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A Prospective Study of Calf Factors Affecting Age, Body Size, and Body Condition Score at First Calving of Holstein Dairy Heifers

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ABSTRACT

Data were collected prospectively on parameters related to first calving on 18 farms located in Northeastern Pennsylvania. This project was designed to study possible residual effects of calf management practices and events occurring during the first 16 wk of life on age, BW, skeletal growth, and body condition score at first calving. Multiple imputation method for handling missing data was incorporated in these analyses. This method has the advantage over ad hoc single imputations because the appropriate error structure is maintained. Much similarity was found between the multiple imputation method and a traditional mixed model analysis, except that some estimates from the multiple imputation method seemed more logical in their effects on the parameter measured. Factors related to increased age at first calving were increased difficulty of delivery, antibiotic treatment of sick calves, increased amount of milk or milk replacer fed before weaning, reduced quality of forage fed to weaned calves, maximum humidity, mean daily temperature, and maximum ammonia levels in calf housing areas. Body weight at calving tended to increase with parity of the dam, increased amount of grain fed to calves, increased ammonia levels, and increased mean temperature of the calf housing area. Body condition score at calving tended to be positively influenced by delivery score at first calving, dam parity, and milk or milk replacer dry matter intake. Withers height at calving was positively affected by treatment of animals with antibiotics and increased mean temperature in the calf area. This study demonstrated that nutrition, housing, and management factors that affect health and growth of calves have long-term effects on the animal at least through first calving.
(**Key words:** calf and heifer management, multiple imputations, longitudinal data analysis)

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Abbreviation key: AFC = age at first calving, **ADG** = average daily gain, **BCSC** = BCS at calving, **BWC** = BW at calving, **MAR** = missing at random, **MCAR** = missing completely at random, **MI** = multiple imputation, **MNAR** = missing not at random, **MM** = mixed models, **WHC** = withers height at calving.

INTRODUCTION

Systems need to be in place to monitor and evaluate progress of heifers on dairy farms because of the large economic investment involved in raising dairy heifers (Tozer and Heinrichs, 2001). Despite the high costs of raising heifers in the US (Gabler et al., 2000), mortality and morbidity rates continue to be near 10% on US dairy operations (USDA, 2002). These rates have changed very little in the past 10 yr (Heinrichs et al., 1994).

Research has shown an association between management and health of dairy heifers. A study of 26 dairy herds in New York by Curtis et al. (1988) indicated that management directly affected the risk of respiratory illness within 14 d of birth. The environment in which the calf is raised also has a profound effect on health and growth. Pritchard et al. (1981) found that treatment for respiratory disease and lung infections in veal calves was directly related to daily weight gains and was associated with air quality in the animal unit. Waltner-Toews et al. (1986) found that a variety of management and housing factors were related to calf and heifer morbidity and mortality. Many of these variables were related to farm size and season. Furthermore, Heinrichs et al. (1987) showed associations among mortality, herd size, and person caring for the calf.

The effect of early calfhood health status on survivorship and age at first calving (**AFC**), after controlling for the farm effect, has been examined (Waltner-Toews et al., 1986). Heifers treated for pneumonia during the first 3 mo of life were 2.5 times more likely to die after 90 d of age than heifers that had not been treated. Heifers with a calfhood history of being treated for diarrhea were 2.5 times more likely to be sold, and heifers

that had been treated for diarrhea were 2.9 times more likely to calve after 900 d (30 mo) of age than other heifers (Waltner-Toews et al., 1986). Calving age <30 d (24 mo) is much more economical because of the extra costs and lost production associated with older calving ages (Gabler et al., 2000; Hoffman and Funk, 1992).

In a large study, Curtis et al. (1989) followed 1171 Holstein heifer calves on several New York dairy farms. Their findings yielded incidence rates for scours of 9.9% within 14 d of birth, 5.2% from 15 to 90 d of age, 7.7% for calves displaying dullness, and 7.4% for calves with respiratory illness. This study was followed by Correa et al. (1988), who evaluated the effects of calf morbidity on AFC on the same animals. Heifers without respiratory illness as calves were twice as likely to calve and calved 6 mo earlier compared with those with respiratory illness as calves. An unexpected result from this study was that heifers displaying dullness or unthriftyness as calves were 1.6 times more likely to calve and calved 2 mo earlier when compared with calves without dullness as calves. Dullness would be expected to increase AFC because of anticipated lower growth rates from inadequate feed intake and less active or normal behavior.

Health status of dairy heifers has been shown to have a significant impact on growth rate of calves especially during the first 6 mo of life (Donovan et al., 1998). Season of birth and occurrence of diarrhea, septicemia, and respiratory disease can significantly decrease heifer growth (height and weight). Donovan et al. (1998) reported that these variables plus farm, birth weight, and exact age when 6-mo data are collected explained 20 and 31% of the variation in BW and pelvic height growth, respectively, from birth to 6 mo. Septicemia and pneumonia slowed growth by 13 to 15 d (to reach the same weight as healthy calves) during the first 6 mo; diarrhea had a much smaller influence on growth (Donovan et al., 1998). Passive transfer of colostral immunoglobulins had no direct effect on growth but did influence weight and height through its effect on health (Donovan et al., 1998).

Previous work by Place et al. (1998) showed that housing and season had significant effects on average daily gain (**ADG**). Other variables, such as calving location, parity of the dam, and delivery score at calving, had significant effects on ADG to 4 mo of age. The present study was carried out to follow these same animals beyond 4 mo of age and up to calving. The introduction of missing data between the first and second phases of this study could introduce bias if traditional screening and listwise deletion methods were used. However, because of the intensive nature of the initial phase of the study by Place et al. (1998), a great deal more is actually known about the farms and animals involved in the study, and reliable estimates of missing responses and predictors could be made if newer methods of statistical analyses were used. Therefore, the objectives of the study were to incorporate a statistical technique for missing data, called multiple imputation (**MI**; Rubin, 1987), to investigate potential factors that affect calving-related measures in dairy heifers and to evaluate the applicability of MI in analyzing field data. Our project was undertaken to study the possible residual effects of calf management practices, nutrition, and environment until early adulthood and how calf-related events might affect AFC, BW at calving (**BWC**), withers height at calving (**WHC**), and BCS at calving (**BCSC**).

MATERIALS AND METHODS

Data Collection

The effects of disease, management, and nutrition on ADG of dairy heifers were studied from birth to 4 mo of age on 795 Holstein calves from 21 commercial dairy farms in Pennsylvania (Place et al., 1998). These farms participated in an 18-mo study following the procedures of the National Dairy Heifer Evaluation Project (Heinrichs et al., 1994). Farms were chosen at random and represented approximately 5% of the dairy farms and 9% of the dairy cows in 2 northeastern Pennsylvania counties (Susquehanna and Wyoming) in 1991. During the initial 18-mo phase of the study, farms were visited biweekly to collect all data.

During each biweekly visit, animals were identified, and health records were updated or collected for the previous 2 wk. Body weight and withers height were recorded until 4 mo of age for each calf. Individual feed intake was measured at each visit, and feed samples were collected for analysis as previously reported (Place et al., 1998). At each visit, measurements were taken for NH_3 concentration, current humidity and temperature, and maximum and minimum temperatures in each housing area throughout the 2 wk prior to the visit. Temperature and humidity were determined with a digital hygrometer and thermometer (Fisher Scientific, Pittsburgh, PA), and NH_3 determination was via a Kwik-Draw basic ammonia detector pump (MINE Safety Appliances Co., Malvern, PA).

Farm management practices were recorded using existing management survey instruments from the National Dairy Heifer Evaluation Project (Heinrichs et al., 1994). Information also was obtained from DHIA, calving and breeding records, and herd veterinarians, as needed.

Following the initial 18-mo phase of the study, farms were visited every 3 mo to follow health events, breeding, and animal movement. Once heifers were near calving, farms were visited every 2 to 4 wk to collect calving

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