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Fertility traits of Holstein, Brown Swiss, Simmental, and Alpine Grey cows are differently affected by herd productivity and milk yield of individual cows

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ABSTRACT

Milk yield has a strong effect on fertility, but it may vary across different herds and individual cows. Therefore, the aim of this study was to assess the effects of breed and its interaction with level of milk production at the herd level (Herd-L) and at a cow-within-herd level (Cow-L) on fertility traits in dairy cattle. Data were gathered from Holstein (n = 17,688), Brown Swiss (n = 32,697), Simmental (n = 27,791), and Alpine Grey (n = 13,689) cows in northeastern Italy. The analysis was based on records from the first 3 lactations in the years 2011 to 2014. A mixed model was fitted to establish milk production levels of the various herds (Herd-L) and individual cows (Cow-L) using milk as a response variable. The interval fertility traits were interval from calving to first service, interval from first service to conception, and number of days open. The success traits were nonreturn rate at 56 d after first service, pregnancy rate at first service, and the number of inseminations. The interval from calving to first service, interval from first service to conception, and number of days open were analyzed using a Cox's proportional hazards model. The nonreturn rate at 56 d after first service, pregnancy rate at first service, and the number of inseminations were analyzed using logistic regression. There was a strong interaction between breed and productivity class at both Herd-L and Cow-L on all traits. The effects of herd and cow productivity differed from each other and differed among breeds. The dual-purpose Simmental and Alpine Grey breeds had better fertility than the specialized Holstein and Brown Swiss dairy cows; this difference is only partly attributable to different milk yields. Greater herd productivity can result in higher fertility in cows, whereas higher milk yield of individual cows within a herd results in lower fertility. These effects at both Herd-L and Cow-L are curvilinear and are stronger in dual-purpose breeds, which was more evident from low to intermediate milk yield levels than from central to high productivity classes. Disentangling the effects of milk productivity on fertility at Herd-L and Cow-L and taking the nonlinearity of response into account could lead to better modeling of populations within breed. It could also help with management—for example, in precision dairy farming of dairy and dual-purpose cattle. Moreover, assessing the fertility of various breeds and their different responses to herd and individual productivity levels could be useful in devising more profitable crossbreeding programs in different dairy systems.
Key words: fertility, survival analysis, milk production, genotype × environment

INTRODUCTION

The reduction in fertility rate along with the increase in milk production in dairy cattle over recent decades (Lucy, 2001) has raised much interest in investigating its causes and in seeking solutions (Walsh et al., 2011; López-Gatius, 2012). Several studies have reported a negative genetic correlation between milk production and fertility traits (Pryce et al., 2004; Tiezzi et al., 2011, 2012), whereas others have found reproductive loss in dairy cattle to be associated with increased herd sizes, higher rates of inbreeding, changes in reproductive physiology, and worsening of body condition (Lucy, 2001; Walsh et al., 2011; Tiezzi et al., 2013). As a consequence, the number of days open has increased, pregnancy rates have decreased, and the level of involuntary culling has increased. However, caution should be exercised in interpreting these negative relationships because the effects on reproductive performance associated with individual cows may be confounded with those at a herd level, which could lead to errors in interpretation. A more comprehensive assessment drawing on expertise from multiple scientific disciplines is needed to study the causes and effects of fertility loss (Bello et al., 2012). The diverse native characteristics of different breeds, and the different genetic improvement schemes among breeds and in different countries, mean that dairy cattle populations around the world have

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different genetic levels of fertility (Nilforooshan et al., 2009).

To address the problem, several countries have incorporated fertility traits into their genetic evaluations, and different models and methodologies have been proposed (VanRaden et al., 2004; Huang et al., 2007). A review by Egger-Danner et al. (2015) found that 15 countries around the world with high levels of milk production include fertility in their total merit indices. It has been suggested that survival analysis may be a better option than linear methods, especially for event-time censored traits, because it allows partial records to be used in the analysis (Schneider et al., 2005). Phuong et al. (2016) proposed an extended lifetime performance model that incorporates the effect of variations in milk yield, energy balance, and body condition on the reproductive success of individual cows. The model therefore successfully simulates the reproductive performance of different cow genotypes across feeding systems.

Crossbreeding of dairy cattle has been used as an alternative to pure breeding and has led to improvements in various traits, including fertility (Weigel and Barlass, 2003). Different breed combinations have resulted in differences in fertility traits (Weigel and Barlass, 2003; Heins et al., 2006; Malchiodi et al., 2014). This means that a better understanding of the characteristics of individual breeds with respect to these traits is needed to design more profitable crossbreeding programs.

Vargas et al. (1998) studied interval fertility traits using event-time techniques of different breeds and crossbreeds and reported that heifers in herds with lower milk yields were more likely to be bred. They found a significant difference between the effects of the milk yield of primiparous cows on interval (d) between calving and first recorded insemination (**iCF**) and on number of days open (**DO**). They also reported a significant effect of heifer weight on age at first calving: herds and heifers with heavier BW at 390 d had a higher probability of calving. Bello et al. (2012) point out that the associations between productivity and fertility may have been overlooked in the past because of confounding factors and inappropriate statistical analyses, the results of which may have been misinterpreted. According to these authors, lack of a clear distinction between herd level (**Herd-L**) and cow-within-herd level (**Cow-L**) in the modeling and between the effects of different dairy production systems may also contribute to misleading conclusions being drawn. LeBlanc (2010) investigated the association between milk production rate and reproductive performance at both Herd-L and Cow-L using pregnancy, insemination, and calving rates as indicators of fertility and found a positive association between pregnancy rate and earlier first insemination in high-yielding herds and cows. The author reported that a high milk yield in cattle may be compatible with good reproductive performance and remarked on the complexity of fertility and the danger of assessing it with only one indicator (i.e., pregnancy rate). In this article, we assess the effect of breed of cow and the interaction of breed and milk productivity measured at Herd-L and Cow-L on interval fertility traits, fertility success traits, and number of inseminations (**INS**) per cow in various breeds of dairy cattle (Holstein, Brown Swiss, Simmental, and Alpine Grey).

MATERIALS AND METHODS

Field Data

Female fertility and milk production data were collected by the Breeders Federation of Alto Adige/Südtirol (Associazione Provinciale delle Organizzazioni Zootecniche Altoatesine/Vereinigung der Südtiroler Tierzuchtverbände, Bolzano/Bozen, Italy) from the northeast of Bolzano (Bozen province) in Italy. The region is mountainous, and its farms are mainly small and operate various systems, from the very traditional (small to medium herd sizes, old buildings, tied animals, lactating cows moved to mountain pastures during the summer) to the more modern (large herd sizes, recent buildings with milking parlors and free animals, high levels of milk production, TMR feeding system; Sturaro et al., 2013). The test days cover the period from 2011 to 2015. Only records from the first 3 lactations and calvings of each cow from the years 2011 to 2014 were analyzed to exclude cows with fertility events in progress. Lactation period was divided into 11 categories of DIM; each category comprised 30 d except the last, an open category of >300 DIM. Breeds with few data and crossbred animals were excluded from the analysis.

Trait Definition and Data Editing

The interval fertility traits were defined as iCF, the interval between first service and conception (**iFC**), and DO. The success traits analyzed were the nonreturn rate at 56 d after first service (**NRR**) and pregnancy rate at first service (**PRF**). The NRR and PRF were coded as binary variables (0, 1), where 1 indicated a cow that did not have a second insemination registered within 56 d of the first service (for NRR) or a cow that became pregnant at the first service (for PRF). The INS was considered an ordinal variable with 5 levels, the fifth being an open class of 5 or more inseminations. Pregnancy status was positively confirmed by a subsequent calving; otherwise, it was set to unknown. Cows without a subsequent calving after the last service were penalized by the addition of a penalty insemination.