Breeding for resource efficiency in grazing animals on resource-poor rangelands

Wendy Rauw

Rauw.Wendy@inia.es

Introduction

Extensive production systems: animals (seasonally) graze on the rangelands

= reduced production costs because animals do not need to be fed

But: droughts and winter

= recurrent periods of under nutrition in which large amounts of body tissue may be catabolized

Variation in grazing ability:

$\rightarrow$ selection may offer the opportunity to breed for a better adaptation to poor quality rangelands

= healthier animals and improved production

Introduction

How to estimate grazing intake?

→ Grazing behavior
→ Fecal markers

These are time consuming methods!

Alternative: animals that are not efficient loose body weight, but those that are will gain (or loose less)
→ Grazing ability is indirectly inferred from changes in body weight during the grazing period

Materials and methods

Rafter 7 Merino flock:

- 5/8 Merino x 3/8 Rambouillet = 450 animals
- 7/8 Merino x 1/8 Rambouillet = 160 animals
- Fullblood Merino = 295 animals

- From 50 sires
- Between 2 to 7 years of age
- 76 to 119 days in gestation at the end of the grazing period

Materials and methods

Current/Previous number of lambs:

- **None = 188 animals**
  - **None = 82**
  - **Single = 48**
  - **Twin = 56**

- **Single = 469 animals**
  - **None = 172**
  - **Single = 191**
  - **Twin = 103**

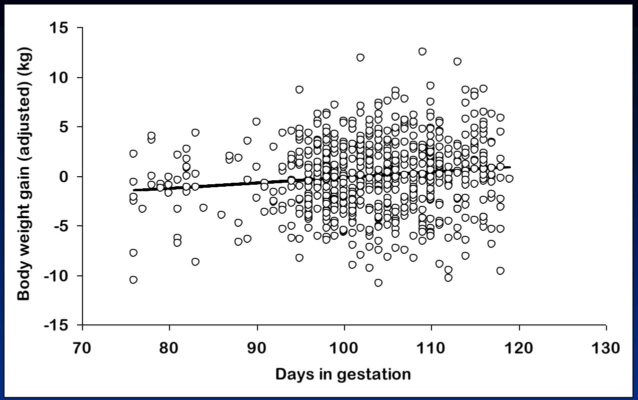
- **Twin = 248 animals**
  - **None = 55**
  - **Single = 81**
  - **Twin = 108**

Materials and methods

Body weight measurements before grazing = January 2nd
And after = March 18th
= Grazing period of 75 days
→ ΔBW and ΔBW%

Wool samples are collected on the same days and ewes are shorn March 22nd and 23rd
→ Fiber diameter, staple length, greasy fleece weight

Statistics



Body weight change:

$\Delta BW(\%)_{ijklmno} =$
$\mu + Line_i + NrLambsCurrent_j + NrLambsPrevious_k + Age_l + Sire(Line)_{mi} + DaysGestation_n + e_{ijklmno}$

ΔBW adjusted = $\Delta BW - (0.05979 \times DaysGestation)$, and
$\Delta BW\%$ adjusted = $\Delta BW\% - (0.1104 \times DaysGestation)$

= adjusted to 0 days in gestation

Then:

$\Delta BW(\%)_{ijklmn} =$
$\mu + Line_i + NrLambsCurrent_j + NrLambsPrevious_k + Age_l + Sire(Line)_{mi} + e_{ijklmn}$,

Statistics

Wool samples:

$WoolTraits_{ijklm} =$
$\mu + Line_i + NrLambsPrevious_j + Age_k + Sire(Line)_{li} + e_{ijklm}$,

ie, without NrLambsCurrent (not significant)

Greasy fleece weight:

$GFW_{ijklmn} = \mu + Line_i + BWstart_j + NrLambsPrevious_k + Age_l + Sire(Line)_{mi} + e_{ijklmn}$

ie, fleece weights are adjusted for body size

Statistics

To test whether change in body weight of the mother influences offspring weaning weights:

$Y_{ijklmnop} = \mu + Line_i + Sex_j + BRType_k + AgeDam_l + WnAge_m + Dam_n + \Delta BW_o + e_{ijklmnop}$

(After Rauw et al., 2007)

Heritabilities (multi-trait animal model):

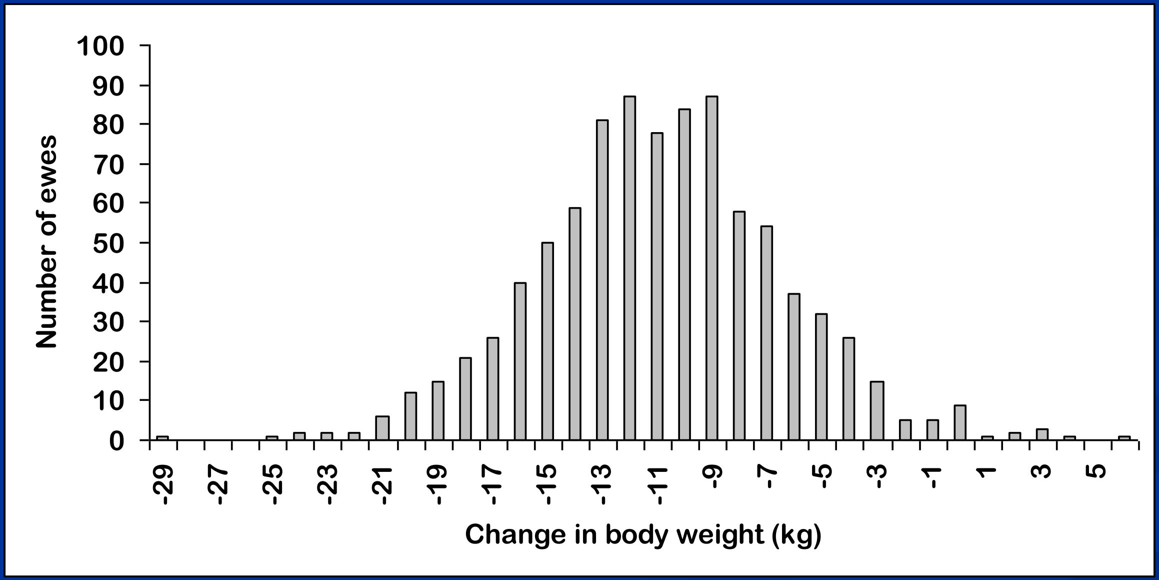
$\Delta BW_{ijklm} = Line_i + NrLambsCurrent_j + NrLambsPrevious_k + Age_l + a_{ijklm} + e_{ijklm}$

$GFW_{ijklm} = Line_i + BWstart_j + NrLambsPrevious_k + Age_l + a_{ijklm} + e_{ijklm}$,

Results

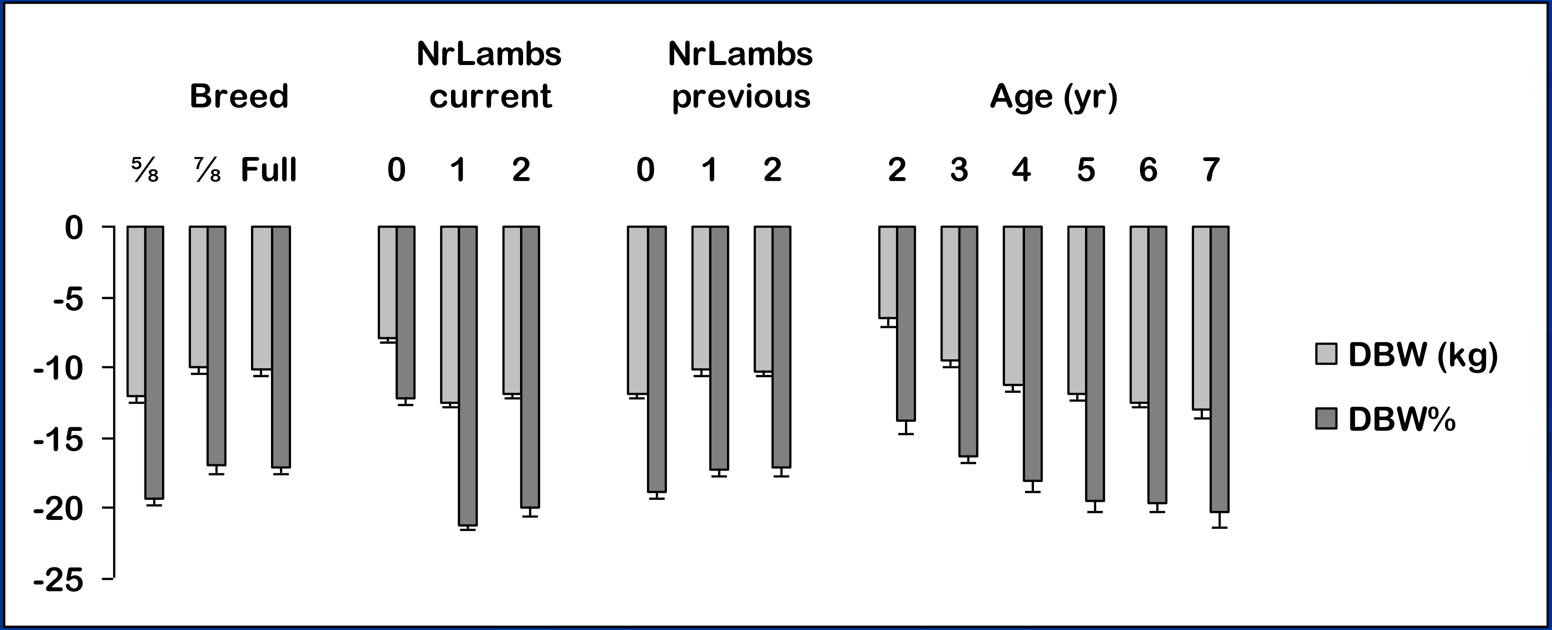
Body weight decreased from 63.1 kg to 56.7 kg
→ 93.6% lost body weight

ΔBW is a normally distributed trait (all animals included):



Results - ΔBW

- Pregnant ewes lost more BW than non-pregnant ewes
- Ewes with 0 NrLambs in the previous lactation lost more BW than ewes with 1 or 2 lambs previously
- Ewes lost more body weight with age, but this was not significant between 4 to 7 years of age
- Effect of sire was significant for ΔBW and ΔBW%



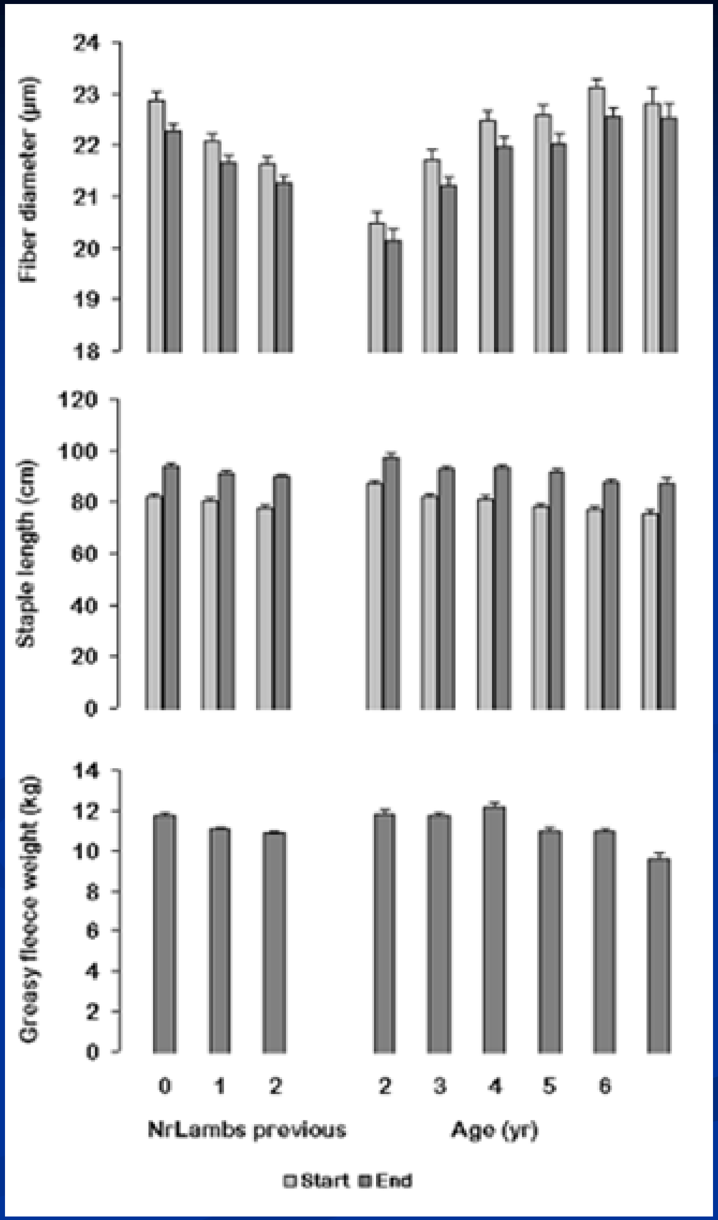
Results – Wool traits

- Grazing
  → longer staple
  → smaller diameter

- More lambs in previous lactation
  → shorter staple
  → smaller diameter
  → less wool

- Increased with age
  → shorter staple
  → larger diameter (“FD blowout”)
  → less wool (adj for size!)

- Sire significant for all traits



Results – Phenotypic correlations

Heavier fleeces = larger diameter, longer staples

Animals with smaller fiber diameters at the start lost less body weight during the grazing period ($r = -0.07$, $P < 0.05$)
= very low but significant correlation

Logistic procedure: Animals with smaller fibers at the start had a higher probability to carry a lamb (or two) to term ($P < 0.05$)

Body weight lost during the grazing period did not significantly influence offspring weaning weights

Results – Heritabilities and genetic correlations

	ΔBW	FD_{start}	SL_{start}	GFW
ΔBW	0.29 (0.05)	-0.23 (0.10)	0.17 (0.07)	-0.21 (0.08)
FD_{start}		0.51 (0.05)	0.37 (0.06)	0.21 (0.05)
SL_{start}			0.39 (0.04)	0.34 (0.09)
GFW				0.36 (0.05)

Wool traits are moderately to highly heritable

ΔBW was moderately heritable

Animals with smaller fiber diameters at the start lost less body weight during the grazing period ($r = -0.23$, $P < 0.05$)

Discussion

Grazing during the winter conditions in the Nevada desert resulted in body weight loss

→ Pregnant animals in particular need to gain weight!

Ewes further into gestation lost less body weight

→ Fetus is growing and puts on overall maternal body weight

Pregnant ewes lost more body weight when adjusted to 0 days in gestation than non-pregnant ewes

→ Pregnancy was at the expense of maternal body reserves

Animals that had given birth the year before lost less body weight

→ Ewes that had dealt with the challenge of supporting pregnancy in a resource-poor environment before were better adapted to deal with the same situation again

Discussion

Reduced fiber diameter → Periods of undernutrition

Literature: wool growth and fiber diameter are usually depressed during reproduction = partially due to competition between tissues for essential nutrients

Present study: no significant effect of current number of offspring

But: most metabolically stressful is last trimester of pregnancy and lactation

Fiber diameter and staple length decreased with number of lambs in the *previous* reproductive cycle → this includes the previous lactation = resource trade-off wool/reproduction

Discussion

In our study: no effect of body weight change on weaning weight

→ **Ewes spent the last several weeks of gestation and their lactation period on pasture feeding after returning from the rangeland**

→ **Birth weight should be recorded**

Discussion

Ewes with finer wool at the start of the grazing period lost less body weight during the grazing period and had a greater probability to carry a lamb to term

Correlation was weak but significant → more research needed

→ Finer wool = greater thermal insulation

→ Animals with finer wool were better adapted to Nevada's cold desert climate

Discussion

Change in body weight is moderately heritable
→ Selection for body weight change will result in a positive selection response

Fiber diameter was highly heritable + animals with finer fibers lost both phenotypically and genetically less body weight during the grazing period

→ Selection for fiber diameter may result in animals that are better adapted to the cold desert climate as a correlated effect

Selection for greater adaptability = selecting animals that can produce wool at acceptable levels while their health and welfare is not being compromised

Under intensive conditions, residual feed intake is estimated as:

$$FI_i = b_0 + (b_1 \times BW_i^{0.75}) + (b_2 \times BWG_i) + (b_3 \times PROD_i) + e_i$$

Feed Intake
Metabolic BW (Maintenance)
Body Weight Gain (Growth)
Production (eggs, milk, wool, pregnancy)

b_0, b_1, b_2, b_3 = intercept & partial regression coefficients

e_i = error term = Residual Feed Intake (RFI)

Extensive grazing: BW $\rightarrow$ $BW^{0.75}$ & BWG

Not FI, nor efficiencies for maintenance and growth

However, rewriting the model gives:

$FI_i = b_0 + (b_1 \times BW_i^{0.75}) + (b_2 \times BWG_i) + (b_3 \times PROD_i) + e_i$

$GE_i = FI_i - b_0 - e_i = (b_1 \times BW_i^{0.75}) + (b_2 \times BWG_i) + (b_3 \times PROD_i)$

b_1, b_2, b_3 = need to be estimated from a controlled experiment

GE = estimate of individual ability to graze at resource limiting rangelands

GE can be included in selection index with a higher value being more beneficial

Increased adaptation rangeland environments, comparison of different species, estimating the grazing load of rangelands


With thanks
to the
Rafter 7
crew


Thanks!
Rauw.Wendy@inia.es