant et al., 2014). Anonymized herd databases were requested from 20 veterinary surgeons across England and Wales with an acknowledged interest in dairy-herd health-management data analysis. Data came from a variety of sources, including on-farm recording software, veterinary practice bureau-recording services, and the records of national milk-recording organizations. Although not a probabilistic sampling method, this convenience sample was considered appropriate because high-quality data were essential for the analysis.

The initial data consisted of databases from 468 dairy herds. The data sets were converted to a standard format for restructuring and initial analysis. Data quality was assessed at the herd-year level over 8 yr, with only calendar years considered acceptable included for each herd. Measures of data quality included identification of herd data sets with random errors (such as calving events recorded without a corresponding insemination event) and systematic errors (such as underrecording of unsuccessful insemination events). Further detail is given by Hudson et al. (2012a). The resulting data were from the years 2000 to 2008, originated from 167 herds, and included 449,471 inseminations from 67,926 cows. Mean 305-d milk yield, calving index, culling rate, and average herd size (estimated by multiplying the number of calving events in a year by the calving index divided by 365) were calculated for each herd for each calendar year.

The data were structured with an individual ISI (the number of days between subsequent inseminations in the same cow, in the same lactation) as a line of data. For each interval, the cow and herd identity were recorded, along with the 305-d adjusted milk yield, start (calving) date, and parity of the lactation in which the ISI occurred. The date, DIM, and insemination number of the insemination ending the interval were also recorded. Lactations with milk yields outside the range 2,500 to 15,000 L and ISI ending at more than 365 DIM were excluded, because these were likely to represent outliers and recording errors.

Data restructuring was carried out in Microsoft Access 2010 (Microsoft Corporation, Redmond, WA).

Descriptive Analysis

A frequency distribution of ISI up to 100 d was plotted. For initial univariate analysis, a subset of intervals between 15 and 30 d was used. The initial distribution demonstrated a clear peak at 15 to 30 d, and this is a range thought likely to contain the first return to estrus following an insemination, without including subsequent cycles (occurring at extended intervals as a result of failed estrus detection or resynchronization protocols). Herds contributing less than 100 ISI within this range were excluded, leaving a sample consisting of 114,573 ISI from 42,252 cows in 159 herds. Summary herd-level statistics for herd-years included in the analysis are shown in Table 1. The distribution of ISI within this sample was assessed using a frequency plot. Bar charts were used to compare the distribution of ISI across different parities (grouped as 1, 2, 3, or 4+), insemination numbers (grouped as 2, 3, 4, or 5+ according to the number of the insemination ending the interval), and lactation 305-d adjusted milk yield [grouped as $<$7,000 L, 7,000 to 10,000 L, and $\geq$10,000 L, based on the approximate bottom quartile ($<$7,021 L), median half, and top quartile ($>$9,934 L) of all insemination-level 305-d lactation yields]. First-lactation heifers were excluded from the univariate yield category plot. Differences between groups were tested with