Plasma prolactin in Romney sheep selected for hogget fleece weight

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ABSTRACT

Two experimental flocks of Romney sheep selected for increased hogget fleece weight show high selection responses (30-40% of their controls) and evidence for altered seasonal patterns of annual wool growth, in line with published evidence from other flocks.

While a preliminary experiment was unable to detect consistently significant line differences in plasma prolactin concentration at set time periods, there were indications of altered seasonal patterns in prolactin concentration and line differences in its association with wool growth. Both selection and control lines showed low prolactin concentrations in June and July (16 ng/ml). Concentrations rose in August, September and October, approximately doubling each month to an average level of 111 ng/ml in early November.

Early results from this longitudinal study, still in progress, suggest that animals from the selected lines tended to maintain their low prolactin concentrations longer into the winter and early spring, and that this tendency is associated with a higher hogget fleece weight. By contrast, in the unselected control lines, high hogget fleece weight tended to be positively associated with increasing prolactin levels over the winter/early spring period.

Keywords: Fleece weight, selection, seasonality, plasma prolactin

INTRODUCTION

In small animals there is increasing evidence for an association between seasonal prolactin levels and the control of fibre growth (Badura and Goldman, 1992). In sheep and goats, plasma prolactin levels vary circadially (Lincoln *et al.*, 1978) and with temperature (Prandi *et al.*, 1988) and season, with minimum levels in winter and maximum levels in early summer (Lincoln, 1990). The latter worker showed that various feral and domesticated breeds and crosses demonstrate a high positive rank correlation of seasonal minimum prolactin concentration with their seasonality of fibre growth.

This paper presents some early results on the effects of selection for increased hogget fleece weight on the seasonality of plasma prolactin concentrations and its association with fleece growth throughout the year. Hawker *et al.*(1988) and McClelland *et al.* (1987) have presented data which indicate that sheep selected for increased hogget fleece weight show a decreased seasonality of fleece production. Relative to the controls, selection responses were proportionately higher in winter than in spring and summer months.

The study is based on two lines selected for increased hogget fleece weight and their unselected controls. The Tokanui Line was established at Whatawahata Research Centre in 1968 (Johnson *et al.*, 1988); the Woodlands line was established at Woodlands Research Station in 1973 (Tait, 1983; Clarke, 1984). Both are now running together at the Tokanui Research Station for comparative evaluation of selection responses and the underlying biological control of fleece production. They show a 30-40% response to selection for increased greasy hogget fleece weight.

MATERIAL AND METHODS

Selection lines

(1) Preliminary trial

An initial study involved selected (HFW) and control (CO) lines from the Tokanui flock. Two days after hogget shearing on 18 September 1991, 25 ewe hoggets (12 months of age) from each line were blood sampled by jugular venipuncture in a time-balanced manner across the lines, for estimation of plasma prolactin concentration. The animals were re-bled on 13 February at the time of two-tooth shearing (17.5 months of age). Further prolactin assays were done the following July (22.5 months of age) six weeks before lambing, and at ewe shearing on 17 December 1992 (27.5 months of age).

(2) Seasonality experiment

Contrasting line differences in early spring and late summer prolactin concentrations and wool production were found for the 1990-born hoggets and prompted the establishment of a more detailed study of seasonal variations in prolactin concentration and wool growth. It involves approximately 300 ewe hoggets and the 1991 and 1992 lamb drops of the Tokanui, Woodlands and Invermay selection and control lines. All animals are also being wool sampled by patch clipping at 9 weekly intervals. The experiment is designed to continue over a 20 month period from 6 or 7 months of age, to ensure that adult as well as developmental patterns of seasonality are evaluated (Bigham *et al.*, 1978). This paper reports early results of trends in plasma prolactin concentration from blood samples taken on 28 May, 3 July, 30 July, 11 September, 6 October and 6 November 1992, for animals from the Tokanui and Woodlands lines running together at the Tokanui Research Station.

Prolactin assays

Plasma prolactin levels were measured in duplicate by radioimmunoassay, using ovine prolactin (NIDDK-oPRL-2) for standards and radioiodination, and ovine prolactin antiserum (NIDDK-anti-oPRL-2). Iodination was by the Iodogen technique (Pierce, Rockford, IL), using [I^{125}]-iodide (New England Nuclear NEZ0033A). The assay method was essentially as prescribed for NIDDK reagents. Separation of antibody-bound label from free label was by antibody precipitation using excess sheep anti-rabbit serum generated at the Ruakura Agricultural Centre. Sensitivity was 0.6 ng/ml; interassay and intraassay variations at 32 ng/ml were of the order of 14% and 12%, respectively.

Statistical analyses

Analysis of results has focused on line differences in plasma prolactin concentration and greasy fleece weight. Associations among these traits have been evaluated for each of the lines separately using simple and partial correlation and regression analyses.

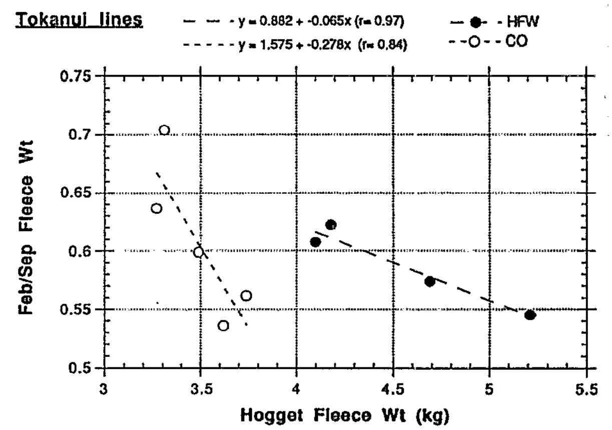
RESULTS

Preliminary experiment

The lines differed in lamb fleece weight by 0.72 kg (24%), in hogget fleece weight by 1.14 kg (33%) and in February fleece weight by 0.56 kg (26%), the relative differences being less for wool grown over spring and summer months (Table 1). The correspondence of these differences with genetic differences within each of the lines was assessed from variation among sire progeny groups (4-8 progeny per sire) and the ratio of February to September fleece weights calculated; high values indicate a high seasonality of fleece weight. Results are plotted in Figure 1.

The graphs show that selection for hogget fleece weight has reduced the seasonality of annual wool production and that within both lines (and more especially the controls) higher genetic merit for hogget wool production is positively associated with a lower seasonality of annual wool growth. Phenotypic differences within the lines indicated similar tendencies - September hogget fleece weight was more highly correlated with subsequent February (0.77 vs 0.57) and December fleece weights (0.52 vs 0.32) in the HFW line than in the CO line.

FIGURE 1: Seasonality of fleece production (February/September fleece weight) for high fleece weight (HFW) and control (CO) ewe hoggets born at Tokanui in 1990.



These early results were also suggestive of different seasonal associations between plasma prolactin and fleece weight. Although not in all cases significant, prolactin concentrations were greater in the HFW line by 27% in September and the CO line by 17% in February (Table 1). Thus the seasonality ratio of February to September prolactin was reduced considerably by selection (from 2.2 to 1.5).

As a consequence of these results, genetic associations of the seasonality ratios for fleece weight and prolactin were very different within and between the lines (Figure 2).

FIGURE 2: Relationship between the seasonality of prolactin concentration and the seasonality (February/September) of fleece weight in ewe hoggets of the high fleece weight (HFW) and control (CO) lines born at Tokanui in 1990.

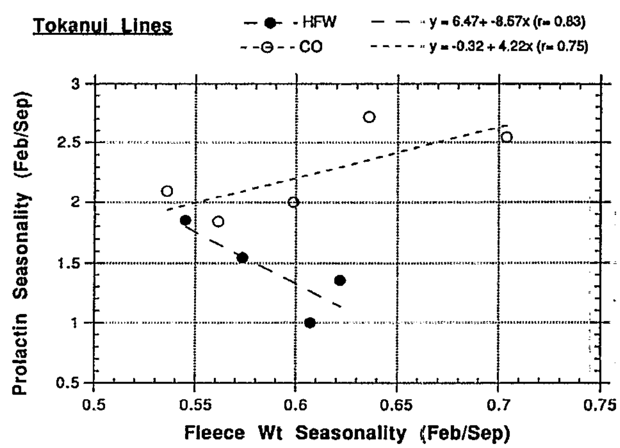


TABLE 1: Line means (and standard deviations) for greasy fleece weight and prolactin concentration (Tokanui ewe hoggets born in 1990)

Line	Fleece weight (kg) Lamb	Hogget	2-tooth	4-tooth	Prolactin concentration (ng/ml) Sep 91 (12 mo)	Feb 92 (17 mo)	Jul 92 22 mo)	Dec 92 (27 mo)
CO	0.94	3.42	2.11	2.64	76	165	16.0	245
	(0.23)	(0.51)	(0.26)	(0.61)	(37)	(94)	(21.1)	(121)
HFW	1.17	4.56	2.67	3.46	96	140	8.5	177
	(0.31)	(0.69)	(0.29)	(0.90)	(35)	(84)	(13.1)	(99)
HFW/CO	1.24	1.33	1.26	1.31	1.3	0.9	0.5	0.7

Selection appears to have reduced the seasonality of prolactin to a greater extent than its effect on the seasonality of wool production and brought about a change from a positive to a negative within-line genetic association of this indicator of the seasonality of prolactin with the seasonality of wool production.

Examination of the phenotypic correlations of prolactin concentration with fleece weight within each of the lines failed to reveal any additional contrasting associations. Differences in prolactin concentration between July and September and between February and July were, for both lines, very highly correlated with the February and September levels themselves. This feature, together with the moderate correlations of number of lambs born at the two-tooth lambing with July prolactin (averaging -0.42 over both lines) and with December prolactin (average +0.29), suggests that pregnancy and lactation effects may have influenced variations in prolactin levels at these later times. The current seasonality study will avoid such confounding of effects.

Seasonality experiment

(1) Fleece and body weights

On average across both flocks, selected hoggets clipped 1.0 kg (35%) more greasy wool (Table 2). This response was associated with 0.3 kg (30%) additional greasy wool as lambs and approximately 15% higher body weights during the winter and early spring. Coefficients of variation were similar in both lines for each trait.

TABLE 2: Line means (and standard deviations) for fleece and body weights (Tokanui and Woodlands ewe hoggets born in 1991)

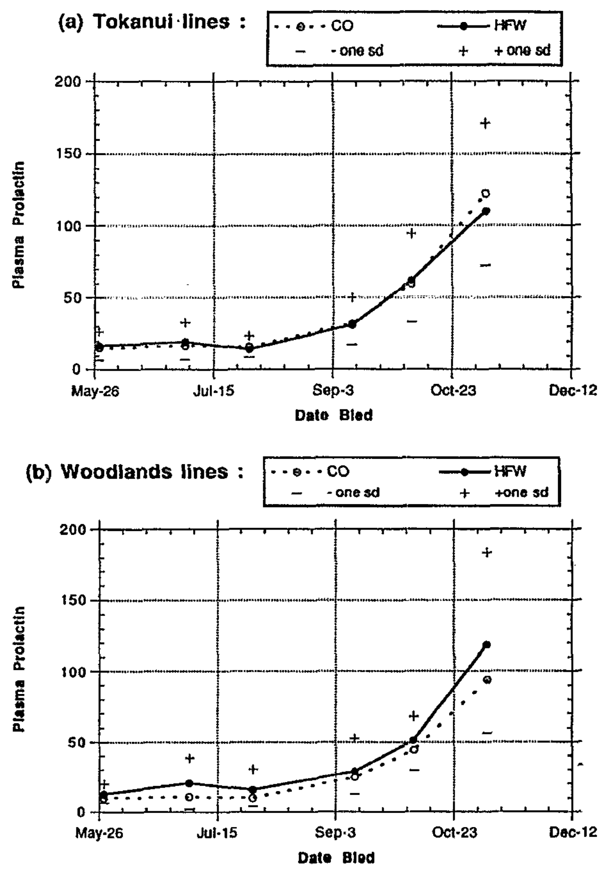
Flock	Line	Fleece weight (kg) Lamb	Fleece weight (kg) Hogget	Body weight (kg) May	Body weight (kg) October
Tokanui	CO	0.94	2.81	30.8	30.7
		(0.21)	(0.37)	(3.9)	(3.8)
	HFW	1.18	3.67	36.0	34.0
		(0.27)	(0.50)	(4.0)	(3.8)
	HFW/CO	1.25	1.30	1.17	1.11
Woodlands	CO	1.08	2.91	32.4	32.1
		(0.24)	(0.45)	(4.7)	(4.4)
	HFW	1.47	4.05	37.0	36.4
		(0.34)	(0.62)	(5.0)	(3.6)
	HFW/CO	1.36	1.39	1.14	1.13

(2) Average plasma prolactin concentration

In agreement with the seasonal prolactin trends found for Romney sheep housed indoors under natural photoperiod (A.J. Pearson, unpublished data), both selection lines and their controls showed low average prolactin levels in June, July and August (16 ng/ml on average across the four lines). Concentrations rose dramatically during August, September and October, approximately doubling each month to an average level of 111 ng/ml in early November (Figure 3).

As the average trends show, differences between the selected and control lines were small relative to time of sampling effects. None were significant. At each age, line differences were never more than 15% of the CO for the Tokanui line (July levels). For the Woodlands flocks (run in the same environment), the prolactin concentration of the HFW line was consistently higher (15 to 90%) than the CO, the difference being greatest in percentage terms in early July (90%) and August (54%). Within the lines, coefficients of variation among animals were greatest over the June to August period for CO (55%) and over the July to September period for HFW lines, the distributions suggesting that some HFW animals were maintaining their low plasma prolactin concentrations longer into the winter than were the CO.

FIGURE 3: Average prolactin concentration and standard deviation (ng/ml) for ewe hoggets from the high fleece weight (HFW) and control (CO) lines of the Tokanui (a) and Woodlands (b) flocks born at Tokanui in 1991.



(3) Within line associations among prolactin concentrations

Tokanui flock

The repeatability of prolactin concentration tended to decline with increasing interval between blood samplings in both lines. Correlations between adjacent monthly samplings were similar for both lines at the July sampling (0.6 to 0.65). In the CO line they declined thereafter (to 0.3 to 0.35), while in the HFW line they increased to 0.75 in August and September. Thus the correlation of previous prolactin levels with later prolactin levels remained high until October in the HFW line compared with August in the CO line. As expected from the average trends and standard deviations shown in Figure 3, changes in prolactin concentration tended to be more highly associated with plasma levels measured at the end rather than the beginning of the period.

Woodlands flock

Broadly similar line differences in the seasonal trend of the repeatability of adjacent monthly prolactin concentrations were found in the Woodlands flock. Highest correlations were found for the July sampling (0.7 to 0.95), declining more slowly thereafter in the HFW line (0.8 in September) than in the CO line (0.6 in September). Repeatabilities were low for both lines (0.15 to 0.3) at the October sampling.

(4) Associations of prolactin with fleece weight

Tokanui flock

In the CO line, greasy hogget fleece weight was positively associated with plasma prolactin in October (0.33) and with the rise in concentration from September to October (0.39) and from August to October (0.36). All other correlations of plasma prolactin were close to zero. A similar result was found when partial correlations were examined to remove variation associated with July liveweight which showed a low correlation with October prolactin (0.16) but a high correlation with hogget fleece weight (0.68).

In the HFW line, greasy hogget fleece weight was negatively associated with plasma prolactin, especially in September (-0.48) and October (-0.49) and negatively associated with the rise in plasma prolactin during the months of August (-0.40) and September (-0.30). The contrasting sign patterns between the lines for significant correlations of prolactin concentration with greasy hogget fleece weight are summarised in Table 3. Animals in the HFW line maintained their negative association of prolactin with fleece weight longer into the winter/early spring period than did animals in the CO line.

TABLE 3: Patterns of significant prolactin associations with hogget fleece weight

Flock	Line	Aug	Aug to Sep	Sep	Sep to Oct	Oct
Tokanui	CO				+	+
	HFW		-	-	-	-
Woodlands	CO		+			
	HFW	-	-	-		-

Woodlands flock

Greasy hogget fleece weight in the CO line was most closely associated (+0.32) with the rise in plasma prolactin from August to September. This change in combination with the fall in prolactin between June and August, gave a multiple correlation with hogget fleece weight of 0.51. Thus, animals which showed declining prolactin through until August and rising prolactin from August to September tended to have higher hogget fleece weights.

While only small numbers of animals were available for the HFW line in the first season of this work, greasy hogget fleece weight tended to be most closely associated (-0.62) with low August to September rises in prolactin and low September (-0.58) and October (-0.58) levels. Thus this HFW line also maintained a negative association of prolactin with fleece weight longer into the winter/early spring period than those in the corresponding CO line.

DISCUSSION

Through its effects on staple strength, winter wool growth is important to the value as well as the efficiency of wool production (Hawker and Crosby, 1985). Although its underlying basis is not understood, it seems that selection of animals for high greasy fleece weight in October has brought about a number of different biological changes which are associated with the growth of wool over the winter period. Furthermore, in view of the relatively small contribution that winter wool production makes to the weight of the hogget fleece, it is likely that variations in winter wool growth are subject to strong genetic influences. This encourages the search for genes and genetic markers affecting winter wool production and/or its responsiveness to nutrition or other managemental influences.

Analyses of unpublished data collected by the late Dr Hugh Hawker on ewe hoggets born on site in the Woodlands selection flock from 1982 to 1984, demonstrated a pronounced seasonal trend in wool growth rates. In the CO, mid-side patch weights indicated a 20% lower follicle productivity in the autumn (June clipping) compared with the summer (March clipping) period, and a 55% lower follicle productivity in winter (September clipping) compared with the summer period. While selection for hogget fleece weight improved follicle productivity during all 3 periods studied, it was particularly effective in reducing (approximately halving) the winter decline in daily follicle productivity per unit area of skin. These Woodlands studies also provide early circumstantial evidence on the effects of body weight growth on fleece weight. Total greasy wool growth on mid-side patches from the lamb to hogget shearings was 15% higher in the HFW compared to the CO line. The greater percentage superiority (25%) in hogget fleece weight of the HFW line over the CO suggests that differences in autumn and winter body growth may be responsible for nearly half of the selection responses in greasy fleece observed at hogget shearing.

Although large between-animal variation is evident, our early results suggest important underlying associations of prolactin concentration with genetic variation in fleece weight and, in particular, with seasonal changes in fleece production during the year. While there is as yet little indication that this trait is of practical value as a genetic marker for selective breeding decisions, the results indicate that it offers promise as a research approach to further our understanding of the physiological genetic control of the seasonality of wool growth in crossbred sheep.

It is likely that this research will need to include studies undertaken under indoor conditions to better control effects associated with nutrition, temperature and animal stress. Nevertheless, outdoor data presented by Lincoln (1990) showed large seasonal variations in prolactin concentration, with a higher coefficient of variation being greater in the winter trough (51%) than at the summer peak (26%). Variation among his very divergent breeds in the degree of seasonality in the growth of wool was more strongly correlated (0.82) with winter prolactin concentration than with prolactin concentration at the peak of its seasonal cycle (-0.46). Further analysis of his published data indicates that breeds which reached their minimum prolactin concentration later in the winter had a higher maximum prolactin concentration in the summer (r = 0.68), indicating that changes in prolactin concentration were also important and that these will give rise to different seasonal patterns in the sigmoid cycle of prolactin concentration for different breeds. Early results from our current seasonality experiment also highlight the need for a longitudinal rather than a cross-sectional trial design, in order that prolactin changes as well as absolute levels can be assessed.

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