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BREEDING FOR EXTENDED LACTATION IN AUSTRALIAN DAIRY COWS: A REVIEW

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SUMMARY

The Australian dairy industry is slowly moving from a seasonal calving system to bi-annual and all year round calving systems, extending lactation beyond the traditional 305 days. Extending lactation by utilising cows which have a high lactation persistency is likely to lead to increasing production, lactation efficiency, increased reproductive performance, and decreased health problems with increased productive life of the cow. Further research is needed to quantify the gains in profitability and define genetic relationships between extended lactation traits, persistency traits after day 305 of lactation and other cow traits such as fertility and survival.

INTRODUCTION

Conventional dairy farming systems in Australia are characterised by seasonal calving patterns, where cows are milked for about 300 days and are dried off at a pre-arranged date for 2 months and subsequently required to calve and be re-mated within a short time period of 6 to 15 weeks. Such patterns are often adopted to maximise labour efficiency and take advantage of pasture growth and high nutritive content (Haile-Mariam and Goddard 2008). Seasonal calving has frequently been adopted in low-cost, pasture-based milk production systems throughout countries such as Australia, New Zealand and Ireland. With the advent of new technologies such as robotic milking systems and high output production systems, the seasonal dairy production system is being phased out to year round calving and milking (Borman *et al.* 2004). Furthermore, welfare concerns such as induced calving and metabolic stresses around calving and early lactation may lead to associated infertility under seasonal calving systems (Knight 2001). These limitations have led to producers to search for alternative systems optimal for milk production and sustaining overall health of the dairy cows. An alternative is extending the lactation period beyond the traditional 305 days of the seasonal system. Several studies conducted in various countries (Van Amburgh *et al*. 1997; Osterman and Bertilsson 2003; Sawa and Bogucki 2009) have shown that cows are capable of extending their milk production well beyond 300 days.

CONSIDERATIONS FOR EXTENDING LACTATION IN DAIRY CATTLE

Extended lactation. In practical terms extending the lactation is only feasible if daily milk yield is sustained over a long period of time (Sorensen *et al.* 2008). Extended lactation in the context of this study may be defined as the ratio of expected milk yield from day 305 to day 610 (given that cattle are in lactation for 2 years) relative to the cumulative yield up to day 305 (Jonas *et al.* submitted). In order to have cows lactating beyond a 305 day lactation, it is important to identify and utilise cows which have a high lactation persistency (Vargas *et al.* 2000).

Lactation persistency. Cows with extended lactations tend to have lower and extended peak production whilst still maintaining a high total milk production over a longer lactation period. This often results in an alteration in the shape of the conventional lactation curve shifting to a flatter more persistent curve (Auldist *et al.* 2007). Cows with longer flatter lactation curves tend to have fewer health and fertility problems, have a longer productive life and are more profitable than cows with a conventional lactation curve of higher peak yield and steeper rate of decline (Dekkers *et al.* 1998; Cole and Null 2009). Persistency is usually defined in two ways independent of milk yield, according to the shape of the lactation curve, or defined relative to total yield or peak yield at a given time towards the end of lactation (Grossman and Koops 2003). In the context of this study persistency may be defined as the ratio of milk yield at day 305 to milk yield at peak (Hall 2008; Jonas *et al.* submitted). There are large amounts of available data to calculate persistency, but very limited data are available associated with the measure of extended lactation proposed here. Further study is needed to quantify the most appropriate measures of extended lactation.

Advantages of extended lactation. There are numerous benefits for adopting an extended lactation system, which include delaying inseminations/mating of cows until after peak lactation which can lead to increased conception rates and a longer recovery period in body condition (Borman *et al.* 2004; Auldist *et al.* 2007), a reduction in the number of calves born to one every two years reducing the need for labour with breeding and calving (O'Brien and Cole 2004), and cows would have greater flexibility to milk until they were pregnant rather than being culled because they could not conceive in time for a 12 month calving cycle (O'Brien and Cole 2004). As a result, lactation and production efficiency is likely to increase. Sorensen *et al.* (2008) and Sawa and Bogucki (2009) demonstrated that having extended lactation periods of 15 months saw a reduction in the incidence of mastitis, lameness, metabolic and reproductive disorders, it also resulted in improved fertility later in the lactation period.

Modelling extended lactations in dairy cattle. Lactation curve models are useful tools in helping define lactation characteristics of individual cows for genetic selection (VanRaden *et al.* 2006), predicting yields of milk and milk components, analyse responses of yield to environmental and management changes, and identify opportunities for maximizing net value effectively (Dematawewa *et al.* 2007). In the past, lack of sufficient data on extended lactations has been an impediment to modelling extended lactations. Until recently, extended lactation records of up to 999 days in lactation length have now allowed extensive examinations of the characteristics of lactation curves of dairy cows.

Lactation curve models can be divided into two classes, mechanistic models based on biological processes of lactation (e.g. mammary gland growth) and empirical models, more favoured due to their simplicity which give a general quantitative description of the lactation process (e.g. test day records) (Vargas *et al.* 2000). The Wood model was conceived to model whole lactations and is a widely used empirical model for modelling dairy lactation curves. However, it may not necessarily be able to describe the shape of the lactation curve past 305 days of lactation (Grossman and Koops 2003). Recently, empirical models such as random regression models (RRM) have been extensively used to model lactation curves (Miglior *et al.* 2007; Stoop *et al.* 2007), and currently have been more popular than the Wood model in modelling extended lactations (Haile-Mariam and Goddard 2008; Pryce *et al.* 2010; Yazgan *et al.* 2010). RRM are advantageous over mechanistic models in that they provide a flexible data-driven method of fitting the cow-specific lactation curves and allow persistency across and within lactations to be genetically evaluated (Yazgan *et al.* 2010). However, RRM are computationally more demanding than the Wood model. Further research is required to identify which of the two models is best to model extended lactation. Only a limited number of studies (Vargas *et al.* 2000; Grossman and Koops 2003; Dematawewa *et al.* 2007 and Steri *et al.* 2009) have looked at modelling extended lactations >305 days, mostly based on opportunistic data of cows that had extended lactations as a result of failure to rebreed. No modelling has been done on planned extended lactations beyond 305 days. This may lead to misleading and biased results which may not be applicable to management and breeding strategies of planned extended lactations, and requires further research to understand and model the biology of extended lactation.

Genetic parameters of extended lactation and persistency traits. Until 2008, no estimates of genetic and phenotypic relationships were available for extended lactations beyond the standard 300 days. Since then only two studies (Haile-Mariam & Goddard 2008; Yazgan *et al.* 2010) have detailed genetic parameter estimates for extended lactations, and the need remains for more comparative research.

Heritability. Heritability estimates from both the studies on extended lactation milk traits (Haile-Mariam and Goddard 2008; Yazgan *et al.* 2010) are in general agreement. Heritabilities were moderate (0.19-0.29) for the yield traits, milk, fat, protein, and lactose, which are very similar to heritabilities of 305 day lactations (Cole and VanRaden 2006; Miglior *et al.* 2007; Stoop *et al.* 2007). These findings suggest that extended lactation traits will respond to selection. There is a genetic component to lactation persistency where heritability estimates range up to 0.36 (Haile-Mariam and Goddard 2008), implying that genetic progress could be made on this trait through selection (Davis 2005).

Genetic, phenotypic and environmental correlations of extended lactation traits. Genetic, phenotypic and environmental correlations between yield traits after day 305 of lactation (extended lactation) were found to be quite high and positive (0.60-0.98), except for somatic cell scores, where genetic correlations with yield traits were negative and small (Yazgan *et al.* 2010). These results are comparable to reports by Miglior *et al.* (2007) which looked at genetic parameter relationships between cumulative yield traits up to day 305 of lactation. Haile-Mariam and Goddard (2008) revealed a pattern of relationships among the days of extended lactation (from day 305 up to 540 days) to be relatively similar to that observed in the first 305 days of the standard lactation due to the high genetic (0.34-0.98) and phenotypic (0.26-0.97) correlations between the two traits. This suggests that they are similar traits, regulated by the same genes (Haile-Mariam and Goddard 2008). In the Haile-Mariam and Goddard (2008) study, persistency of milk yield in the first 300 days was adjusted to have genetic correlations of zero with the mean milk yield in the first 300 days and despite this adjustment, genetic correlation was between 0.34 and 0.36. These findings suggest that selection on persistency of milk yield of the first 300 days and mean milk yield can be used to improve milk yield after 300 days (Haile-Mariam and Goddard 2008; Cole and Null 2009). However, the limitation of the two studies (Haile-Mariam and Goddard 2008; Yazgan *et al.* 2010) is that they did not look at relationships (covariances) between the yield traits and other milk and cow traits (fertility) in the extended lactation phase. Hence, further study in needed on the relationships between other yield traits, persistency traits and other cow traits in the extended lactation phase to assist in selection criterion decisions in a breeding program. Perhaps there needs to be a modification in the selection index in order to include extended lactation traits, persistency traits, fertility and survival as a selection index to help producers maximise their profit from breeding. Given there are no covariance estimates between such traits and extended lactation traits, more research is needed to quantify the impact and profitability of modifying the selection index. Furthermore, there are no economic analyses on the effects of persistency on feed costs, milk revenue, health and reproduction on lactation lengths beyond the standard 305 days, and more research is essential before widespread recommendations can be made.

CONCLUSIONS

Adopting an extending lactation in the dairy industry has demonstrated some potential advantages of improving production and lactation efficiency. However, more research is needed to quantify the gains in profitability and define genetic relationships between extended lactation traits, persistency yield traits such as fat, protein and lactose after day 305 of lactation and other cow traits such as fertility and survival. Extended lactation as a trait on its own does not need to be included as a breeding objective but may be included in a selection index with persistency, calving interval and survival but further research is required to quantify these relationships. Such studies are currently in progress for Australian dairy cattle.

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