

## Parity, milk production, and reproduction

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Our objective was to evaluate associations of parity, milk, fat and protein percent and yield, and production system [intensively fed (n = 28,675 cows) or mainly pasture-fed (n = 4,108)] on reproduction. We examined hazard of not being bred (HNBRED), of pregnancy (HPREG), probability of pregnancy to first mating (PREG1), and odds of becoming pregnant in a lactation (OPAL) using logistic regression and survival analysis including interactions. Cows were from 13 studies conducted in Australia (14.6%), Canada (2.4%), and the USA (83.0% of cows). Cows were 38.5% parity 1, 27.3% parity 2, 16.7% parity 3, 9.0% parity 4, and 8.6% parity  $\geq 5$ . Parity  $\geq 5$  cows compared to cows of parity 1 had a greater HNBRED (HR = 2.45), lesser HPREG (HR = 0.73), and reduced OPAL (OR = 0.36); however, the parity  $\geq 5$  cows had similar PREG1 to parities 2 to 4, but differed to parity 2, 3 and 4 for all other measures. This suggests a possibility of a higher proportion of sub-fertile parity  $\geq 5$  cows than other parities. Associations between parity and reproduction were influenced by milk yield, and milk component percentages and yields at approximately 70 DIM. All milk production measures had quadratic associations with OPAL such that either low or high production or concentration of solids reduced OPAL. This reduced OPAL reflected a greater HNBRED for lower milk yield, and milk protein and fat yielding cows. Milk yield and protein percent had quadratic associations with HPREG. When centered milk yield was categorized into quartiles, there were small differences in HPREG. In contrast, the association of milk protein percent with HPREG was optimal at approximately 0.5% above group mean milk protein percentage. Milk fat percentage (HR = 0.90), fat yield (kg/d; HR = 0.78), protein yield (kg/d; HR = 0.71), and milk solids yield (kg/d; HR = 0.84) were all linearly associated with reduced HPREG. Production system was not associated with PREG1, but was for HNBRED, HPREG, and OPAL. Marked associations of increased parity with reduced reproductive performance should focus research on physiological changes with age to increase productive life of cows.

longevity, milk, parity, pregnancy

## **Associations of parity with health disorders, body condition score, and body weight in dairy cows in different production systems**

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Our goal was to evaluate associations of parity with health disorders, body condition score (BCS) and body weight (BW) in different production systems. Retrospective data were obtained from 13 studies in Australia (AU), Canada (CA), and the USA with a total of 28,230 Holstein cows used. Parity  $\geq 5$  represented 9.0%, parity 4 9.8%, parity 3 19.0%, parity 2 28.1%, and parity 1 34.1% of cows. There were 15.5% in AU, 14.7% in CA, and 69.8% in the USA. Odds of disease were evaluated with mixed-effects multi-level models that included cow within group as a random effect and parity, production system [intensively fed ( $n = 28,675$ ) or predominantly pasture-fed ( $n = 4,108$ )], and year of study that was mean centered were tested as fixed effects. The associations of parity and system with BCS and BW < 30 d before calving and 7 to 100 DIM were assessed by mixed models with significance denoted at  $P > 0.05$ . Lactational incidence (LI) risk of clinical hypocalcemia increased with parity from 0.1% for parity 1 to 13% for parity  $\geq 5$  cows. The marked monotonic increase in risk suggests profound differences in metabolism with increased parity. The LI of clinical mastitis was 17.4%. The odds or hazard of mastitis increased moderately with parity, being 2.5 times greater in parity  $\geq 5$  than parity 1. The LI of lameness also increased with parity; odds of lameness were 5.6 times and hazard 4.7 times greater for parity  $\geq 5$  than parity 1. The LI of retained placenta was 7.4% and increased with parity; parity  $\geq 5$  had 2.3 times greater odds than parity 1. The LI of metritis was 10% and endometritis 14%, with greatest odds for parity 1. The LI of clinical ketosis was 3.3% with a marked increase in odds with parity. The prevalence of subclinical ketosis was 26.8% with only parity 1 having lower odds than other parities. BW increased yet BCS decreased with increased parity, warranting investigation into the role of labile tissue reserves in older cows. Meaningful differences in disease risk with parity suggest a need to carefully consider parity structure in study design and methods to reduce risk of health disorders tailored to cows of different ages.

disease, age

## Associations of parity with survival and blood metabolites in dairy cows in different production systems

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Our objective was to evaluate the associations of parity with survival and blood metabolites in different production systems. Retrospective data were obtained from 13 studies in Australia (AU), Canada (CA), and the USA. Our survival dataset contained 30,780 Holstein cows, with 5.5% in AU, 6.9% in CA, and 87.6% in the USA. Survival analysis models were used to evaluate time to removal. The hazard of death increased with increased parity, but the pattern of culling differed with production system (pasture vs intensively fed). There were 5,154 Holstein cows in the pre-calving, calving, and immediate post-calving metabolic datasets. Cows in parity 1 were 26.9%, parity 2 27.7%, parity 3 21.6%, parity 4 11.8%, and parity  $\geq 5$  11.9% of the sample. Of these, 5.3% were in AU, 92.6% in CA, and 2.1% in the USA. Measures near peak lactation provided 1,951 observations with 54.4% from AU and the rest from CA. Concentrations of metabolites were evaluated with mixed-effects multi-level models that included cow within group as a random effect and parity, production system and year of study that was mean centered were tested as fixed effects. Concentrations of BHB and non-esterified fatty acids (NEFA) increased with parity on DIM 1 to 3 and at peak lactation. On DIM 1 to 3 differences in glucose, NEFA, and BHB indicated a greater reliance on mobilized lipid to export energy to peripheral tissues as BHB. Ca and P had marked differences in concentrations among parity groups at times, i.e.  $>0.20$  mM in Ca for parity 1 and 2 to parity  $\geq 5$  and  $>0.33$  mM for older parities compared to parity 1 for P on the d of calving. The marked differences in risk of death and concentrations of metabolites with parity at all times evaluated are consistent with reduced reproduction, health, and body condition for higher parity cows and demonstrate the considerable risk of confounding in evaluation if simple cut-points are used to diagnose subclinical disorders. There is a need to use parity-controlled models to better understand older dairy cows and the changes in metabolism associated with age that underpin the increases in health risks with increased parity.

age, calcium, culling, free fatty acids