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Effect of milk production on reproductive performance in dairy herds

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ABSTRACT

The objective of the present study was to assess the relationship between individual cow milk yield and fertility, accounting for the contextual effect of the herd. A data set including 657,968 lactations from 677 dairy herds in Argentina from 2001 to 2012 was used. The odds of pregnancy by 100 d in milk (DIM) were assessed by a multilevel logistic model (with cow as the first and herd as the second hierarchical level), and time to pregnancy was assessed by a proportional hazards regression model. Multilevel logistic models included the fixed effects of milk yield by 80 DIM, parity, year, and calving season at cow level and quartiles of herd milk yield by 80 DIM as a contextual effect. The proportional hazards model included the effect of daily cow-level milk yield as time-dependent variable, with milk yield at herd level as the stratification variable. Cows producing 1 standard deviation over the mean milk yield of their herd had 1.3 percentage point lower pregnancy by 100 DIM (from 31.4 to 30.1%; odds ratio = 0.942) when in herds in the top quartile of milk yield, whereas they increased 0.5 percentage points (from 27.9 to 28.4%) when in herds in the lowest quartile of milk yield. Only 4% of the observed variation in pregnancy by 100 DIM was explained by the random effect of the herd. Similarly, cows producing 1 standard deviation (8 kg/d) greater than the herd mean daily milk had 1.3% lower hazard of pregnancy (hazard ratio = 0.987) at 63 DIM in herds in the top quartile of milk yield, whereas they had 14.8% higher hazard (hazard ratio = 1.148) in herds in the lowest quartile of milk yield. The magnitude of the negative association between the cow's daily milk yield and the hazard of pregnancy increased with DIM. In conclusion, the relationship between milk yield and reproductive performance is statistically significant, but the effect size is practically small and is modulated by herd production level.
Key words: milk yield, reproductive performance, contextual effect, multilevel model

INTRODUCTION

The dairy industry in Argentina has undergone substantial changes during the last 25 yr. Traditionally, the dairy industry has heavily relied on grass for milk production, but in the 1990s an important intensification took place. As a consequence of that process, the national milk production per year increased from 6,000 to 10,000 million kg, whereas the number of herds decreased from 30,141 to 15,000 and the average herd size increased from 67 to 134 cows. This improvement in productivity was accompanied by an increase in stocking rate per hectare, whereas the average individual milk yield increased only from 8.5 to 11.5 kg/d. Conversely, between 2002 and 2012 the average individual milk yield increased from 11.5 to 18.5 kg/d, whereas the total dairy cow population decreased from 2,005,000 to 1,748,000 (Parellada and Schilder, 1999; Taverna, 2013). This intensification in the use of agricultural resources during recent decades, a worldwide trend, has led to an increase in productivity (FAO, 2005). During the same period, there was a decline in some measures of the fertility of dairy cows (Lucy, 2001; Butler, 2003; Melendez and Pinedo, 2007; Piccardi et al., 2013). Therefore, some researchers have proposed an antagonistic relationship between milk yield and fertility (Lucy, 2001; Butler, 2003). Many studies have addressed this controversial topic with inconsistent approaches and results. Some

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Table 1. Descriptive data about number of herds, dairy cows per herd, milk yield at 305 DIM, and pregnancy by 100 DIM for the 12-yr period (2001–2012) used in the study[1]

Year	Herds (no.)	Cows[2] Mean (minimum–maximum)	Milk305[3] Median (IQR)	PREG100 (%)[4] Median (IQR)
2001	163	141 (26–660)	5,950 (5,091–6,911)	33 (26–41)
2002	175	145 (26–714)	5,767 (4,961–6,738)	31 (23–40)
2003	271	138 (26–802)	6,390 (5,520–7,378)	30 (23–38)
2004	320	151 (27–917)	6,923 (5,969–7,939)	32 (23–41)
2005	397	138 (26–987)	7,140 (6,158–8,180)	31 (25–40)
2006	463	147 (26–1,221)	7,189 (6,211–8,290)	30 (25–40)
2007	503	148 (26–1,267)	7,105 (6,129–8,186)	28 (20–35)
2008	530	155 (26–1,111)	7,360 (6,339–8,493)	28 (20–37)
2009	522	167 (26–1,339)	7,417 (6,423–8,541)	28 (19–34)
2010	519	172 (27–1,506)	7,910 (6,832–9,116)	30 (23–36)
2011	526	186 (26–1,648)	8,153 (7,089–9,351)	29 (21–35)
2012	476	188 (27–1,673)	7,697 (6,695–8,835)	27 (20–34)

[1]The mean number of lactations per cow was 2.03 (range = 1–11), and the mean number of years per herd in the study was 6.89 (range = 1–12).

[2]Number of lactations that commenced per herd per year.

[3]Raw milk yield in 305 DIM per herd per year, expressed in kilograms; median and interquartile range (IQR; 25th to 75th percentile).

[4]Percentage of cows pregnant by 100 DIM per herd per year; median and interquartile range (IQR; 25th to 75th percentile).

found some negative associations (Eicker et al., 1996; Gröhn and Rajala-Schultz, 2000; Lucy, 2001; Butler, 2003; Melendez and Pinedo, 2007; Madouasse et al., 2010; Piccardi et al., 2013), whereas others reported a positive relationship (Rajala-Schultz et al., 2001; Campbell et al., 2009; Cook and Green, 2016). These inconsistencies could be the result of biased indicators (i.e., measures of production and reproduction) used (LeBlanc, 2010), selection bias due to management decisions in studies performed in commercial dairy herds (Morton, 2006), or the way multilevel data were handled by researchers (Bello et al., 2012). Multilevel models allow us to assess contextual effects by including a higher-level predictor that represents the effect of the context or group to which individuals belong (Snijders and Bosker, 2012). We can use this analysis to separately estimate the relationship between milk yield and reproductive performance at cow and herd levels. The relationship at the herd level (the herd contextual effect) may differ in magnitude and even direction from the relationship at the cow level.

Our working hypothesis was that milk yield and reproductive performance in dairy cows are not necessarily antagonistic and that this relationship is influenced by the effect of the herd. Hence, the main objectives of this study were to assess the relationship of cow-level milk yield with reproductive performance and whether that association changes with the level of herd milk production and to estimate the magnitude of herd contextual effect. An additional objective was to estimate the trend of indicators of reproductive performance over time in Argentinean dairy herds.

MATERIALS AND METHODS

Data Set

A retrospective longitudinal study was conducted using a data set including dairy herds from the province of Buenos Aires, Argentina. Production, reproduction, and health information was gathered by the official dairy herd improvement association (Asociación de la Regional Pampeana de Entidades de Control Lechero). Data for all the lactations ("cow" is used to mean "lactation") started between January 1, 2001, and December 31, 2012 (1,573,593 cows from 862 herds), were extracted from commercial software (DIRSA S.A., Gonnet, Argentina). Descriptive data about herd numbers, herd size, herd's milk yield at 305 DIM, and herd's pregnancy rate by 100 DIM are shown in Table 1 and Figure 1, and descriptive data about pregnancy rate per 21-d period for all the cows included in the study are shown in Figure 2.

Lactation and Herd Selection

Only lactations with valid reproductive and milk production data were included in the study. Lactations were considered as having valid reproductive records when they met all the following criteria: (1) they had at least 1 AI recorded; (2) for lactations with a record of a subsequent calving, it was required that they had a recorded AI between 260 and 290 d before that new calving; and (3) cows with no record of new calving but with a positive pregnancy diagnosis were considered