Breeding for improved feed efficiency and decreased methane emissions in sheep

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GrassToGas

INTERNATIONAL SYMPOSIUM ON THE NUTRITION OF HERBIVORES

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement N° 772787

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Outline:

- Intensive phenotyping platform
- Results:
  - Feed efficiency and methane emissions
  - Trade offs
  - Genetic parameters
- Environmental analysis
- Final remarks

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Animals - Traits

Wool traits: FD, yield, SL, colour, FW

BCS

BW, CW

REA - BF

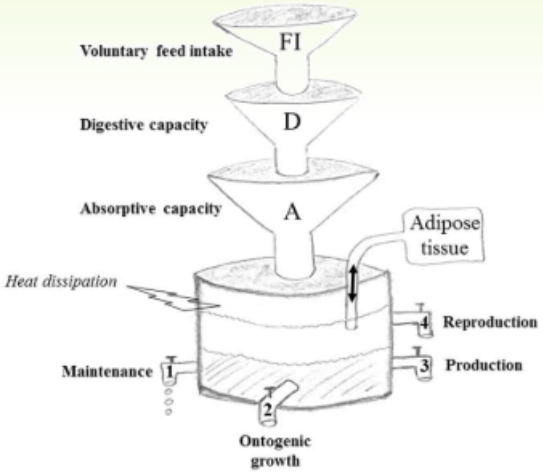
Visual assessment

FEC

Methane

FAMACHA

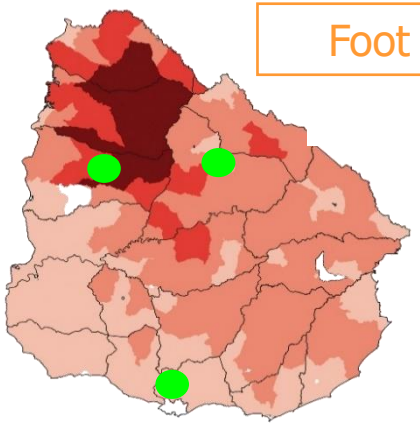
Feed intake



Huber 2017, Rauw et al, 2008

Behaviour

Foot rot



RFI

Temperament

Twinning rate

Lamb-adult survival

Fertility

Scrotal circ

Maternal ability-
Easy lambing

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Calendar

Birth

Weaning

Spring	Summer	Fall	Winter	Spring	Summer	Fall

Lambs

Birth — Weaning — FEC — FEC — Shearing — Feet — Mating

Ewe

Lambing — Feet — Mating — US — Shearing — Lambing — Mating

Shearing

TEXEL URUGUAY — RFI - CH4 J-F

CORRIEDALE — RFI - CH4 F-A

Sociedad Criadores Merino Australiano del Uruguay — RFI - CH4 A-O

MERINO DOHNE URUGUAY — RFI - CH4 O-N

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Informative nucleus (3 years)

	MA	Cor	MD
Foetus/ewes (%)	109	135	142
Hogg/ewes (%)	38	35	43
Mortality to docking (%)	10	6	10
Mortality to weaning (%)	12	7	12
Lambing (%)	97	123	126
Weaning (%)	95	122	124

MA Merinos, Cor Corriedales, MD Dohnes

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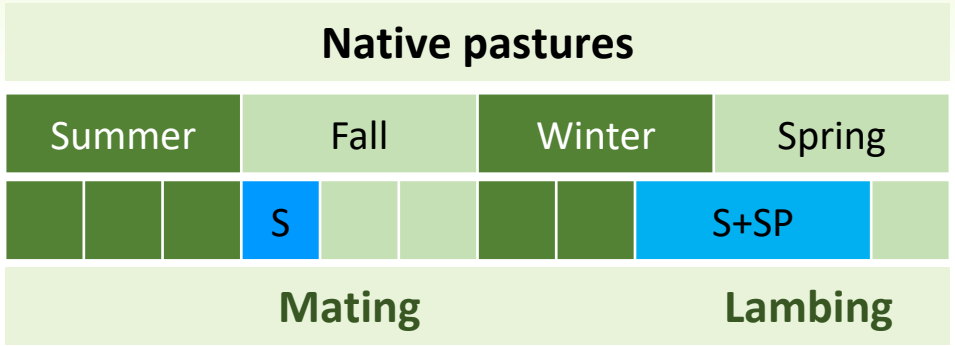

MA Merinos, Cor Corriedales, MD Dohnes

		MA	Cor	MD
Ewes	BW mating (kg)	**50,8**	**56,5**	**59,6**
	BCS mating (units)	2,9	3,1	3,3
	Fleece weight (kg)	3,96	4,20	3,51
	Fiber diameter (µ)	**15,6**	**28,2**	**20,1**
Lambs	BW weaning (kg)	23,7	26,0	27,9

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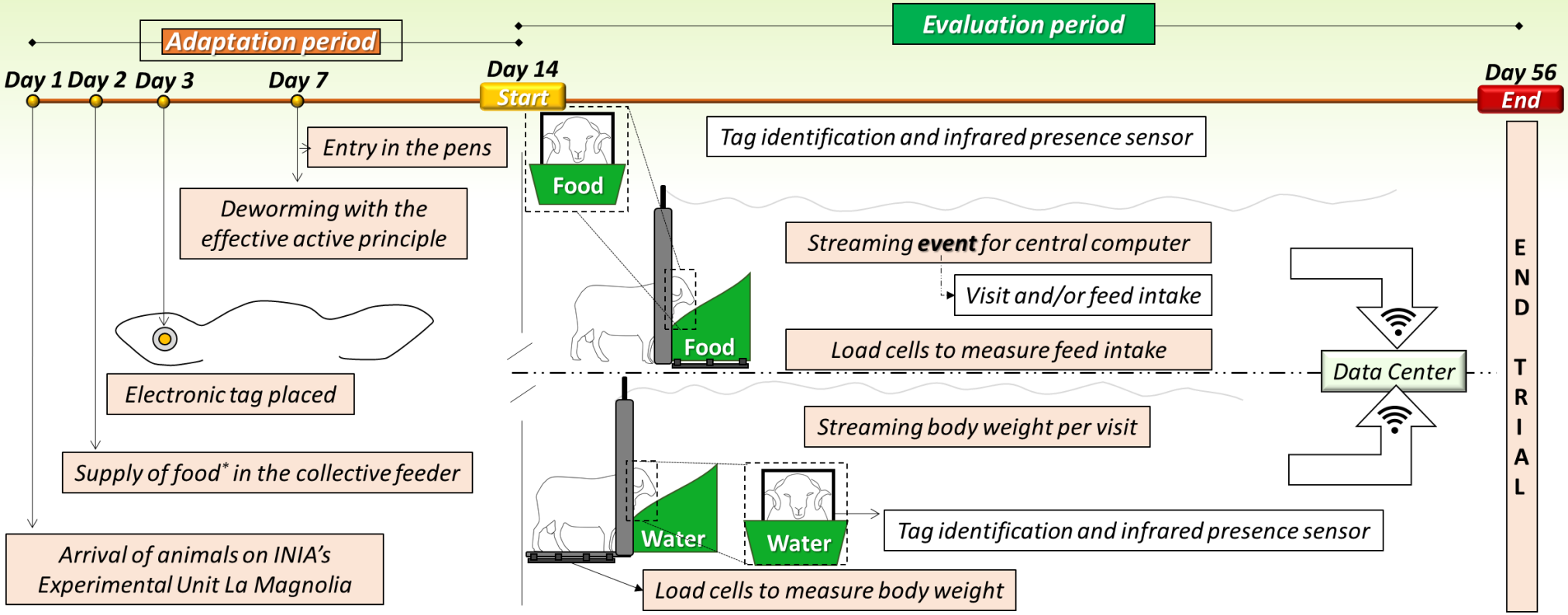
RFI test

Amarilho-Silveira et al., 2022. Livestock Science 258, 104889

VIDEO



RFI model: age, sex-pen-trial, average daily gain, mean metabolic body weight, BF

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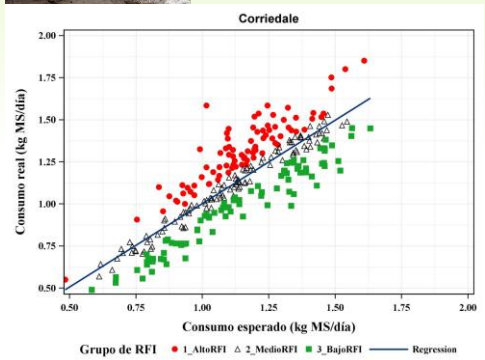
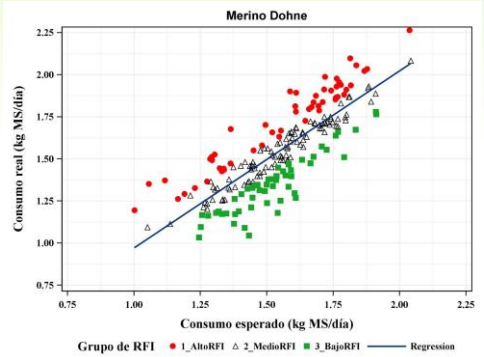
Feed efficiency

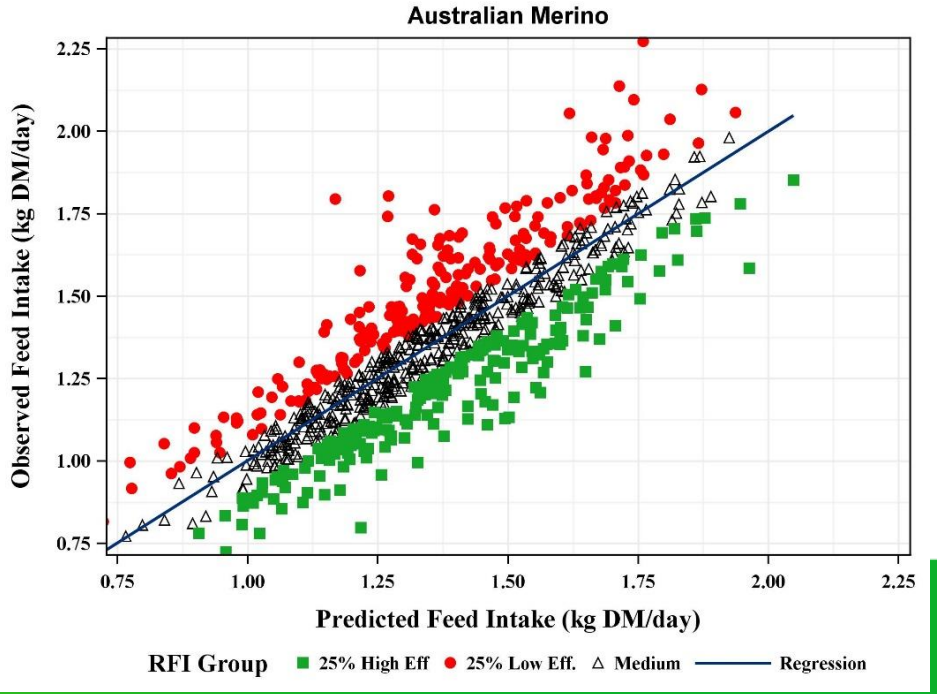
	Mean (sd) (n)								
	Corriedale			Merino			Dohne		
BW (kg)	42.9	23.3	464	40.9	6.4	1195	50.2	5.5	357
Intake (kgDM/a/d)	1.4	0.6	464	1.4	0.3	1195	1.5	0.3	357
Methane (g/a/d)	20.3	9.5	464	22.3	5.6	1195	26.8	5.7	357
REA (cm^2)	8.2	4	464	7.5	1.5	1195	10	2	357
FAT (mm)	2.7	1.6	464	1.9	0.7	1195	2.5	0.9	357
BCS	3.3	0.7	5242	2.8	0.4	1217	3.1	0.6	1616
Fleece weight (kg)	3.8	1.3	139971	3.1	0.9	73968	3.0	0.9	5960
Fiber diameter (µ)	25.6	3.1	139307	16.3	1.7	73744	18.2	1.4	5834
FEC	1543	2493	28075	1298	1905	35399	1815	2789	2870

Genotyped Corriedale 1056; Merino 3179; Dohne (96 just starting)

2016 (IN) - 143 (commercial) = 2159
(including Creole, Texel, Merilin)







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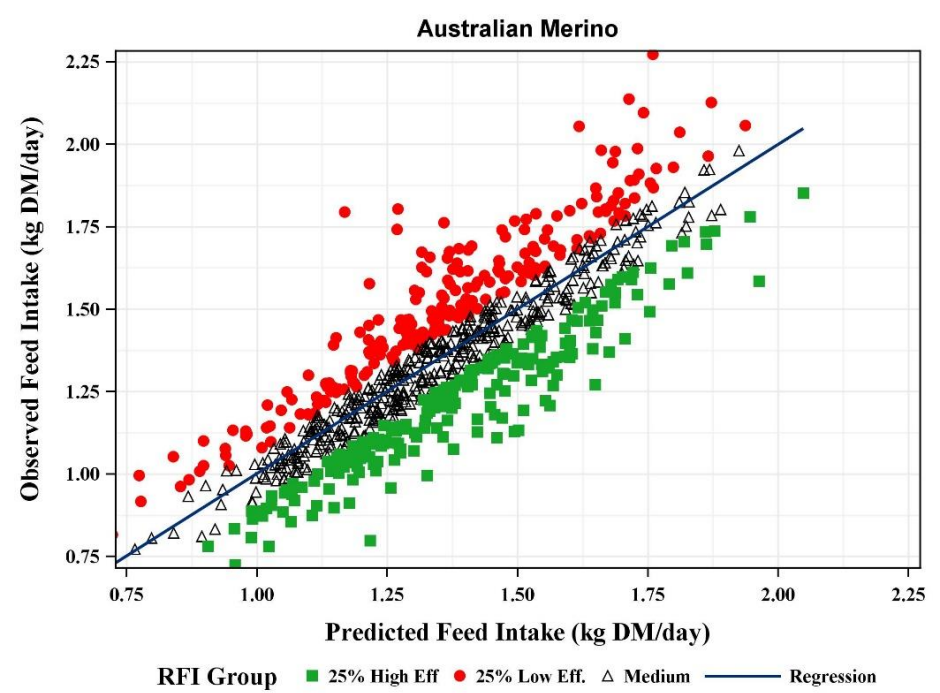
Efficiency - contrasting groups

De Barbieri et al. 2020, EAAP 71, 560



	High eff	Medium	Low eff
RFI (kgDM/d)	-0.17 c	-0.01 b	0.15 a
Feed intake (kgDM/d)	1.2 c	1.3 b	1.5 a
Feed conversion ratio	6.4 c	7.4 b	8.5 a
N° of meals	54 c	60 b	73 a
Methane (g/d)	22.6 b	22.9 b	24.1 a
Methane yield (g/kgDM)	7.1 a	6.4 b	5.9 b
Methane intensity (g/kgBWG)	6.9 b	7.1 b	7.5 a

= REA / FAT
= BW gain/ BW
= BCS
= Fleece weight (4,1 kg), fibre diameter (14,9 µm)

More efficient 20-23 % < intake

More efficient 6 % <methane (g/d)

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Feed efficiency (FE)

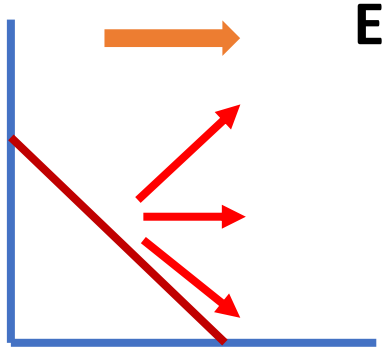
Douhard et al. 2022. Proceedings of the 12th WCGALP. 264-267
Douhard et al. 2022. Evolutionary Applications 00, 1-16
Douhard et al. 2021. Evolutionary Applications 14, 2726-2749

- **More limited feed resources**
- **Selection for feed efficiency**

→ Allocation constrains →

Trade off: production, reproduction, health

E maintenance activity (RMR)



E intake

+

+

=

E productivity

Selection for FE leads to a decrease in RMR

↓

Little evidence on negative consequences on health/reproduction traits

↓

RFI and GIN resistance lines were tested under infectious challenge - no trade off

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Trade off

Navajas et al. 2022. Proceedings of the 12th WCGALP. 195-198
Ferreira et al. 2021. Animal Production Science, 61, 754–760

Health (nematodes)

GHG emissions

Feed efficiency

Wool and Growth

		FEC line		
		Resistent	Susceptible	p
GIN free	RFI (kgDM/d)	0,02	-0,02	0,116
	Feed intake (kgDM/d)	0,97	0,98	0,969
	Feed converstion ratio	9,0	7,6	0,161
	BW gain (g/a/d)	123	143	0,168
GIN	RFI (kgDM/d)	0,01	-0,01	0,334
	Feed intake (kgDM/d)	1,13	1,12	0,849
	Feed converstion ratio	8,0	11,1	0,074
	BW gain (g/a/d)	144	123	0,144

Pearson correlation coefficients of feed efficiency and GHG emissions with EPD of production traits and FEC

	Expected progeny difference			
	Weaning weight	Yearling weight	Gastrointestinal nematodes	Fleece weight
Residual feed intake	-0,05	-0,04	0,08	0,10
Dry matter intake adjusted	**0,19**	**0,20**	0,07	**0,23**
Methane adjusted	**0,15**	**0,16**	0,05	0,07
CO_2 adjusted	**0,24**	**0,24**	0,04	0,07

High emitters (Marques et al., 2022, GGAA, 189-190):
- ✓ Heavier, and larger BWG
- ✓ Eat more, may have higher RFI

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Background

More efficient sheep:

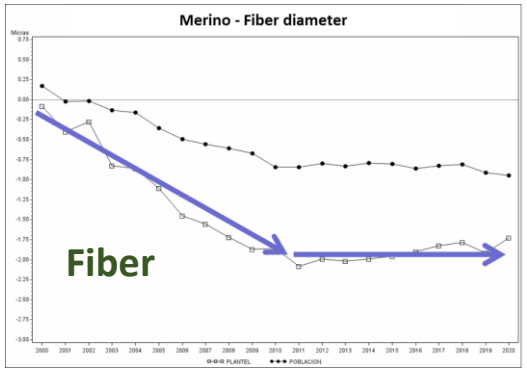
Less *in vivo* backfat (Zhang et al., 2017)(Lines et al., 2014) **(body reserves, resilience)**

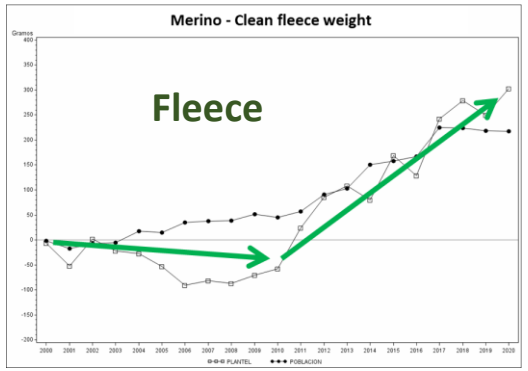
No differences in backfat or fleece weight (Redden et al., 2014)

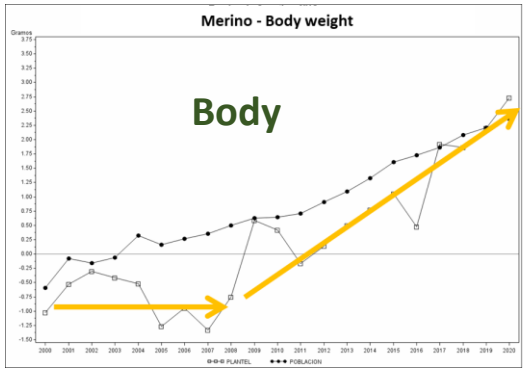
Under restricted intake no differences on DMI, and better BW, ADG, less fat (Redden et al., 2014)

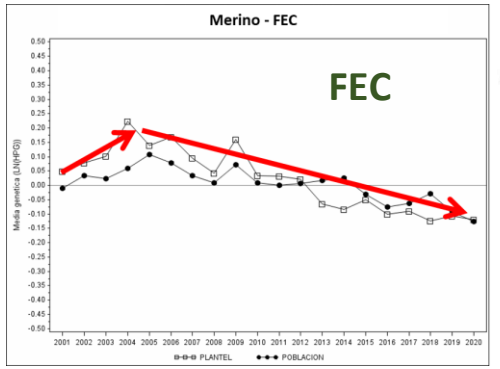
(Beef cattle) Similar/less reproduction (calving rate) (Arthur et al., 2014)

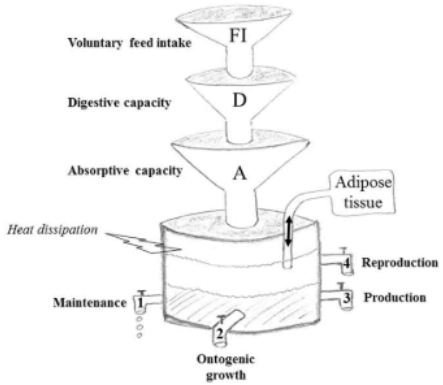
Uruguay











Huber 2017, Rauw et al, 2008

Hypothesis: More efficient ewes would present poorer reproductive performance under semi extensive grazing systems

Objective: To evaluate the productive and reproductive performance of ewes with contrasting RFI measured as lamb in their first year of life

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Material and methods - Results

De Barbieri et al. 2022. EAAP 73, 674

261 Hoggets
Born in 2018 & 2019
first mated at 17 months of age
y = RFI group + year + pregnancy rank + e

=

Production:
- ✓ Body weight (cycle)
- ✓ BCS
- ✓ Wool: FD & GFW

Reproduction:
- ✓ Fertility. Prolificacy. Lambing %
- ✓ kg of weaned lambs/mated or lambed ewe

	High ef	se	Med.	se	Low ef	se
Feed intake (kgDM/d)	1.17 c	0.02	1.24 b	0.01	1.38 a	0.02
Visits to eat (n)	49 c	1.8	58 b	1.2	69 a	1.8
Visits to drink (n)	5.6 b	0.2	5.9 ab	0.1	6.2 a	0.2
Rib eye area (cm^2)	7.4	0.2	7.3	0.1	7.2	0.2
Backfat (mm)	2.1	0.1	2.2	0.1	2.3	0.1
Bodyweight gain (g/d)	172	4.7	164	3.1	162	4.8
Metabolic bodyweight (kg)	15.9	0.2	15.5	0.1	15.7	0.2
Methane (g/d)	22.3	0.6	22.1	0.4	23.5	0.6

In agreement with Redden et al. (2014) Zhang et al. (2017) Lima et al. (2019) Tortereau et al. (2019) Muir et al. (2020)

	High eff	Low eff
Lamb (kg weaned/mated ewe)	20.8	19.1
Body weight at mating (kg)	45.6	44.3
Greasy Fleece Weight (kg)	2.8	2.8
Fibre diameter (µm)	15.5	15.7
Fertility (%)	91	79
Prolificacy (%)	120	110
Weaning (%)	100	79

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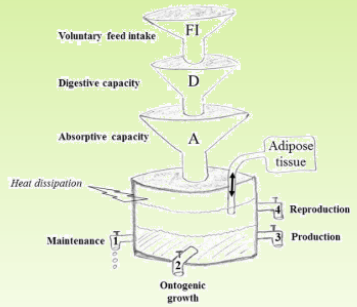
Discussion



Huber 2017, Rauw et al, 2008

Native grasslands:

- Variation in **quantity** (30-50% CV on seasonal pasture growth) (Berretta y Bemhaja, 1998)
- Variation in **quality**: CP (6-15%), DMD (50-61%), ME (1.8-2.2 Mcal/kgDM) (Berretta et al. 2000)

There is a potential restriction on intake (¿?) (Grazfeed, Freer et al, 1997) → **Supplementation + High Q/Q pastures**

Body condition score ~ 3

Feed intake is correlated among ages (Paganoni et al, 2018; Muir et al., 2020)

Improved environment can mask resilience/plasticity (Huber 2017)

Under restricted intake, no differences FI between RFI groups, better performance for low RFI, lower maintenance requirements, higher efficiency in the use of energy… (Redden et al., 2013; Cantalapiedra Hijar et al., 2018)

No detected effect (restricted intake, restriction to potential reproduction)

Improved targeted nutrition can mask a potential trade-off between feed efficiency and reproduction

No effect of RFI group on reproduction (similar Fat, BCS), in sheep selected for wool for >20 years when grazing

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Merino - Genetic parameters

Preliminary results: Marques et al. 2022. 12th WCGALP. 160-163
New analyses: Marques et al, in preparation

Heritability (sd) - diagonal - bold

G correlation (sd)

	FW	FD	BW	FEC	CH4	FI	RFI	REA	BF
FW									
FD									
BW									
FEC									
CH4									
FI									
RFI									
REA									
BF									

P correlation

FW fleece weight, FD fibre diameter, BW bodyweight, FEC faecal egg count, CH4 daily methane, FI feed intake, RFI residual feed intake, REA rib eye area, BF backfat thickness

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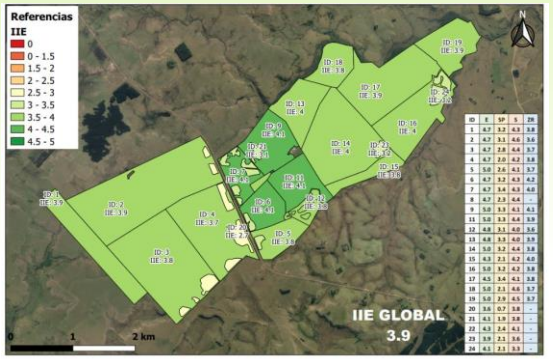
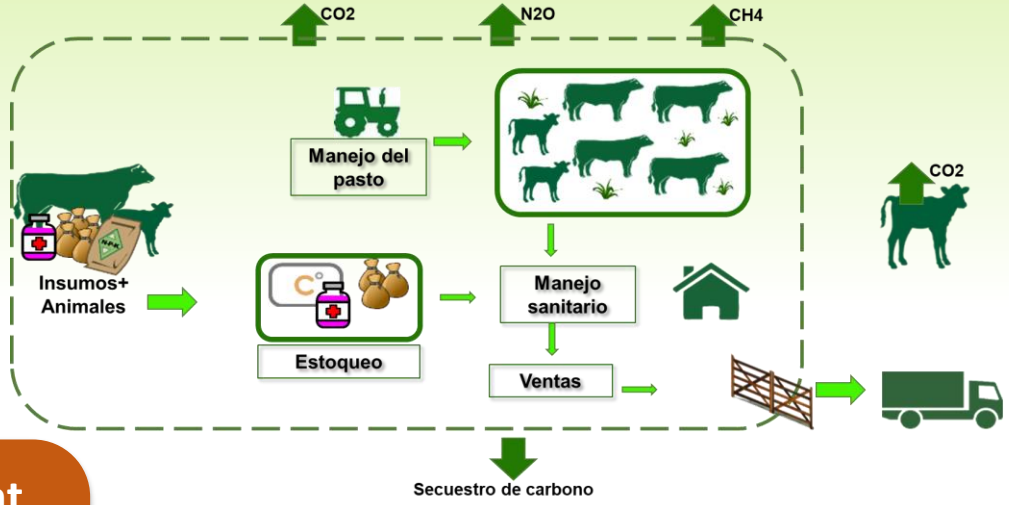
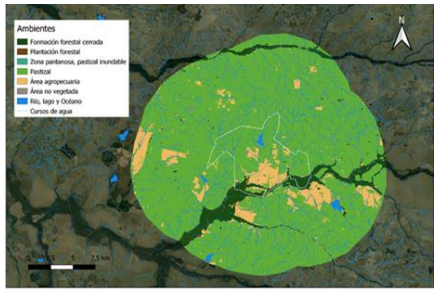
Environmental analysis

Blumetto et al., Procceedings IGC, 2023





Lifecycle assessment for carbon footprint
Biodiversity: ecosystem level
Biodiversity: community level
Carbon stock
Water quality



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LCA

Blumetto et al., Procceedings IGC, 2023

	Average	Min-Max
Área (ha)	2075	480-5300
Beef meat (kg/ha)	102	63-170
Sheep meat (kg/ha)	28	17-41
Wool (kg/ha)	6.2	4.7-10
kg CO2eq/ha	2214	1880-2469
kg CO2eq/kgbeef	16	11.4-19.9
kg CO2eq/kgsheep	11	7.6-13.6
kg CO2eq/kgwool	49	35.7-63.6

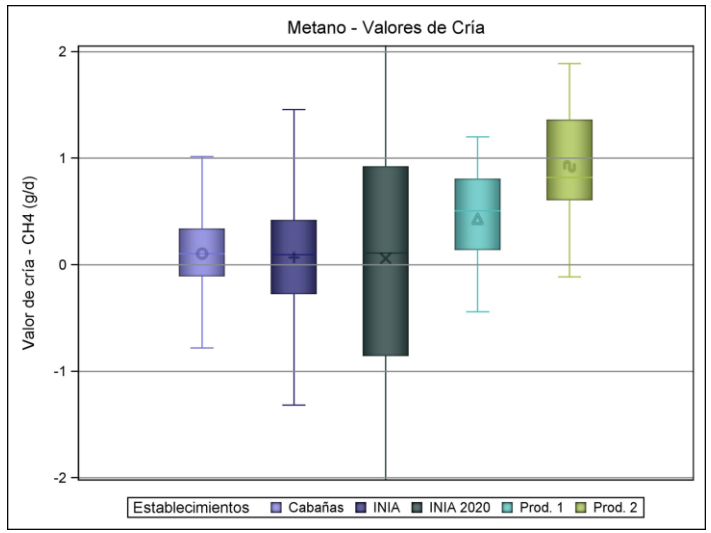
75-80% methane

- Green label (SUL)
- RWS (Textile Exchange)
- Organic wool (GOTS)
- Nativa (Chargeurs)
- Origen (Engraw)
- Nativa Regen (Chargeurs, LTSA)

NATIVA PRECIOUS FIBER

Modelling breeding:

- Different scenarios - different animals (median - upper quartile)
  - 14 % less E intake (more efficient animals)
  - 17 % less emission (less emitter animals)
  - 13 % more wool production (more productive animals)
- Emission intensity effect:
  - Scenario 1: - 20%
  - Scenario 2: - 13%
  - Scenario 3: - 6%



Promisorio: genética cuantitativa y genómica

Vera et al., 2022

Sustainable Fashion Awards 2022

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Summing up

- A platform for estimating FE and ME (infrastructure, protocols, analyses)

1. Characterization >2000 animals (IN) - Corriedale, Merino, Dohne, Texel, Merilín, Creole
2. More efficient animals (RFI) eat less, *emit less methane*, at the same level of production
3. No clear evidence for trade offs between FE and health or reproduction
4. Genetic parameters for FE and ME in Merinos (others in process)
5. Genomic assisted genetic evaluations
6. 5 Breeds are evaluating their rams for FE/ME- Central test sire evaluation (breeders + research)
7. This information/tools can assist in designing profitable and environmentally sustainable ruminant production systems

- To do:
    1. Continue monitoring potential trade offs, including more traits (IC, HS, WC, lifetime) and animals
    2. Reference population (to continue) + Grazing evaluations
    3. Study the inclusion of information related to FE/ME on breeding indexes
    4. Animal selection for improved RFI and lower emissions
        1. Greater impact by implementing genomic selection

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Oscar Blumetto

Gabriel Ciappesoni

INIA URUGUAY

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Thanks to the ISNH (Pablo Chilibroste) for the opportunity

Invitation to follow the projects in the social media

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SMAll RuminanTs breeding for Efficiency and Resilience