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Weaning Weights in a Range Purebred Merino and Crossbred Merino x Rambouillet Flock

W.M. Rauw[1,3,4], *H.A. Glimp*[1], *W. Jesko*[2], *L. Gómez-Raya*[1]

[1] *Department of Animal Biotechnology, University of Nevada - Reno, Mail Stop 202, NV 89557, Reno, USA.*

[2] *Rafter 7 Ranch, Yerington.*

[3] *Corresponding author. Phone 775/784-6888, Fax 775/784-1375, E-mail wrauw@cabnr.unr.edu.*

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Summary

The Rafter 7 Merino flock was initiated in Nevada in 1990 with the purchase of 500 purebred Rambouillet ewes. A grade-up program was initiated using Australian Merino genetics with the aim of developing a purebred Merino flock. Early in the project the Rafter 7 Merino line was created, which is approximately 5/8 Merino and 3/8 Rambouillet and has been a closed line since 1999. In a genetic selection program that includes weaning weight, weights must be adjusted for environmental factors. The present study investigated factors influencing weaning weight in 9,594 lambs.

Results show a decrease in lamb weaning weights with the inclusion of Merino blood in the lines. At weaning, rams were heavier than ewes ($P < 0.001$) and weights decreased with increased litter size ($P < 0.001$). Lambs born from 2-year-old dams had lower weaning weights than lambs born from older dams ($P < 0.01$), and lambs born from 5-year-old dams had lower weaning weights than lambs born from 3-year-old dams ($P < 0.05$). Weaning weight of lambs born from 3-, 4-, 6-, and 7-year-old dams did not significantly differ.

Multiplicative-adjustment factors for adjusting lamb weaning weights to a common sex, age of dam, and birth-rearing type were compared with values from the *Report of the National Sheep Improvement Program Technical Committee*. Adjustment factors were slightly lower for triplet ewes and rams born from a 3- to 6-year-old dam. Other adjustment factors were very similar, suggesting that adjustment factors derived from more intensive production systems are applicable to our extensive production systems as well.

Key Words: Sheep; Weaning Weight; Adjustment Factors; Merino; Rambouillet

Introduction

The Rafter 7 Merino flock was initiated in Nevada in 1990 with the purchase of 500 purebred Rambouillet ewes from two prominent breeders in the western United States. These ewes were mated via artificial insemination with imported semen from Australian Merino rams. The initial breeding objective was to develop a purebred Merino flock with Australian genetics that would be adapted to the western rangeland environment. Since females or embryos could not be imported, a grade-up program (1/2, 3/4, 7/8, 15/16 and higher Merino breeding, with 15/16 Merino being considered purebred by the world animal breeding community) was implemented utilizing semen from imported rams.

It was observed early in the project that Merino x Rambouillet F1 offspring produced approximately 70 percent more clean wool, while the weaning weight of lambs per ewe was not significantly different from purebred Rambouillet. It was decided to develop a selection line from the best 1/2 Merino ewes and a limited number of 3/4 Merino ewes and rams known as the Rafter 7 Merino line. This line is therefore approximately 5/8 Merino and 3/8 Rambouillet and has been a closed line since 1999.

In a genetic selection program, much of the variation attributable to phenotypic records is environmental and must be accounted for by use of appropriate adjustment factors, such as breed and sex (Boggess et al., 1991). Knowledge of these factors is essential for efficient management and for the accurate estimation of breeding values (Assan and Makuza, 2005). Currently, weaning weights of purebred and crossbred Merino sheep are adjusted utilizing the adjustment factors recommended by SID (1997), which were largely derived from more intensive production systems. These adjustment factors may not be appropriate for purebred and crossbred Merino sheep raised in an extensive production system. The purpose of this study was to evaluate the influence of Merino genetics on weaning weights and to evaluate factors influencing weaning weights in the Rafter 7 flock. These factors may be valid for other Merino or crossbred Merino x Rambouillet flocks as well.

Materials and Methods

Animals

Complete weaning weight records were available on a total of 9,594 animals born between 1992 and 2005. The number of records for each line and sex are given in Table 1. Since 2001, the flock genetics include only fullblood and Rafter 7 Merinos. Between 1999 and 2005, Rafter 7 lambs were sired by approximately 53 sires and fullblood Merinos by 48 sires. Of all Rafter 7 and fullblood Merino lambs, eight were born as triplets but raised as a single, 42 animals were born as triplets but raised as a twin, 176 animals were born as a twin but raised as a single, and two animals were born as a single but raised as a twin.

Management

The Rafter 7 Ranch includes approximately 3,400 acres of private property plus grazing permits on approximately 85,000 acres of Bureau of Land Management (BLM) land and 4,500 acres of U.S. Forest Service land. Approximately 250 acres of the private land are in irrigated pasture for the sheep flock and hay production. Ewes were mated via artificial insemination or in single-sire pastures from mid-November to late-December for approximately 40 days, with hay fed only when snow cover prevented grazing or available forage was inadequate. The ewes were treated for internal parasites at the onset and end of the mating season and were then managed under herder supervision on the desert rangelands until mid-March. Shearing has generally been the last week of March. Following shearing, the ewes were treated for internal and external parasites and vaccinated with an 8-way *Clostridium spp.* vaccine to provide passive immunity to their lambs through colostrum. The ewes were then branded with a unique number in scourable paint, and the ewe's ear tag and paint brand numbers were recorded.

The lambing program was based on a modified set-stocking program with up to 250 pre-lambing ewes within a breed group in a pasture that is adjacent to three vacant pastures. The ewes were not fed any supplemental feed other than an appropriate trace mineral salt pre- or post-lambing. When a ewe lambed, her paint brand number was recorded with the lambing date, and the lamb(s) were ear tagged with the appropriate numbered metal tag; the lamb's tag number and sex were recorded; and a rubber elastrator ring was applied to the tail. Any observations on ewe health, condition or status and lamb vigor were also noted on the record sheet. The ewe and her lamb(s) were then moved to one of the adjacent vacant pastures, until a pasture was determined to contain enough ewes and lambs and then another pasture was used. Only ewes with udder, milk or behavioral problems or with weak or triplet lambs, or ewes with grafted lambs, were moved to the barn for further observation or treat-

Table 1. Number of records for each line and sex.

	Rambouillet[a]	1/2 Merino[b]	3/4 Merino[c]	7/8 Merino[d]	Fullblood Merino[e]	Rafter 7 line[f]
Ewe	167	605	898	636	1028	1787
Ram	130	462	728	596	989	1568
Total	297	1067	1626	1232	2017	3355

[a] 1992 to 1994.
[b] 1992 to 1997.
[c] 1993 to 1998.
[d] 1995 to 2000.
[e] 1997 to 2005.
[f] 1999 to 2005.

ment. Some ewes were moved to shelter with their lambs during extreme weather conditions, but this practice has been used on a very limited basis. Only approximately 15 lambing pens under shelter have been provided for ewe numbers ranging from 500 to 1000 ewes during the study. Any ewes with problems at lambing were critically checked and generally culled after the lambs were weaned.

When the smaller pasture groups of lambs were approximately two weeks old, two pasture groups were mixed together. This process was continued until a maximum of three or four groups were managed from four to five weeks of age in an intensive pasture rotation system of four to six pastures per group until weaning.

At four to eight weeks of age, the lambs and ewes were treated for internal parasites, the lambs were vaccinated with an 8-way *Clostridium spp.* vaccine and a plastic ear tag, identically numbered as the small metal tag at birth, was inserted. Any physical or genetic problems were recorded at this time, such as leg and horn deformities, jaw defects, the presence of face wool and wrinkles, or being carrier of the black gene. Weaning was generally in mid-August, when the lambs were between three and four months of age. Weaning weights were recorded, along with any technician observations of physical or genetic defects. The lambs received their second treatment of *Clostridium spp.* vaccine, were treated for internal parasites, and then managed as a group on high-quality, irrigated pasture until the sexes were separated in late-September. Selection of replacement ram and ewe lambs generally occurred in late-October. Male lambs not kept for replacement or sale as rams were castrated. Surplus ewe and wether lambs were then sold.

Data handling and statistical analysis

The SAS program was used for the statistical analysis (Statistical Analysis Systems Institute, 1985). The model used to analyze the weaning weights was (Proc Mixed):

$$Y_{ijklmnop} = \mu + L_i + S_j + YOB_k + B\text{-}RType_l + AgeDam_m + WnAge_n + Dam_o + e_{ijklmnop}, \quad (1)$$

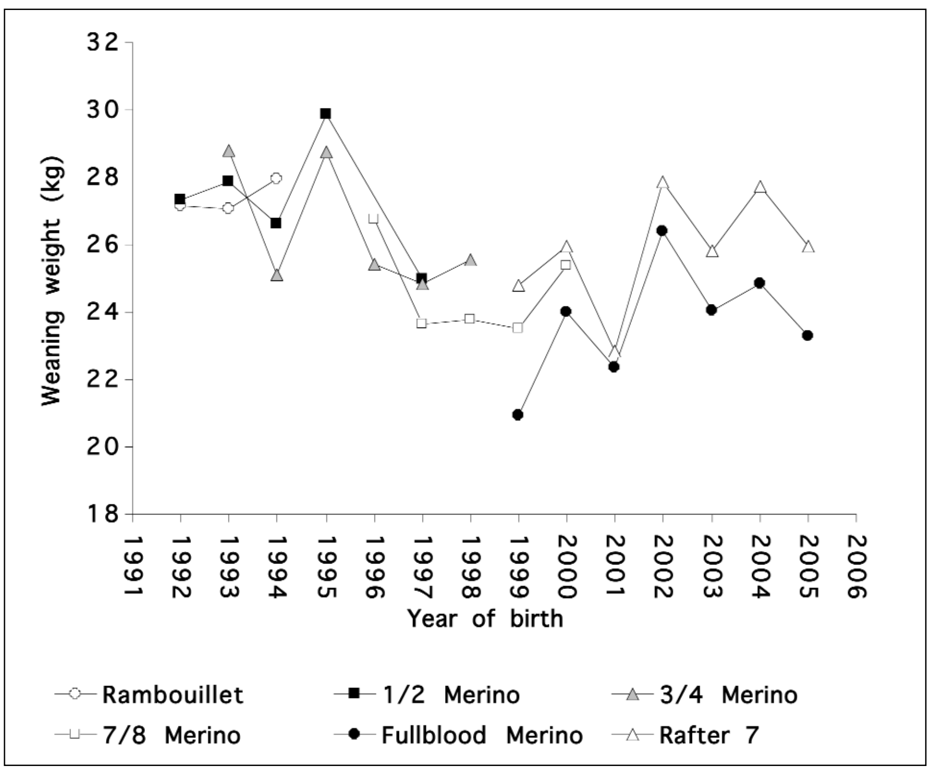
where μ = overall mean, L_i = effect of line i (1/2, 3/4, 7/8 fullblood, and Rafter 7 Merino), S_j = effect of sex j (ewe, ram), YOB_k = effect of year of birth k (1999 to 2005), $B\text{-}RType_l$ = effect of birth-rearing type l (single-single, twin-twin, triplet-triplet, triplet-single, triplet-twin, twin-single, single-twin), $AgeDam_m$ = effect of age of the dam m (2 to 7 years), $WnAge_n$ = effect of age at weaning n, and $e_{ijklmno}$ = error term of animal o, $e_{ijklmno} \sim NID(0, \sigma^2_e)$. Weaning weight measured on animal o of line i, sex j, year of birth k, birth-rearing type l, age of the dam m and age at weaning n is denoted by $Y_{ijklmno}$. All effects were considered fixed-class effects, with the exception of the effect of 'age at weaning,' which was included as a covariate effect, and the effect of 'dam,' which was considered random. Initially, the effect of the interaction between birth-rearing type and age of the dam was also included, but as this was not significant, this effect was excluded from further analysis.

Results and Discussion

Trend in weaning weight with inclusion of Merino genetics

Figure 1 presents least squares means of weaning weight for each line and each year. Only least squares means estimated from 30 or more observations are shown. Values were adjusted for the effects of model (1). In 1994, purebred Rambouillets had higher weaning weights than either 1/2 ($P = 0.0061$) or 3/4 Merinos ($P = 0.0001$). The 1/2 Merinos had a higher weaning weight than 3/4 Merinos in 1994 ($P = 0.0021$) and 1995 ($P = 0.0411$). The 3/4 Merinos had higher weaning weights than 7/8 Merinos and fullblood Merinos in 1997 ($P = 0.0156$ and $P = 0.0025$, respectively) and 1998 ($P = 0.0001$ and $P = 0.0065$, respectively). Weaning weight was higher in 7/8 Merinos than in fullblood Merinos in 1997 ($P = 0.0004$), 1999 ($P = 0.0001$), and 2000 ($P = 0.0085$). Rafter 7 Merinos (about 5/8 Merino) had higher weaning weights than 7/8 Merinos in 1999 ($P = 0.0001$), and had higher weaning weights than the fullblood Merino line in all years but 2001 ($P = 0.0001$). Summarized, within year, weaning weights decreased with the inclusion of Merino blood in the lines. This is in agreement with observations by Sakul et al. (1993), who observed that offspring from Targhee dams and Merino sires grew more slowly than offspring from Targhee dams and Rambouillet sires. The overall

Figure 1. Least squares means of weaning weight for Rambouillet, 1/2 Merino, 3/4 Merino, 7/8 Merino, fullblood Merino and Rafter 7 Merino lambs between 1992 and 2005.



trend in weaning weight over the entire period decreased up to 1999, with increasing inclusion of Merino genetics in the flock. Thereafter, weaning weights increased with increasing selection pressure in the flock.

Factors influencing weaning weight

Because the breeding program aimed at producing Rafter 7 and purebred Merinos, and therefore data on 1/2, 3/4, and 7/8 Merinos are limited, factors influencing weaning weight are estimated for those two lines only. Table 2 presents estimates and standard errors of factors influencing weaning weight, according to model 1, in the Rafter 7 Merino line and the fullblood Merino line between 1999 and 2005. All factors included in the model were highly significant ($P < 0.001$).

Least squares means for each level of breed, sex, birth-rearing type and age of dam are presented in Figure 2. Birth-rearing type levels with different birth than rearing type had high standard errors due to a low number of records. As expected from Figure 1, Rafter 7 Merino sheep were heavier at weaning than fullblood Merino lambs. A portion of this difference is likely due to the opportunity for increased selection pressure within the Rafter 7 Merino line during the period, whereas the primary objective in the fullblood Merino line was the increase in population size. Rams were heavier at weaning than ewes. This is in agreement with observations by Matika et al., (2003) and Assan and Makuza (2005). As can be observed in Figure 1, average weaning weights differed for each individual year but no trend could be distinguished. The effect of year reflects variation in the physical environment resulting from changes in the weather conditions, which directly affect the quantity and quality of available food resources (Matika et al., 2003).

Several studies report on the effect of birth type on weaning weight where lambs from larger litters are found to weigh less than lambs from smaller litters (e.g., Boujenane et al., 1991; Matika et al., 2003). This difference in birth weight often persists through weaning (Boujenane et al., 1991; Matika et al., 2003) as offspring have to compete for milk. In the present study, only 221 fullblood and Rafter 7 Merino lambs (4.6 percent) had a rearing type that differed from birth type. As expected, weaning weight decreased with increasing litter size. Single born-single raised had higher weaning weights ($P < 0.001$) than twin born-twin raised, which had higher weaning weights ($P < 0.05$) than triplet born-triplet raised. Lambs born and raised in a triplet litter tended to have lower weaning weights than lambs born in a triplet litter but raised in a twin or single litter ($P < 0.10$). Lambs born and raised in a twin litter had lower weaning weights than lambs born in a twin litter but raised in a single litter ($P < 0.01$).

Lambs born from 2-year-old dams had lower weaning weights than lambs born from older dams ($P < 0.01$). Lambs born from 5-year-old dams had lower weaning weights than lambs born from 3-year-old dams ($P < 0.05$). This latter observation resulted mainly from low weaning weights in 5-year-old dams in the year 2002 ($P < 0.05$; results not presented). Weaning weights of lambs born from 3-, 4-, 6- and 7-year-old dams did not significantly differ. Results are somewhat different from those presented by Matika et al. (2003), who observed an increase in weaning weight from 2-year-old ewes which peaked at four years. The observation that young dams produce smaller offspring results from the fact that they are challenged simultaneously with the drive to grow, support pregnancy and sustain lactation in a food-resource-limited situation (Rauw et al., 1999).

The phenotypic correlation between weaning weight (adjusted for the effects of line, sex, year of birth, birth-rearing type and the age of the dam) and weaning age was positive and highly significant ($r = 0.20$, $P < 0.001$). Results indicate that weaning weight increased about 133 grams per day.

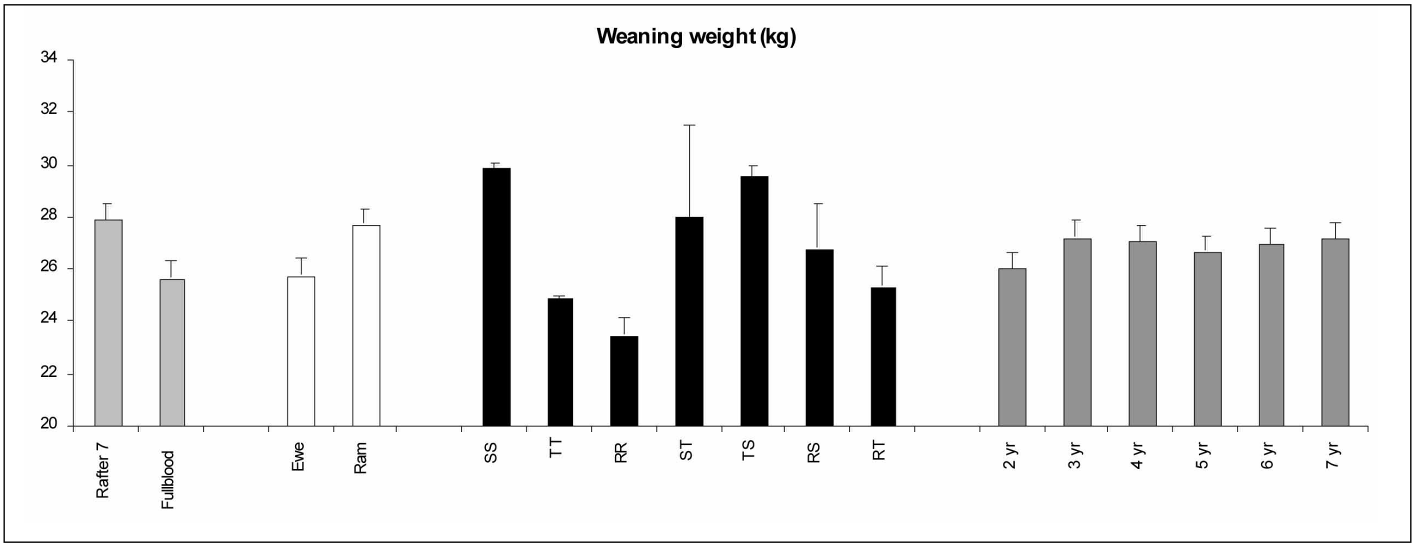
Table 3 presents multiplicative adjustment factors for adjusting lamb weaning weights to a common sex, age of dam, birth-rearing type in comparison

Table 2. Estimates (SE) of factors influencing weaning weight (kg) for each subclass.

Factor	Subclass	N	Factor estimate (SE)
Intercept		5341	8.99 (0.801)
Breed	Rafter 7 Merino	3355	0.00 (0.00)
	Fullblood Merino	1986	-1.98 (0.176)
Sex	Ewe	2804	0.00 (0.00)
	Ram	2537	1.98 (0.134)
Year of birth	1999	425	-1.17 (0.347)
	2000	583	0.287 (0.310)
	2001	1021	-2.16 (0.283)
	2002	943	2.47 (0.272)
	2003	875	0.641 (0.313)
	2004	963	1.66 (0.262)
	2005	531	0.00 (0.00)
Birth type	Single – Single	2294	5.04 (0.153)
	Twin – Twin	2746	0.00 (0.00)
	Triplet –Triplet	73	-1.38 (0.651)
	Single – Twin	2	3.15 (3.50)
	Twin – Single	176	4.72 (0.388)
	Triplet – Single	8	1.94 (1.75)
	Triplet – Twin	42	0.466 (0.791)
Age dam (yr)	2	1103	-1.14 (0.333)
	3	1193	0.0669 (0.322)
	4	1097	-0.0649 (0.322)
	5	921	-0.453 (0.325)
	6	679	-0.154 (0.333)
	7	348	0.00 (± 0.00)
Age at weaning (d)		5341	0.133 (0.00636)

N = number of animals in each subclass.

Figure 2. Least squares means (SE) of weaning weight for each subclass of the class variables breed, sex, birth-rearing type and age of dam. SS = single born-single raised, TT = twin born-twin raised, RR = triplet born-triplet raised, ST = single born-twin raised, TS = twin born-single raised, RS = triplet born-single raise, RT = triplet born-twin raised.



with values from the *Report of the National Sheep Improvement Program (NSIP) Technical Committee* (1986) for single born-single raised, twin born-twin raised and triplet born-triplet raised lambs. Values of the present study were adjusted for effects included in model 1, with the exception that 'age of the dam' was included for ages 2 and '3 to 6' only. Adjustment factors were slightly lower for triplet ewes born from 3- to 6-year-old dams. Other adjustment factors were very similar. This implies that the adjustment factors recommended by SID (1997), which were largely derived from more intensive production systems, are applicable to our more extensive production system as well.

Out on the ranges, sheep experience significant fluctuations on both quantity and quality of forage. According to Thomas and Kott (1995), ewes commonly experience prolonged bouts where less than 50 percent of the National Research Council's (NRC) requirements are met. This results in significant amounts of weight loss, while pregnant animals in particular are supposed to gain weight (Rauw et al., 2006). Early gestation is critical for placentomal growth, differentiation, and vascularization, and fetal organogenesis (Vonnahme et al., 2006). Vonnahme et al., (2006) observed that fetuses from ewes fed a 50-percent-restricted diet were markedly lighter than those from control-fed ewes. This may influence postnatal growth and weaning weights and may have been responsible for fluctuations observed between years of birth (Figure 1). Future experiments will aim at further investigating the relationship between resource limited range conditions and offspring weaning weight.

Table 3. Multiplicative adjustment factors for adjusting lamb weaning weights to a common sex, age of dam, and birth and rearing type[a] in comparison with values from the Report of the National Sheep Improvement Program (NSIP) Technical Committee[b] (1986; between brackets).

Item	Age of dam (yr)	Single	Twin	Triplet
Ewe	2	1.04 (1.08)	1.24 (1.29)	
	3-6	1.00 (1.00)	1.18 (1.19)	1.28 (1.36)
Ram	2	0.96 (0.98)	1.14 (1.17)	
	3-6	0.93 (0.91)	1.10 (1.08)	1.19 (1.23)

[a] Values are given for single born – single reared, twin born – twin reared, and triplet born – triplet reared lambs only.
[b] Values were calculated from Targhee, Suffolk and Polypay flocks throughout the United States.

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