Reproductive Systems for North American Dairy Cattle Herds

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KEYWORDS

• Dairy cattle • Reproductive efficiency • Reproductive management • Economics

KEY POINTS

- Reproductive inefficiency compromises the health and longevity of individual cows and the profitability of herds.
- In the average dairy herd, the combination of estrous detection and ovulation synchronization protocols yields the best economic return.
- Genomic selection of animals is particularly profitable in situations in which little is known about their genetic background.
- Biosensor systems in milking parlors may allow for the design of reproductive strategies tailored for cows according to their physiologic needs while optimizing economic return.

INTRODUCTION

Reproductive management of dairy animals has been marked by extensive progress in the past 50 years, from the creation of prostaglandin drugs (prostaglandin F2 alpha [$PGF_{2\alpha}$]) that allow the synchronization of estrus in the 1970s to the implementation of on-farm *in vitro* embryo production programs and the use of genomic selection to aid in breeding strategies. Such progress has been realized because reproductive efficiency has long been identified as critical for the profitability of dairy herds. Herds with efficient reproductive programs benefit from having a large proportion of cows in the most productive phase of lactation,[1] greater availability of replacement animals, greater genetic progress,[2,3] reduced proportion of reproduction culls,[4,5] reduced

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cost of reproductive programs,[2,4] and improved health. Furthermore, improved reproductive performance might reduce emission of greenhouse gases because of the reduced number of animals per unit of production and the reduced retention of replacement animals.[6,7]

For years, fertility in dairy cows has declined in multiple regions of the world and diverse production systems.[8–11] Changes in cow physiology associated with greater milk production, nutritional management, housing, increased herd size, reduced expression of estrus, and genetic makeup of the dairy cattle population have been identified as reasons for the decrease in reproductive efficiency.[8,12,13] Nonetheless, the downward trend in reproductive efficiency has been virtually halted because of the extensive progress in the knowledge of reproductive biology, physiology, and management.[14] For example, calving interval (CI) has declined significantly in the past 10 years (**Fig. 1**A), most likely because of reduced calving to first artificial insemination (AI) interval (**Fig. 1**B, C).[14] The positive trend in daughter pregnancy rate (DPR) observed in the past 10 years (**Fig. 1**D)[14] may be a result of more controlled voluntary waiting periods (VWPs) and shorter calving to first AI intervals. However, the importance of modern genetic selection programs that have focused on milk yield, productive life, reproduction, and health should not be disregarded.[3,6,13]

REPRODUCTIVE EFFICIENCY AND DAIRY HERD PROFITABILITY

The income of dairy herds is mainly originated from sales of milk (88% of gross income), cows for dairy purposes, cull animals, and calves (12% of gross income),[15] whereas the largest expenses are associated with feeding the herd (60% of total operating costs) and rearing replacement animals (25% of total operating costs).[15] Reproductive efficiency affects the profitability of dairies in several ways that are not always easy to account for. Improved reproductive performance has many beneficial effects: increased efficiency of milk production by shifting the milking herd to a more productive phase of the lactation[1]; improved income over feed cost (IOFC) and milk yield per day of CI[16]; reduced reproductive culls,[5] reduced need for replacement animals and increased percentage of the lactating herd that is multiparous[4,15]; improved genetic gain because of more selective culling of lactating cows and more stringent selection of replacement animals[13,15]; and, reduced cost of reproductive interventions.[2,4] However, significant improvement in reproductive performance results in a greater proportion of the adult herd dry,[4] demanding proper planning to accommodate dry cows and maternity needs.

The lactation curve and the dry matter intake (DMI) of mature cows determine that the efficiency of milk production is significantly greater during early versus late lactation (**Fig. 2**).[16] Consequently, the highest efficiency of milk production is achieved when most of the cows in a herd conceive within the first 100 days in milk (DIM). For example, consider 2 herds that have a VWP of 50 days, an average DIM at first AI of 60 days, and cows that are eligible to become pregnant for 13 consecutive cycles (from 50 to 312 DIM). In the herd with average milk yield of 12,500 kg per 305 days of lactation, improving 21-day pregnancy rates (PR; i.e., the percentage of eligible cows that become pregnant every 21 days) from 12% to 33% would reduce the average CI by 63 days (from 440 to 377 days) and result in an increase of 7% in the IOFC and 1.51 kg of milk per cow per day of CI (551 kg of milk per cow per year; **Fig. 3**A).[16] If the same improvements in 21-day PR are achieved in the herd with average milk yield of 9000 kg per 305 days of lactation, IOFC would increase 8% and milk yield would increase by 1.11 kg per cow per day of CI (405 kg of milk per cow per year;