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Genetic relationships between detailed reproductive traits and performance traits in Holstein-Friesian dairy cattle

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ABSTRACT

The objective of the study was to estimate the genetic relationships between detailed reproductive traits derived from ultrasound examination of the reproductive tract and a range of performance traits in Holstein-Friesian dairy cows. The performance traits investigated included calving performance, milk production, somatic cell score (i.e., logarithm transformation of somatic cell count), carcass traits, and body-related linear type traits. Detailed reproductive traits included (1) resumed cyclicity at the time of examination, (2) multiple ovulations, (3) early ovulation, (4) heat detection, (5) ovarian cystic structures, (6) embryo loss, and (7) uterine score, measured on a 1 (little or no fluid with normal tone) to 4 (large quantity of fluid with a flaccid tone) scale, based on the tone of the uterine wall and the quantity of fluid present in the uterus. (Co) variance components were estimated using a repeatability animal linear mixed model. Genetic merit for greater milk, fat, and protein yield was associated with a reduced ability to resume cyclicity postpartum (genetic correlations ranged from −0.25 to −0.15). Higher genetic merit for milk yield was also associated with a greater genetic susceptibility to multiple ovulations. Genetic predisposition to elevated somatic cell score was associated with a decreased likelihood of cyclicity postpartum (genetic correlation of −0.32) and a greater risk of both multiple ovulations (genetic correlation of 0.25) and embryo loss (genetic correlation of 0.32). Greater body condition score was genetically associated with an increased likelihood of resumption of cyclicity postpartum (genetic correlation of 0.52). Genetically heavier, fatter carcasses with better conformation were also associated with an increased likelihood of resumed cyclicity by the time of examination (genetic correlations ranged from 0.24 to 0.41). Genetically heavier carcasses were associated with an inferior uterine score as well as a greater predisposition to embryo loss. Despite the overall antagonistic relationship between reproductive performance and both milk and carcass traits, not all detailed aspects of reproduction performance exhibited an antagonistic relationship.

Key words: fertility, milk production, body size, calving, carcass

INTRODUCTION

Historical intensive selection for milk production in dairy cows has succeeded in increasing milk yield, but has done so to the detriment of functional traits such as animal health (Berry et al., 2011a) and reproductive performance (Veerkamp and Beerda, 2007; Berry et al., 2014). Reproductive traits are now routinely included in national breeding goals to improve reproductive performance while still achieving genetic gain for milk production (Miglior et al., 2005). Reproductive traits included in dairy cow breeding objectives, however, have almost exclusively been limited to producer-recorded traits such as calving interval or days open. Detailed reproductive traits, including the ability of the cow to resume and express estrus postpartum, establish and maintain pregnancy, as well as cow uterine health, can provide a greater insight into reproductive performance. Detailed reproductive traits, measured by hormone levels (Royal et al., 2002a; Berry et al., 2012) and ultrasound examination of the reproductive tract (Carthy et al., 2015), have been shown to be genetically associated with traditional reproductive traits. Little is known, however, about the effect of current breeding strategies on the detailed aspects of reproductive performance such as follicular dynamics and uterine health.

Extensive studies have documented the antagonistic genetic relationship between milk production and traditional reproductive traits (Berry et al., 2014). Greater milk production has been associated with a reduction

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in cyclicity postpartum (Royal et al., 2002b; Fitzgerald et al., 2014b) and an increased likelihood of both cystic structures (Hooijer et al., 2001; Zwald et al., 2004; Fitzgerald et al., 2014b) and multiple ovulation (Fitzgerald et al., 2014b). Although generally confined to traditional reproductive traits, the genetic correlations between reproductive performance and other performance traits (e.g., type traits, BCS, live weight) have also been documented in several populations (Berry et al., 2014). Inferior genetic merit for calving interval has been reported to exist in dairy cows genetically predisposed to a greater risk of calving difficulty (Eaglen et al., 2013). Corresponding genetic associations with detailed aspects of reproductive performance in lactating dairy cows are, however, lacking.

The objective of the present study was to estimate the genetic relationships between detailed reproductive traits, derived from ultrasound examination of the reproductive tract, and a range of performance traits in Holstein-Friesian dairy cows. Performance traits considered included calving performance (i.e., calving difficulty and perinatal mortality), milk production, carcass related traits, BCS, and body size. The results of this study will fill a knowledge gap on the genetic parameters necessary to quantify the implications of current breeding strategies on the underlying, more detailed components of reproductive performance.

MATERIALS AND METHODS

Data

Records were available from the Irish Cattle Breeding Federation (Bandon, Co. Cork, Ireland) database on (1) ultrasound examination records of the reproductive tract, (2) calving performance, (3) individual cow milk production, (4) carcass traits, and (5) linear type traits. Supplementary data on animal pedigree, breed composition, and cow parity were also available.

Detailed Reproductive Traits. Detailed reproductive traits were derived from ultrasound examination of the reproductive tract carried out by one commercial company (Reprodoc Ltd., Fermoy, Co. Cork, Ireland) using real-time B-mode ultrasound scanner with a 5-MHz transducer. Ultrasound examinations were performed at various time points postpartum at the discretion of the producer. Data were available on 194,880 ultrasound records from 114,306 lactations on 72,120 dairy cows in 894 herds. The traits have been described in detail by both Carthy et al. (2014) and Fitzgerald et al. (2014a). The detailed reproductive traits included (1) the resumption of cyclicity (**CYC**), (2) multiple ovulation (**MO**), (3) early ovulations (**EO**), (4) detected heat (**DH**), (5) cystic structures (**CS**), (6) embryo loss (**EL**), and (7) uterine score (**USC**).

Resumption of cyclicity was defined as having resumed normal estrus cyclicity at the time of examination and was defined in this study as the presence (CYC = 1) or the absence (CYC = 0) of a noncystic corpus luteum (**CL**) on the ovaries at the time of examination (Carthy et al., 2014). Multiple ovulations were defined as the presence of >1 CL (MO = 1) on one or both ovaries at the time of examination in cycling cows (Fitzgerald et al., 2014a). Early ovulation was defined as ovulation having occurred (EO = 1) or not (EO = 0) by 15 d postpartum. Date of ovulation was determined by the size and density of the CL up to 6 d postovulation, after which an accurate ovulation date could not be determined. Therefore, EO could only be determined from ultrasound examinations up to 21 d postpartum; if examination occurred >21 d postpartum EO was set to missing.

Detected heat was only defined within a herd's AI breeding season; if no ovulation was detected by ultrasound examination during this period, DH was set to missing. If an insemination occurred within 5 d of the estimated date of ovulation, determined by ultrasound examination, then heat was assumed to have been detected (DH = 1). If no recorded insemination existed within ±5 d from the date of ovulation, heat was assumed not to have been detected (DH = 0).

Cystic structures were defined as the presence (CS = 1) or absence (CS = 0) of a cystic structure (>25 mm; follicular or luteal) on the ovaries at time of ultrasound examination (Carthy et al., 2014). Uterine score, measured on a scale from 1 to 4, was based on the tone of the uterine wall, the size of the lumen, and the quantity of fluid present in the uterus (Carthy et al., 2014). Uterine score was defined as (1) little or no fluid (<2 mm) with normal tone and normal lumen, (2) small quantity of fluid (2–5 mm) with normal tone and slightly enlarged lumen, (3) large quantity of fluid (5–60 mm) with moderately flaccid tone and enlarged lumen, and (4) very large quantity of fluid (>60 mm) with a flaccid tone and very enlarged lumen.

Embryo/fetal loss was assumed to have occurred if an embryo was deemed to be unviable (i.e., no detectable heartbeat) at the time of ultrasound examination (EL = 1). However, if a subsequent calving date was less than 260 d from date of examination (<3% of recorded unviable embryos), embryo loss was assumed not to have occurred (EL = 0). Predicted calving date was calculated from the estimated gestational age of embryo/fetus at the time of examination, assuming 283 d gestation length (i.e., average gestation length of different dairy breeds; Norman et al., 2009). If a cow