Relative performance of Wiltshire and Perendale sheep

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Abstract

Performance data are reported for flocks of Wiltshire and Perendale sheep grazed together for four years on a North Island hill country property (Whatawhata) and for four years on a South Island breeding/finishing property (Winchmore). Wiltshire ewes were lighter than Perendale ewes post-joining at Whatawhata, and at weaning at Winchmore. Greasy fleece weights of the Wiltshire and Perendale yearlings were 0.8 and 2.2 kg respectively, and 0.5 and 3.3 kg respectively for the ewes. As a result of a confounding effect of fibre shedding between day length and date of shearing, Wiltshire ewes exhibited a linear decrease in harvested fleece weight from the yearling stage whereas Perendale ewes showed a curvilinear age effect, with a maximum fleece weight at three to four years of age. Wiltshire ewes had a significantly lower reproductive rate, and lamb survival than Perendale ewes at both locations, with reproductive rate, fertility and litter size increasing significantly following the transfer of the flocks from Whatawhata to Winchmore. While there was no significant difference in the total weight of lambs weaned by the two breeds at each location, the loss in wool production would be compensated by lower shearing and management costs for Wiltshire sheep that shed completely.

Keywords: live weight; fleece weight; reproductive rate; Perendale; Wiltshire; sheep

Introduction

It has been estimated that there are currently between twenty and fifty thousand Wiltshire and Wiltshire cross ewes in New Zealand (Morrison 2010). New Zealand Wiltshire sheep are direct descendents of the first group of English Wiltshire Horn sheep imported into Western Australia in 1952 (Thatcher & Pascoe 1973). Growing little wool at a time of buoyant wool prices, the breed almost died out. A small group of two rams and fifteen ewes survived to be transferred to Victoria in 1969 to found the "Barra Simbal" stud, the source from which all Australasian Wiltshire sheep have descended (Morrison 2010). Some of the Victorian Wiltshire ewes were crossed with Poll Dorset rams to reduce the phenotypic expression of horns (Morrison 2010).

The first Wiltshire sheep arrived in New Zealand from Australia in 1972 as four Poll Dorset x Wiltshire Horn ewes and one Wiltshire Horn ram from the "Gee Tee" stud in New South Wales. This group was farmed in the Wairarapa and selectively bred to produce a polled Wiltshire flock. In 1984 the enlarged flock was purchased in its entirety and transferred to "Ardo", a property near Marton, where it has since provided the basis for Wiltshire sheep in New Zealand (Morrison 2010). In the interim there have been further importations of Wiltshire and Wiltshire Horn sheep used for crossing and back-crossing on several properties within New Zealand. The majority of New Zealand Wiltshire sheep are polled and shed all, or most, of their fleece annually in the spring. As well as being useful as a terminal sire, this makes the New Zealand Wiltshire sheep a useful model for studies on the hormonal control of wool growth (Parry et al. 1991; Pearson et al. 1996). Wiltshire sheep have also been used in the development of a low cost easy care sheep with minimal wool growth on the belly, escutcheon and crutch regions (Scobie et al. 2006).

Perendale sheep were initially developed in the mid 1900s as an interbred Cheviot and Romney. They were developed for hill country conditions as a dual-purpose sheep producing meat and wool suitable for hand-knitting yarns and carpets. Approximately 9% of the national flock are classified as Perendale, with "Perendale cross" sheep also being included in the 28% of the national flock classified as "Other" (Beef + Lamb New Zealand 2011).

Currently there are no published data on the relative performance of New Zealand Wiltshire sheep when compared to the production of common New Zealand sheep breeds. This paper reports data collected over two four-year periods while flocks of Wiltshire and Perendale sheep were grazed together in two contrasting environments.

Materials and methods

Wiltshire flock

Sheep in the self-replacing flock of approximately 150 Wiltshire ewes used in this study were direct descendants of a group of approximately 100 Wiltshire ewes, exhibiting a tendency to shed wool, selected from the "Ardo" flock and established at AgResearch Flock House, near Bulls, in 1991. On 28 July 1994 the flock was relocated to the Whatawhata Research Centre, near Hamilton on North Island hill country. Five unrelated Wiltshire rams were sourced from five different breeders in 1995 and joined with five randomly selected groups of ewes as single sire joining to create five "sire family" groups. The same rams were used in 1996 following re-randomisation of the ewes across joining groups. No rams were introduced from outside the flock after 1996 with the heaviest yearling ram, free of any structural faults, in each of the five sire lines joined with a re-randomised group of ewes, excluding mother-son and half-sib matings. The complete flock was relocated to the Winchmore Research Station, near Ashburton, on South Island breeding/finishing country on 17 April 2000.

Perendale flock

Sheep in the self-replacing flock of approximately 200 Perendale ewes used in this study were direct descendants of a group of Perendale ewes considered to be representative of the New Zealand Perendale breed selected from 23 farms and established at Whatawhata Research Centre in 1970 as part of a breed comparison (Dalton & Ackerley 1974). The flock was later used to study the inheritance of loose wool bulk (Sumner et al. 2007). During the "selection phase", beginning in 1987, the flock consisted of two selection lines each comprising five "sire family" lines. No rams were introduced from outside the flock after 1988. The complete flock was relocated to the Winchmore Research Station on 10 July 1997.

Flock management

The Wiltshire and Perendale flocks were managed conjointly between 28 July 1994 and 10 July 1997, while both flocks were located at Whatawhata, and between 17 April 2000 and January 2004 while both flocks were located at Winchmore. While at Whatawhata, both flocks were grazed together as part of a large mob of approximately 1,500 experimental ewes encompassing several trials. The large flock was separated into its component sub-flocks over joining and lambing. While at Winchmore, the Wiltshire and Perendale flocks were grazed as separate entities on adjacent paddocks and managed similarly.

All ewes in both flocks were routinely weighed and the live weight recorded pre-joining (March), post-joining (April/May) and at weaning (December/January). Pre-joining live weights for rising two-year-old ewes were not recorded in any year as this age group was grazed in a separate mob. Ewes were shorn pre-lambing and the greasy fleece weight recorded.

Lambs were individually identified at birth, when sex and live weight were recorded. They were subsequently weaned in December at Whatawhata and in January at Winchmore when their live weight was recorded and subsequently shorn as a precaution against flystrike. Thereafter the lambs were managed as single sex groups. Their live weight was next recorded as a yearling in September/October when they were again shorn and their fleece weight recorded. Potential sires for each flock were selected on the basis of performance as a yearling and the remainder culled after yearling shearing.

Statistical analysis

All recorded parameters, after adjustment for appropriate variables outlined below, were analysed for breed effects at Whatawhata over the four-year period of 1994 to 1997, and at Winchmore over the four-year period of 2000 to 2003. With no recorded pre- and post-join live weight data for the Wiltshire ewes in 1994, and the pre-join live weight data for the Wiltshire ewes in 2000 being recorded before the ewes were relocated to Winchmore, analyses of these traits were restricted to the three year periods of 1995 to 1997, and 2001 to 2003, at Whatawhata and Winchmore respectively. Similarly with the Perendale ewes being relocated to Winchmore in 1997 before lambing, analysis of ewe live weight at weaning was restricted to the three-year period of 1994 to 1996, and the four-year period of 2000 to 2003, at Whatawhata and Winchmore respectively.

A residual maximum likelihood (REML) model was run using GenStat (Payne et al. 2009) with ewe and year of record as random effects for all continuous variables. Fixed effects associated with breed, location, ewe age, number of lambs born and number of lambs weaned, were included for the ewe analyses. To take account of physiological events that can affect a ewe's live weight during the year, each of the three values for ewe live weight recorded during the year were adjusted by different covariates. Pre-joining live weight was adjusted for number of lambs weaned in the previous year, post-joining live weight was not adjusted and live weight at weaning was adjusted for number of lambs weaned. Fixed effects associated with sex, dam age and birth rank were included for birth weight analyses and sex, birth date, birth/weaning rank, dam age and age at weaning were included for the other lamb analyses. Additional terms of age at yearling live weight and interval between lamb shearing and yearling shearing were added to the lamb model for analysing the yearling data.

Ewe reproductive performance was quantified as "net ewe reproductive rate" or the number of lambs weaned (LW) per ewe joined (EJ), comprising four measured components (Turner 1969). Namely:

$$\begin{matrix}\text{Net}\\ \text{reproductive}\\ \text{rate}\end{matrix} = \begin{matrix}\text{Ewe}\\ \text{survival}\end{matrix} \times \begin{matrix}\text{Ewe}\\ \text{fertility}\end{matrix} \times \begin{matrix}\text{Litter}\\ \text{size}\\ \text{born}\end{matrix} \times \begin{matrix}\text{Lamb}\\ \text{survival}\end{matrix}$$

Each of these components can be measured individually as:

$$\frac{LW}{EJ} = \frac{EPL}{EJ} \times \frac{EL}{EPL} \times \frac{LB}{EL} \times \frac{LW}{LB}$$

where EPL = Number of ewes present at lambing, EL = Number of ewes lambing and LB = Number of lambs born. A logistic generalised linear mixed model (GLMM) for parameters describing fertility of the ewe and survival of the lamb, with ewe and year of record as random effects, was run using GenStat (Payne et al. 2009). Fixed effects associated with breed, location and ewe age were included.

Table 1 Numbers of records of lambs born, yearlings weighed and ewes joined each year in each flock while both flocks were at Whatawhata and at Winchmore.

Year of record	Wiltshire					Perendale				
	Lambs		Yearlings		Adult	Lambs		Yearlings		Adult
	Ewes	Rams	Ewes	Rams	Ewes	Ewes	Rams	Ewes	Rams	Ewes
Whatawhata										
1994	61	70	19			117	101	74	55	227
1995	50	42	51	41	116	90	90	76	71	219
1996	40	30	35	27	121	90	85	60	60	209
1997	52	50	27	16	118	89	104	50	59	202
Subtotal	203	192	132	84	355	386	380	260	245	857
Winchmore										
2000	58	40	25	31	91	145	104	108	82	152
2001	77	63	42	26	88	133	147	120	82	173
2002	66	58	61	56	88	116	109	117	119	186
2003	113	112	52	40	139	59	77	92	77	80
Subtotal	314	273	180	153	406	453	437	437	360	591
Total	982		549		761	1,656		1,302		1,448

Table 2 Numbers of records of ewes by age classification group joined from 1994 to 1997 and 2000 to 2003.

Ewe age classification	Whatawhata		Winchmore	
	Wiltshire	Perendale	Wiltshire	Perendale
2	87	214	109	168
3	67	228	87	150
4	71	159	55	121
5	54	135	42	83
>5	76	121	113	69
Total	355	857	406	591

Results

Number of observations

The numbers of records of lambs born, yearlings weighed and ewes joined each year in each flock while both flocks were at Whatawhata and at Winchmore are shown in (Table 1). The breed by age distribution for the ewes at each location is shown in Table 2, with data for six-year-old and older grouped into one classification labeled as ">5". A higher proportion of aged Wiltshire ewes was retained to conserve genetic stock.

Ewe performance

Live weight. Breed by location means for each of the three recorded ewe live weights are shown in Table 3. While there was no significant difference in live weight pre-joining or at weaning when the two breeds grazed at Whatawhata, the Wiltshire ewes lost weight during mating on hill country ($P < 0.002$). When the two breeds were grazed at Winchmore there was no difference in the mean adjusted pre- and post-joining live weight. Subsequently the Wiltshire ewes lost weight during lactation while the Perendale ewes gained weight, to become significantly heavier than the Wiltshire ewes at weaning ($P < 0.001$).

Both breeds showed a significant curvilinear age effect for live weight at the end of joining ($P < 0.001$), when their live weight was largely free of the constraints of either the previous lactation or impending pregnancy and lactation (Fig. 1a). The quadratic term was significantly smaller at Whatawhata than at Winchmore ($P = 0.008$) but did not differ between breeds ($P = 0.87$), with the surviving ewes of both breeds reaching a plateau on live weight at five years of age.

Fleece weight. Mean greasy fleece weight following pre-lamb shearing at each location in the spring, after adjustment for ewe age, is shown in Table 3. There was a large difference between breeds in the weight of wool harvested at both locations (Whatawhata ($P <0.001$), Winchmore ($P <0.001$)) with the recorded fleece weight of the Wiltshire ewes being approximately 15% of that for the Perendale ewes (0.5 vs 3.3 kg). The mean fleece weight of the Wiltshire ewes was heavier at Winchmore than at Whatawhata ($P = 0.05$) while the fleece weight of the Perendale ewes was not significantly different between the two locations ($P = 0.37$).

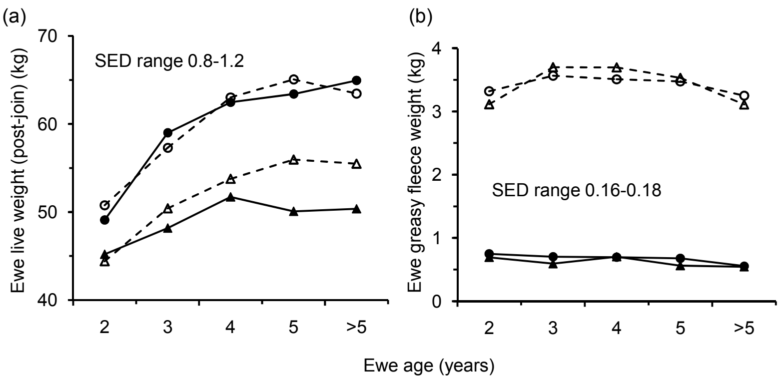
There was a significant curvilinear effect of age for the weight of greasy fleece harvested from the Perendale ewes ($P <0.001$), with a maximum at three to four years of age but no significant curvilinear age effect ($P = 0.72$) for that harvested from the Wiltshire ewes (Fig. 1b).

The quadratic coefficient for the effect of age in the Perendale ewes was significantly larger ($P < 0.001$) when at Whatawhata than at Winchmore indicating a more pronounced effect of age on wool growth at Whatawhata. In contrast the mean slope of the linear relationship for Wiltshire ewes at each location was significantly negative.

Table 3 Adjusted means and standard error of the difference (SED) with associated P values for location and breed effects on ewe live weight and ewe greasy fleece weight recorded for Wiltshire and Perendale ewes while grazing at Whatawhata between 1994 and 1997 and grazing at Winchmore between 2000 and 2003. Bold text indicates significance at P <0.05. Italic text indicates significance between P = 0.05 and P = 0.10.

Location	Breed	Pre-join live weight (kg)	Post-join live weight (kg)	Wean live weight (kg)	Greasy fleece weight (kg)
Whatawhata	Wiltshire	51.1	49.4	51.2	0.37
	Perendale	51.6	52.0	51.7	3.29
Winchmore	Wiltshire	58.2	59.3	58.1	0.62
	Perendale	59.5	59.7	61.8	3.41
Between breeds within location					
Whatawhata	SED	0.6	0.5	0.6	0.05
	P value	0.40	**<0.001**	0.37	**<0.001**
Winchmore	SED	0.7	0.6	0.6	0.05
	P value	*0.07*	0.48	**<0.001**	**<0.001**
Between locations within breeds					
Wiltshire	SED	1.2	1.7	1.6	0.13
	P value	**<0.001**	**<0.001**	**<0.001**	**0.05**
Perendale	SED	1.2	1.7	1.6	0.13
	P value	**<0.001**	**<0.001**	**<0.001**	0.37
Location by breed interaction					
	P value	0.37	**0.002**	**<0.001**	**0.02**

Figure 1 Effect of age in Wiltshire and Perendale ewes at Whatawhata and at Winchmore on (a) mean live weight post-joining in April/May and (b) mean greasy weight. ▲ = Wiltshire at Whatawhata; ● = Wiltshire at Winchmore; △ = Perendale at Whatawhata; ○ = Perendale at Winchmore.



Ewe reproductive performance

Breed by location means for net reproductive rate and its four components adjusted for breed, location and ewe age, are shown in Table 4.

Net reproductive rate (LW/EJ). Wiltshire ewes had a significantly lower net ewe reproductive rate at both Whatawhata (P = 0.007) and at Winchmore (P < 0.001). Both breeds had a significantly higher reproduction rate at Winchmore than at Whatawhata (P < 0.001). There was no significant location by breed interaction (P = 0.20).

Ewe survival (EPL/EJ). There was no significant difference in ewe survival between the breeds or between the locations, with an overall mean ewe survival of 0.97 ± 0.01 (Standard error of the mean (SEM)).

Ewe fertility (EL/EPL). There was an indication of a significant interaction between location and breed (P = 0.06), with more Perendale than Wiltshire ewes giving birth to a lamb at Whatawhata (P = 0.02), but no difference in fertility between the two breeds while grazing at Winchmore (P = 0.66). Ewe fertility was higher for both the Perendale ewes (P = 0.004) and the Wiltshire ewes (P = 0.04) at Winchmore.

Litter size (LB/EL). Litter size born was significantly greater at Winchmore than at Whatawhata for both the Wiltshire (P = 0.002) and Perendale ewes (P < 0.001). There was no significant difference in litter size between the breeds at Whatawhata (P = 0.41), while the Perendale ewes had a higher litter size than the Wiltshire ewes at Winchmore (P = 0.01). This differential response was reflected in a significant location by breed interaction (P = 0.02).

Lamb survival (LW/LB). Lamb survival within each breed was not significantly different between the locations (Wiltshire, P = 0.66; Perendale, P = 0.84) with significantly more Perendale lambs than Wiltshire lambs surviving at Whatawhata (P = 0.006) and at Winchmore (P < 0.001).

Sex ratio. The sex ratio of males born within the Wiltshire and Perendale flocks at Whatawhata was 0.49 and 0.50 and at Winchmore was 0.46 and 0.49 respectively. The range in the 95% confidence interval between individual estimates was 0.46 to 0.54 with no significant difference from a 50/50 sex ratio for either flock at either site.

Lamb performance

Birth weight. There was no significant difference in birth weight between the breeds at Whatawhata (P = 0.12) and at Winchmore (P = 0.94) (Table 5). Wiltshire lambs born at Whatawhata tended to be lighter than Wiltshire lambs born at Winchmore (P = 0.06). There was no significant difference in birth weight of Perendale lambs born at the two locations,

Table 4 Adjusted means and standard error of the difference (SED) with associated P values for location and breed effects on ewe reproductive performance recorded for Wiltshire and Perendale ewes while grazing at Whatawhata between 1994 and 1997 and grazing at Winchmore between 2000 and 2003. LW = Number of lambs weaned, EJ = Number of ewes joined, EPL = Number of ewes present at lambing, EL = Number of ewes that lambed, LB = Number of lambs born. Bold text indicates significance at P <0.05. Italic text indicates significance between P = 0.05 and P = 0.10.

Location	Breed	Ewe reproductive rate (LW/EJ)	Ewe survival (EPL/EJ)[a]	Ewe fertility (EL/EPL)[a]	Litter size (LB/EL)	Lamb survival (LW/LB)[a]
Whatawhata	Wiltshire	0.75	0.95	0.78	1.36	0.78
	Perendale	0.88	0.97	0.84	1.32	0.85
Winchmore	Wiltshire	1.11	0.97	0.96	1.66	0.75
	Perendale	1.32	0.97	0.95	1.75	0.86
Between breeds within location						
Whatawhata	SED	0.05	0.28	0.02	0.04	0.03
	P value	**0.007**	0.26	**0.02**	0.41	**0.006**
Winchmore	SED	0.05	0.36	0.01	0.04	0.03
	P value	**<0.001**	0.95	0.66	**0.01**	**<0.001**
Between locations within breeds						
Wiltshire	SED	0.11	0.53	0.06	0.08	0.04
	P value	**<0.001**	0.39	**0.004**	**0.002**	0.66
Perendale	SED	0.11	0.50	0.05	0.08	0.03
	P value	**<0.001**	0.74	**0.04**	**<0.001**	0.84
Location by breed interaction						
	P value	0.20	0.52	*0.06*	**0.02**	0.62

[a]Back-transformed means quoted with the SED calculated to give the corresponding P value in the logistic regression.

resulting in a significant location by breed effect (P = 0.04).

As a consequence of the recorded difference in litter size, the adjusted mean of the total weight of lambs born per ewe was significantly greater at Winchmore than at Whatawhata for the Wiltshire (P = 0.02) and Perendale (P = 0.01) ewes (Table 5).

Weaning weight. Mean weaning weight of lambs was higher for Wiltshire (P < 0.001) than Perendale (P < 0.001) lambs, and higher at Winchmore (P < 0.001) than at Whatawhata (P < 0.001) (Table 5). There was no significant location by breed interaction (P = 0.75).

The combined effect of the location and breed effects for litter size and lamb survival resulted in no significant difference in the total weight of lambs weaned per ewe by the Wiltshire (P = 0.67) and Perendale (P = 0.71) ewes at the two locations (Table 5). Both Wiltshire (P < 0.001) and Perendale (P < 0.001) ewes weaned significantly more lambs per ewe at Winchmore than at Whatawhata (Table 4). There was no significant location by breed interaction (P = 0.58).

Yearling performance

Live weight. There was a significant location by breed interaction (P <0.001) for mean yearling live weight (Table 5). Both the Wiltshire (P = 0.005) and Perendale (P < 0.001) yearlings were heavier at Winchmore than at Whatawhata, with the Perendale yearlings being significantly heavier than the Wiltshire yearlings at Winchmore (P <0.001), but not at Whatawhata (P = 0.23).

Fleece weight. The fleece weight of the Wiltshire yearlings was approximately 36% (0.8/2.2) of that of the Perendale yearlings (Table 5). More wool was harvested from the Wiltshire yearlings at Winchmore than at Whatawhata (P = 0.006) but not significantly so from the Perendale yearlings at the two locations (P = 0.12), resulting in a significant location by breed interaction (P < 0.001).

Discussion

The flocks in this study can be considered to reflect the productive performance of their respective breeds under two very different environments and farming systems. Each flock can be considered to be representative of their respective breed type within New Zealand. While it would have been desirable to contrast production of the Wiltshire flock with a representative Romney flock as the principal sheep breed in New Zealand (Beef + Lamb New Zealand 2011), no suitable data were available within the flocks grazed together at the two locations. Data from the Perendale flock provided a creditable comparison.

Table 5 Adjusted means and standard error of the difference (SED) with associated P values for location and breed effects on lamb birth weight, lamb weaning weight, yearling live weight, yearling greasy fleece weight, and the total weight of lamb born and weaned per ewe recorded for Wiltshire and Perendale lambs and yearlings while grazing at Whatawhata between 1994 and 1997 and grazing at Winchmore between 2000 and 2003. Bold text indicates significance at P <0.05. Italic text indicates significance between P = 0.05 and P = 0.10.

Location	Breed	Lamb birth weight (kg)	Lamb wean weight (kg)	Yearling live weight (kg)	Yearling greasy fleece weight (kg)	Total weight of lambs born/ewe (kg)	Total weight of lambs weaned/ewe (kg)
Whatawhata	Wiltshire	4.11	22.7	35.2	0.75	5.67	26.4
	Perendale	4.21	21.5	34.6	2.07	5.73	26.7
Winchmore	Wiltshire	4.30	25.1	37.5	0.94	6.66	36.8
	Perendale	4.30	23.8	40.4	2.24	6.77	36.5
Between breeds within location							
Whatawhata	SED	0.07	0.4	0.5	0.065	0.14	0.8
	P value	0.12	**<0.001**	0.23	**<0.001**	0.64	0.67
Winchmore	SED	0.06	0.3	0.4	0.060	0.14	0. 9
	P value	0.94	**<0.001**	**<0.001**	**<0.001**	0.44	0.71
Between locations within breeds							
Wiltshire	SED	0.10	0.6	0.8	0.069	0.41	2.0
	P value	*0.06*	**<0.001**	**0.005**	**0.006**	**0.02**	**<0.001**
Perendale	SED	0.10	0.5	0.8	0.108	0.40	2.0
	P value	0.39	**<0.001**	**<0.001**	0.12	**0.01**	**<0.001**
Location by breed interaction							
	P value	**0.04**	0.75	**<0.001**	**<0.001**	0.84	0.58

The Wiltshire flock used in the current study was sourced from the "Ardo" flock run on a lowland property in the Rangitikei region of the southern North Island. A comparison of the productivity of the Wiltshire flock grazed at Whatawhata and Winchmore with a report of productivity of the "Ardo" flock (Morrison 2010), indicates that under Morrison's management his ewes were considerably heavier at approximately 80 kg, with a higher lambing performance of 180%, assumed to be a measure of litter size (LB/EL), more multiple lambs and, as a consequence, a lighter mean birth weight of 3.4 kg, than recorded at either Whatawhata or Winchmore. "Ardo" ewes are also reported as having a higher fleece weight of 0.8 to 1.5 kg than that for the Wiltshire ewes reported here. This may reflect a different time of shearing at "Ardo" or the result of the initial sheep purchased for the research flock being selected for a propensity to exhibit shedding, with an associated reduced fleece weight when shorn in the spring (O'Connell et al. 2012).

The different pattern in the age effect for the weight of greasy wool harvested from the two breeds can be interpreted as a direct reflection of shedding exhibited by the Witshire. Wiltshire sheep exhibit a pronounced seasonal pattern of fibre shedding related to day length (Pearson et al. 1996) where the bulk of the follicles are in a resting phase, during the winter and the retained fibres are actively pushed out of the follicle in the following spring as a new fibre grows in November/January. There is thus a potential for a confounding effect between day length related to a specific day of the year and the time when yearlings and ewes are shorn to fit with "on-farm" management. The weight of fleece wool harvested from Wiltshire ewes reported here indicates that fibre shedding in this breed increases with age (O'Connell et al. 2012) as a related but distinctly different physiological process to the seasonal output from individual wool follicles in the Romney (Woods & Orwin 1988) and breeds developed from it by crossing (Bigham et al. 1978). Perendale ewes in this study exhibited a pronounced curvilinear age effect for the weight of shorn greasy wool, with a maximum at three to four years of age. A similar trend was previously reported by Sumner and Dick (1997) for the same Perendale flock recorded at Whatawhata.

The product of the individually derived components of net reproductive rate exceeds the estimated reproductive rate calculated directly, as each of the individual components were derived from a series of mean values adjusted for different fixed effects.

Although the Wiltshire lambs exhibited a significantly greater adjusted weaning weight than the Perendale lambs, the between breed difference was reversed by one year of age. With lambs being destined for slaughter at approximately six months of age, the potential live weights of sheep slaughtered from each breed are likely to be similar. This will potentially yield a similar meat return from each breed slaughtered at the same time.

With most farmers currently not receiving a payment for "wool pull" at the time of slaughter, there is no financial penalty associated with the reduced wool growth of Wiltshire sheep at slaughter. In the case of adult ewes, the reduction in wool returns for the Wiltshire compared with the Perendale equates to approximately 2.6 kg of wool worth between 300 and 350 c/kg greasy at 2011/12 prices or between $7.80 and $9.10 per head. With average contract shearing prices of approximately $3.50 per head plus associated costs, and up to $1.70 per head for crutching (Lincoln University 2010), a saving in dagging costs, and less mustering to undertake these operations, the difference in net returns between farming Wiltshire and Perendale sheep is reduced, particularly for Wiltshire sheep that shed completely. There are also fewer problems associated with flystrike over the summer in sheep with less wool in the breech area (Scobie et al. 2002), such as in shedding Wiltshire ewes compared with Perendale ewes. Overall, the greater the amount of shedding exhibited by the Wiltshire flock, the closer will be the net income from Wiltshire and Perendale sheep. Additionally farming Wiltshire sheep may better align with some production systems than Perendale sheep or indeed a breeder's personal choice of sheep breed.

Despite the marked difference in environmental conditions and timing of management procedures at Whatawhata and Winchmore, the Wiltshire and Perendale flocks adjusted to the different conditions exhibiting a similar relative overall productivity at each location. Contrary to anecdotal farming opinion there was no marked location by breed interaction of commercial significance.

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