BRIEF COMMUNICATION: Heritability of IGF-1 and its genetic correlation with milk yield in Holstein-Friesian cows in selected Victorian herds.

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INTRODUCTION

Insulin-like growth factor-1 (IGF-1) is a small peptide, produced mainly in the liver. It controls the growth and differentiation of many cell types through stimulation of the cell cycle (Rechler & Nissley, 1990). IGF-1 has been implicated as being involved in many biological processes and is thought to be related to milk production and reproductive potential of the dairy cow due to its association with the partitioning of nutrients among biological functions (Bauman & Currie, 1980) and its direct stimulatory affect on the ovaries (Spicer *et al.,* 1993).

Recent studies in Holstein-Friesian (HF) cows on pasture-based diets found that plasma IGF-1 concentrations in early lactation were affected by nutrient intake, and that inter-animal variation was greater than within-animal variation (Obese, 2003). This was confirmed in pasture based diets by a study conducted in New Zealand by Fahey *et al.* (2003). Studies by Moyes (2004) show there is an opportunity to rank cows within a herd on their plasma concentrations of IGF-1 after assaying a limited number of samples within a lactation, or possibly over a lifetime. The rankings have the potential to be related to parameters for milk yield and composition as well as reproductive performance and could therefore be used as a tool in dairy cow management and breeding programs.

Selecting for low IGF-1 to improve feed conversion efficiency in pigs and young beef cattle is currently practiced on a commercial basis in Australia (Johnston *et al.,* 2002). Heritability estimates of 0.18 to 0.48 have been reported for plasma IGF-1 in dairy and beef cattle (Davies *et al.,* 2000; Grochowska *et al.,* 2001; Johnston *et al.,* 2001). Such estimates indicate sufficient genetic variation for the gradual alteration of IGF-1 concentrations through breeding selection. The objectives of the present study were to derive heritability estimates for plasma concentrations of IGF-1 in HF cows in Victorian herds as well as genetic correlations between IGF-1 and milk yield and composition parameters.

MATERIALS AND METHODS

Approximately 5,800 HF cows in 21 commercial herds throughout Victoria were included in the study. Blood samples were collected from the tail vein of each cow around the start of the mating period. Samples were placed on ice immediately, centrifuged at 1,800 x g for 10 minutes, and plasma was frozen at -20ºC until assays were undertaken. Concentrations of total IGF-1 were measured using the DSL-10-2800ACTIVE™ Non-extraction IGF-1 ELISA kit (Diagnostic Systems Laboratories, Webster, Texas, USA) in the laboratories of Primegro Ltd, Adelaide, according to the methods of Obese *et al*. (2008). Inter-assay variation (Coefficient of variation) was 6.9% for Kit Control A (low) and 4.3% for Kit Control B (high). Mean intra-assay variation was 4.5% (low) and 3.0% (high). Milk production data were obtained from monthly or bimonthly herd test records. Milk fat and protein composition was determined by near infrared spectroscopy using a Fossmatic 4000/5000 Combi (Foss Electric, Denmark) at the commercial herd testing laboratories used by each herd. Heritabilities and genetic correlations of IGF-1 and milk yield were calculated using ASReml (Gilmour *et al.,* 2006) with age, herd, year/season, calving system and days in milk at the time of blood sampling as fixed effects and sire as a random effect. Cows were only included in this analyses if they were in at least their second lactation, and their sire had at least four other daughters in the study regardless of which herd they were in. This resulted in 2,860 cows and 159 sires in the analyses.

RESULTS AND DISCUSSION

Heritability for IGF-1, 305-day milk yield and 305-day milk protein yield was moderate, while the heritability for 305-day fat yield was low (Table 1). The genetic correlation between plasma IGF-1 and milk production was moderate and negative for all of the milk production traits considered (Table 1).

The heritability estimates for plasma concentrations of IGF-1 calculated in this study are within the range of 0.18 to 0.48 that has been

TABLE 1: Means and heritabilities of plasma IGF-1, 305-day milk, fat and protein yields, and genetic correlations between IGF-1 and 305-day milk, fat and protein yields.

Trait	Mean ± standard deviation	Heritability ± standard error	Genetic correlation with IGF-1
Plasma IGF-1	90 ± 39.3 ng/mL	0.21 ± 0.05	NA
305-day milk yield	7,471 ± 1,988.4 kg	0.22 ± 0.06	-0.25
305-day fat yield	292 ± 74.5 kg	0.10 ± 0.04	-0.31
305-day protein yield	250 ± 62.5 kg	0.17 ± 0.06	-0.20

reported for dairy and beef cattle in recent studies (Davies *et al.,* 2000; Grochowska *et al.,* 2001; Johnston *et al.,* 2001). The heritability estimate for milk yield in the current study was identical to that calculated in an Irish study with 6,000 cows (Berry *et al.*, 2003) and very similar to that calculated in an Australian study with 3,000 cows (Madgwick *et al*., 1991) where heritability of milk yield was reported as 0.16. A review by Veerkamp (1998) reported that heritabilities for milk yield ranged from 0.16 to 0.50. Moderate heritability of IGF-1 indicates that it could be gradually altered by genetic selection. A moderate negative genetic correlation between IGF-1 and milk yield means that many of the same genes affect these two traits. Since IGF-1 has a similar heritability to, and moderate genetic correlations with milk production factors, cows are predisposed to decreasing plasma IGF-1 with selection for increased milk yield. This effect was particularly evident in an Irish study that compared the North American derived HF strain to the New Zealand strain (McCarthy *et al.*, 2005). The study showed that the North American strain cows (bred for higher milk production) had significantly lower plasma IGF-1 than the New Zealand strain cows. Further analyses will investigate the genetic correlations between IGF-1 and fertility for this cow population.

Preliminary investigations indicate a significant phenotypic relationship between IGF-1 and fertility in dairy cows in Victorian herds. If genetic correlations confirm this, there may be the potential to use IGF-1 in the dairy industry as a marker for performance potential. For example, it could be incorporated into a multi-trait selection index to allow selection for high milk yield without affecting fertility.

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REFERENCES

Bauman, D.E.; Currie, W.B. 1980: Partitioning of nutrients during pregnancy and lactation: a review of mechanisms involving homeostasis and homeorhesis. *Journal of dairy science* **63**: 1514-1529.

Berry, D.P.; Buckley, F.; Dillon, P.; Evans, R.D.; Rath, M.; Veerkamp, R.F. 2003: Genetic relationships among body condition score, body weight, milk yield and fertility in dairy cows. *Journal of dairy science* **86**: 2193-2204.

Davies, M.E.; Simmen, R.C. 2000: Genetic parameter estimates for serum insulin-like growth factor-I concentration and carcass traits in Angus beef cattle. *Journal of animal science* **78**: 2305-2313.

Fahey, J.; Morgan, S.R.; Napper, A.R.; Roche, J.R.; Kolver, E.S.; Verkerk, G.A. 2003: A comparative study of ovarian follicle dynamics and IGF-1 concentration during an oestrus cycle in two genotypes of lactating Holstein-Friesian cows offered pasture or total mixed ration. *Proceedings of the Association for the Advancement in Animal Breeding and Genetics* **15**: 227-231.

Gilmour, A.R.; Gogel, B.J.; Cullis, B.R.; Thompson, R. 2006: ASReml User Guide Release 2.0 VSN International Ltd, Hemel Hempstead, Hertfordshire, UK.

Grochowska, R.; Sorensen, P.; Zwierzchowski, L.; Snochowski, M.; Lovendahl, P. 2001: Genetic variation in stimulated GH release and in IGF-I of young dairy cattle and their associations with the leucine/valine polymorphism in the GH gene. *Journal of animal science* **79**: 450-476.

Johnston, D.; Herd, R.M.; Kadel, M.J.; Graser, H.U.; Arthur, P.F.; Archer, J.A. 2002: Evidence of IGF-1 as a genetic predictor of feed efficiency traits in beef cattle. *Proceedings of the World Congress on Genetics Applied to Livestock Production*. Montpellier, France **7**: 10-16.

Johnston, D.J.; Herd, R.M.; Reveter, A.; Oddy, V.H. 2001: Heritability of IGF-1 in beef cattle and its association with growth and carcase traits. *Proceedings of the Association for the Advancement of Animal Breeding and Genetics* **14**: 63-166.

Madgwick, P.P.; Beard, K.A.; Goddard, M.E. 1991: Possibilities for incorporating selection for feed conversion efficiency into the National Dairy Herd Improvement Program. *Proceedings of the Association for the Advancement in Animal Breeding and Genetics* **9**: 45-48.

McCarthy, S.; Mee, J.F.; O'Connor, P.; Rath, M.; Dillon, P. 2005: The effect of strain of Holstein-Friesian cow and feeding system on selected plasma metabolic hormones and reproductive performance. *Proceedings of the Agricultural Research Forum, Tullamore, Ireland.* p. 52.

Moyes, T.E. 2004: Variation in Concentrations of Insulin-Like Growth Factor-1 in Pasture-fed Holstein-Friesian Cows. Ph.D. Thesis, The University of Melbourne, Melbourne, Australia. p. 57-81.

Obese, F.Y. 2003: Concentrations of Insulin-like Growth Factor-1 (IGF-1) and Insulin-like Growth-Factor Binding Protein-3 (IGFBP-3) in the Plasma and Milk of Pasture-fed Dairy Cows in Early Lactation. Ph.D. Thesis, University of Melbourne, Melbourne, Australia.

Obese, F.Y.; Humphrys, S.; Macmillan, K.L.; Egan, A.R.. 2008: Measuring concentrations of insulin-like growth factor-I with an enzyme-linked immunosorbent antibody assay in plasma samples from Holstein cows. *Journal of dairy science* **91**: 160-168.

Rechler, M.M.; Nissley. S.P.1990: Insulin-like growth factors. In: Sporn, M.B.; Roberts, A.B. eds. Peptide growth factors and their receptors I,. Springer-Verlag, Heidelberg, Austria. **95**: 263-267.

Spicer, L.J.; Alpizar, E.; Echternkamp, S.E. 1993: Effects of insulin, insulin-like growth factor-I and gonadotropins on bovine granulosa cell proliferation, progesterone production, oestradiol production, and (or) insulin-like growth factor-I production *in vitro*. *Journal of animal science* **71**: 1232-1241.

Veerkamp, R.F. 1998: Selection for economic efficiency of dairy cattle using information on live weight and feed intake: A review. *Journal of dairy science* **81**: 1109-1119.