UNIVERSITY OF HOHENHEIM

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GENOMIC ANALYSES OF PARASITE RESISTANCE TRAITS IN GERMAN CROSSBRED MERINO

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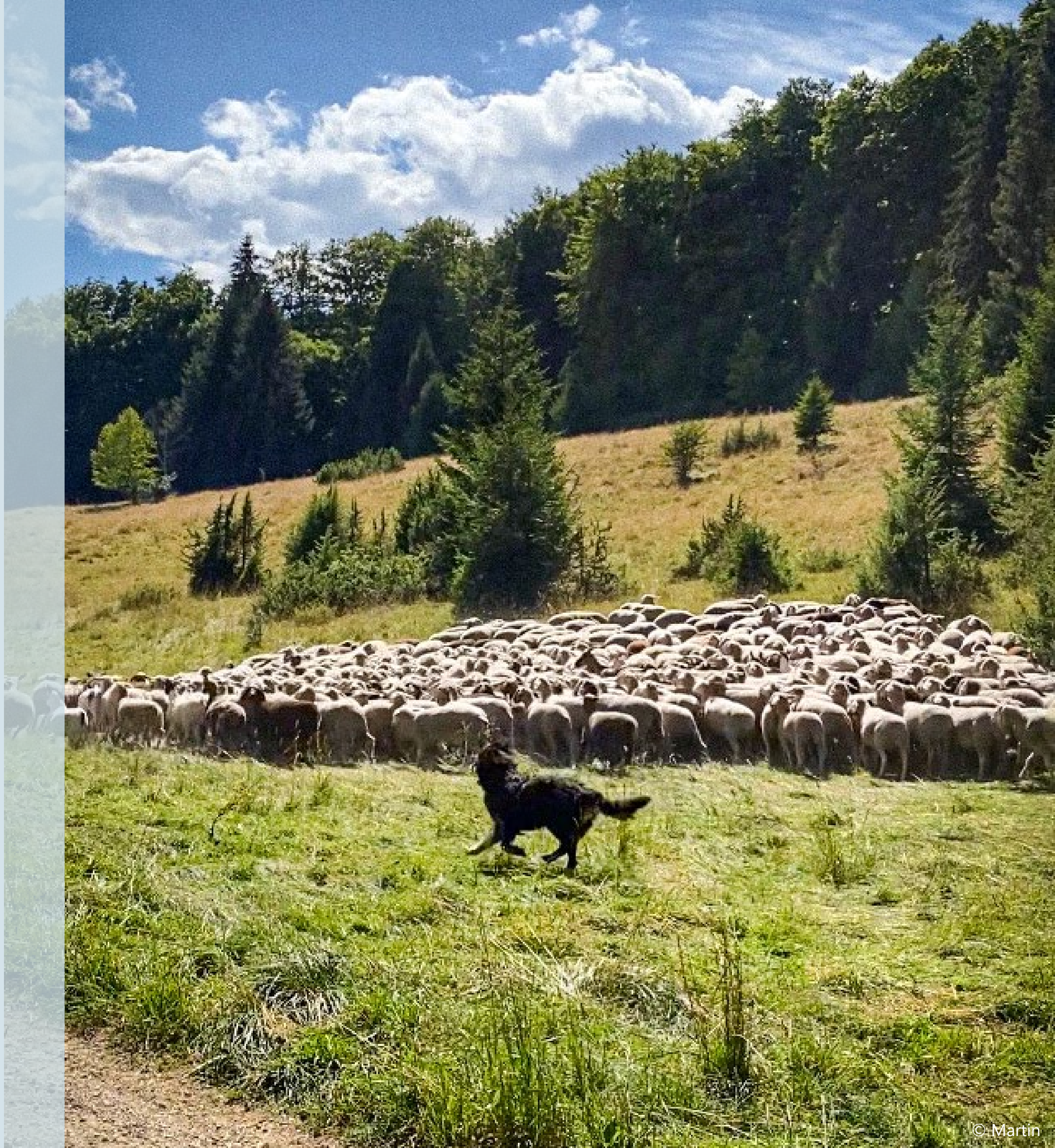
MOST GERMAN SHEEP ARE HOUSED ON PASTURE…

- **Animal friendly & ‚natural'** husbandry which satisfies consumer desires (Montossi et al. , 2013)
- Grazing sheep is important for **landscape conservation**
- **Majority of income** (59%) generated through **landscape management subsidies** (BLE, 2022)



MOST GERMAN SHEEP ARE HOUSED ON PASTURE…
… AND ARE THEREFORE EXPOSED TO GIN*

GIN infections

- **Decrease animal welfare**

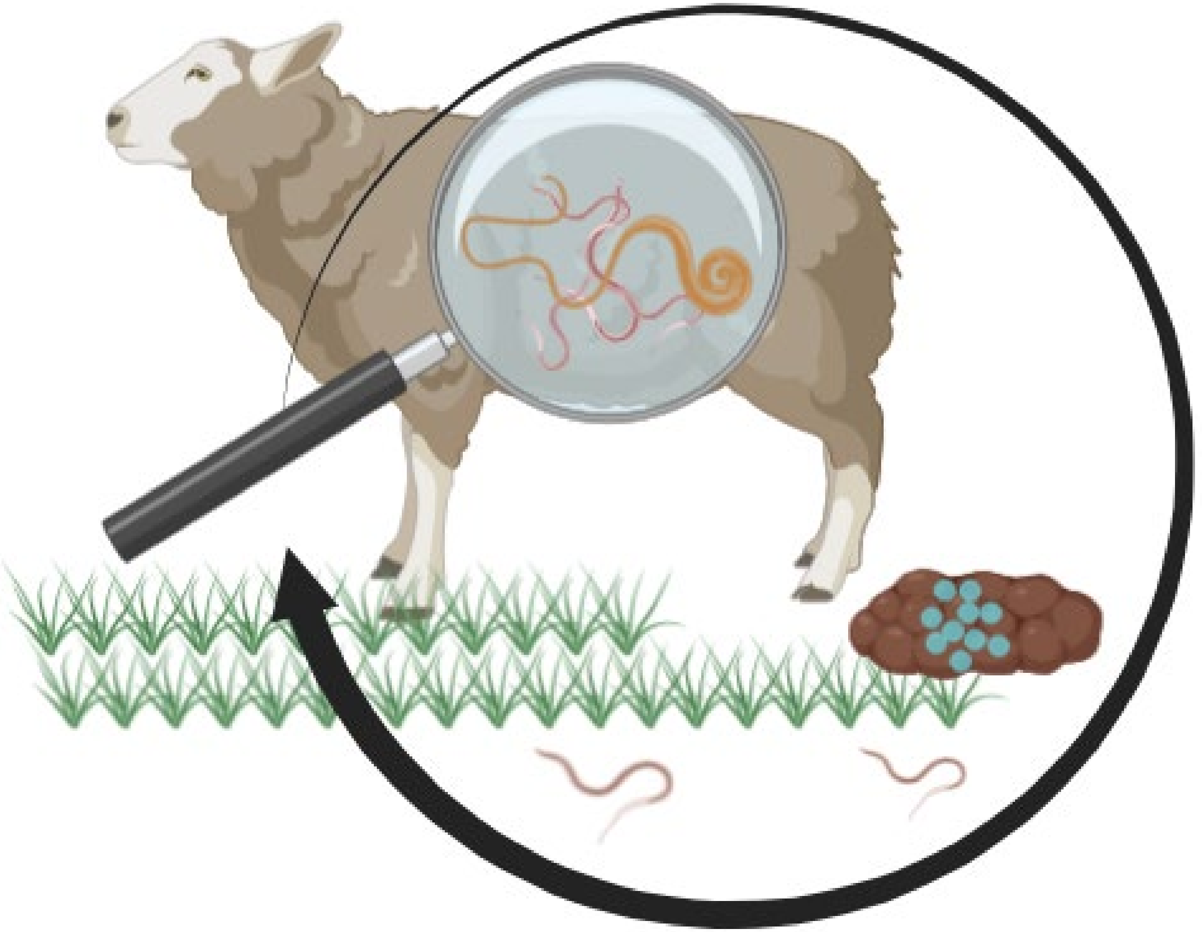
→ Symptoms of parasitosis: weight & wool loss, anemia, diarrhea, …

→ Often lethal to vulnerable animals (e.g. lambs, periparturient ewes)

- **Decrease production**

→ Economic losses (~10.9 Mio. €/year in GER, Charlier et al., 2020)

*gastrointestinal nematodes



GIN ARE INCREASINGLY RESISTANT AGAINST ANTHELMINTIC DRUGS: TREATMENT BECOMES MORE AND MORE INEFFECTIVE!

Aim of **deworming**:
Prevention of too high parasite load & parasitosis.

Depending on the anthelmintics used: **up to 60% ineffective treatments** in German herds (Voigt et al., 2022)

→ **Emerging need for alternative strategies!**

ALTERNATIVE:
BREEDING SHEEP WITH IMPROVED GIN RESILIENCE

- Sustainable
- Long-term potential

Selection on low fecal egg counts (**FEC**) to improve GIN resistance

- Implemented in breeding programs, e.g. in AUS & NZL
  (Brown et al., 2006; Dodds et al., 2014)

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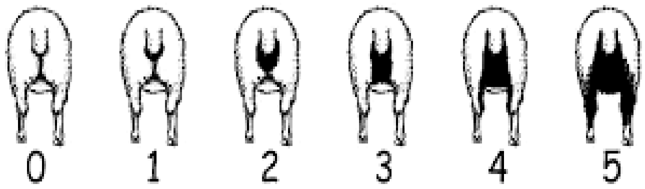
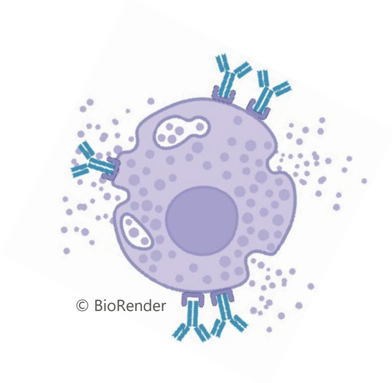
Increasing diarrhea incidence observed ('**low FEC diarrhea**')
(Karlsson & Greeff, 2004; Hassan et al., 2022)





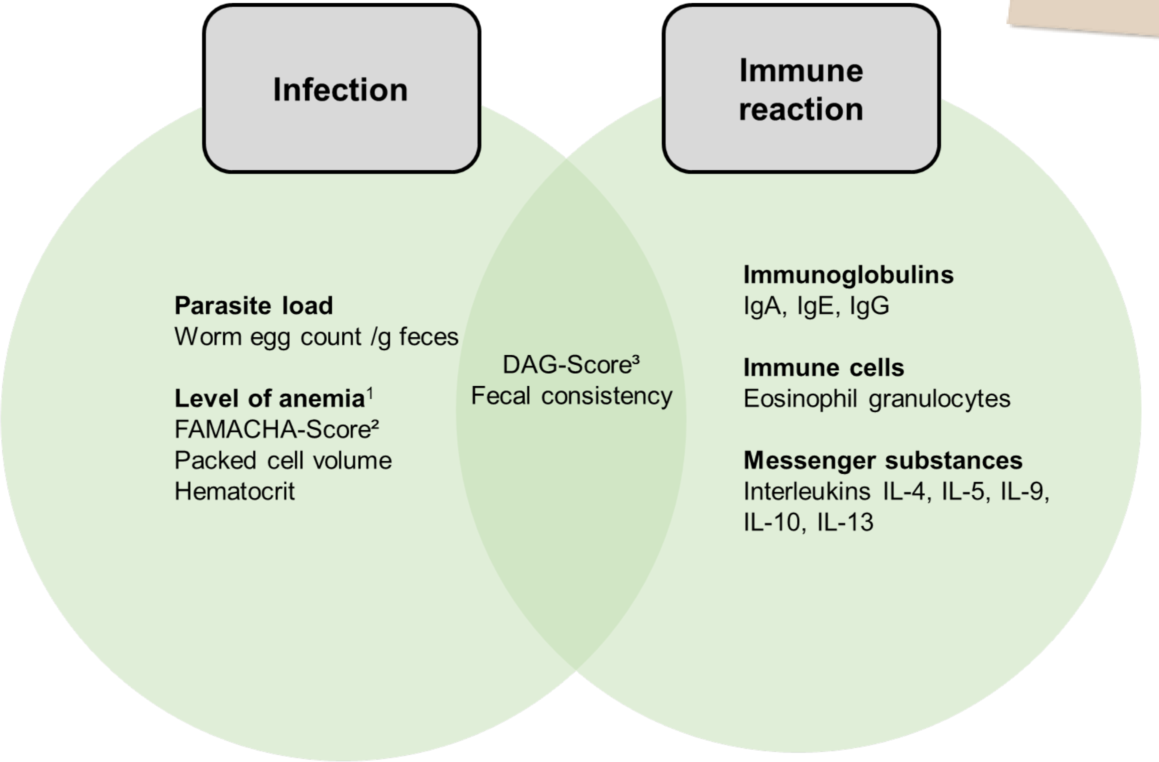
Discussion: selection of **one-sided immune response?!**
(hypersensitivity against GIN?!)

ALTERNATIVE:
BREEDING SHEEP WITH IMPROVED GIN RESILIENCE

- Sustainable
- Long-term potential

One-sided breeding goals may not be sustainable!

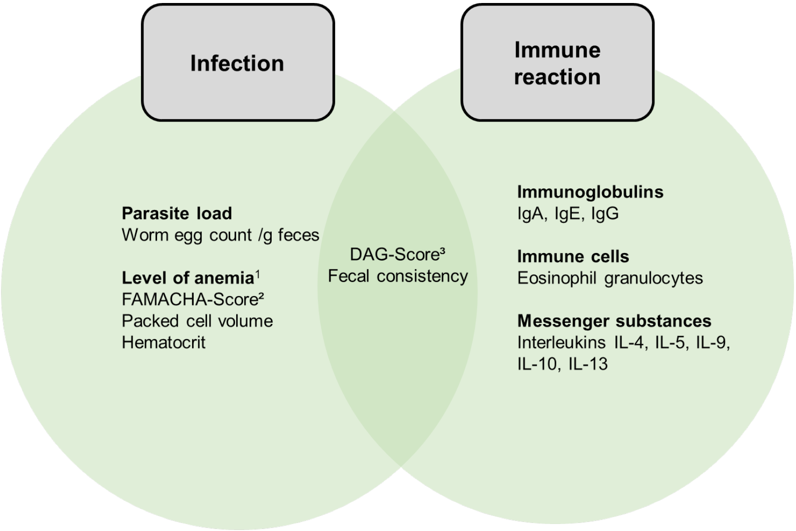
Recommended for breeding goals:
Consideration & combination of different aspects



[1] only indicative for blood-sucking nematode species
[2] Classification of the degree of anemia based on the eyelid color using the FAMACHA© color chart
[3] Classification of fecal soiling in the anus area (diarrhea indicator)

(Schmid et al., 2024a,b)

URGENTLY NEEDED: KNOWLEDGE ABOUT THE GENETIC BACKGROUND OF PARASITE RESISTANCE TRAITS IN GERMAN SHEEP

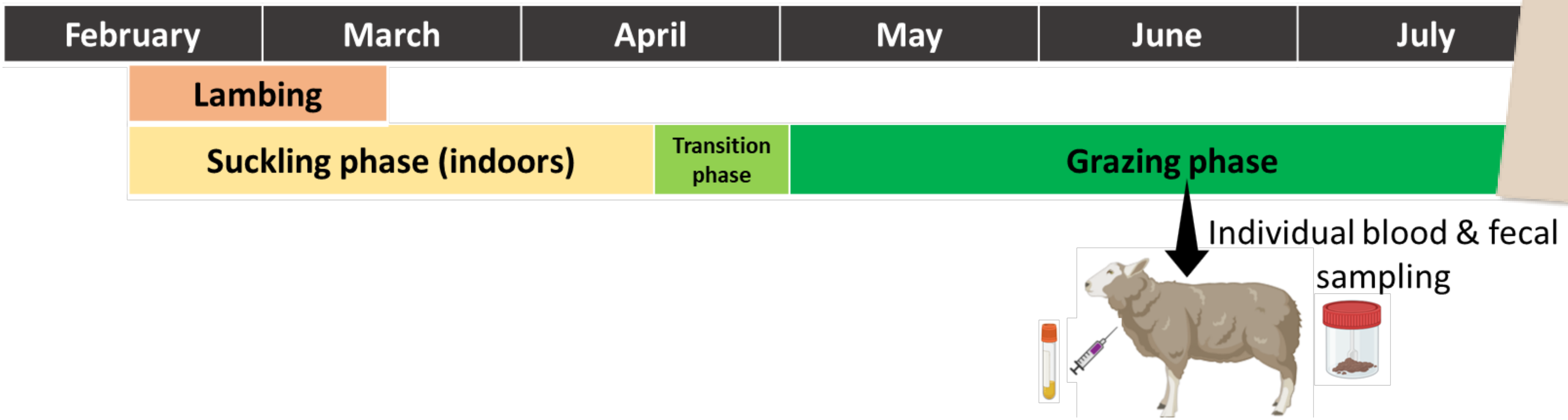


STUDY GOALS

Joint genetic analyses of FEC, immunoglobulin A in plasma & feces

Heritabilies & genetic correlations in German Merino and Merino crossbred lambs

STUDY DESIGN



On average:
- **Age** at sampling: **13 weeks**

→ **32 days post infection**

- **3 farms** (Southern Germany)
- **2 grazing systems**:

→ Extensive (lambs with ewes, mostly transhumance)

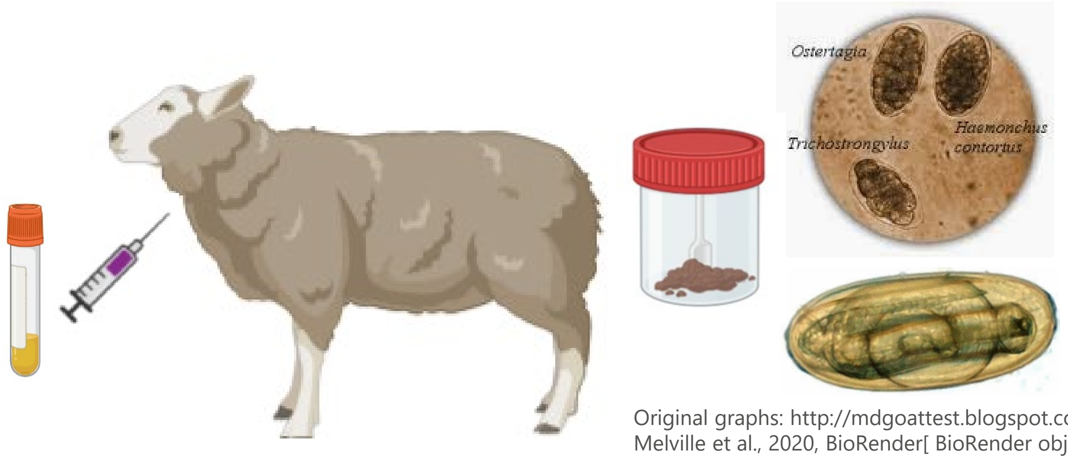
→ Intensive (weaned lams, paddock)

- **5 crosses** (maternal: Merino)

→ Sire breeds: Ile de France (IDF), Merino (MER), Black-headed mutton (BHM), Suffolk (SFK), Texel (TXL)

→ **2 years**: 2021 & 2022

SAMPLING, GENO- & PHENOTYPING



Original graphs: http://mdgoattest.blogspot.com, Melville et al., 2020, BioRender[BioRender object]

Fecal sample

- FEC of Trichostrongylides (**FECt**)
- FEC of Nematodirus spp. (**FECn**)

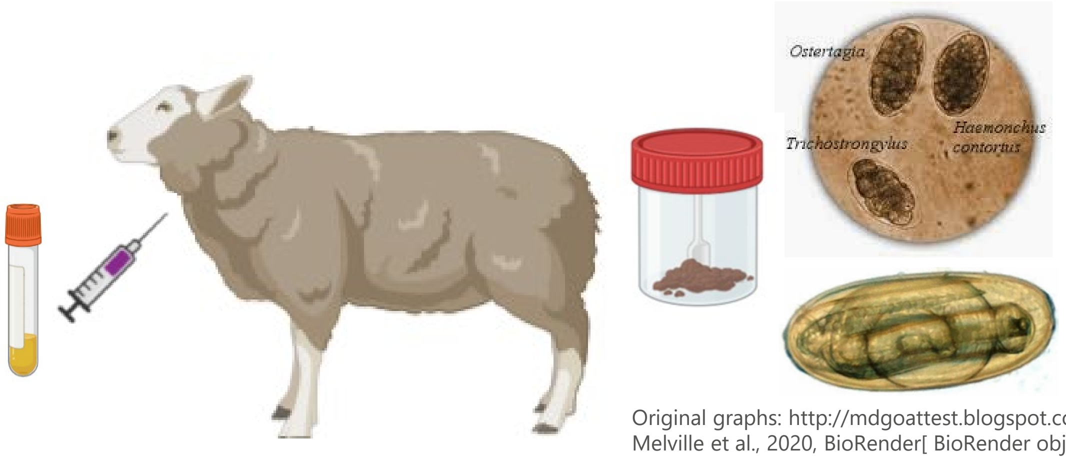
→ modified sedimentation-flotation method (sensitivity 10 epg) (Sargison, 2008)

- Fecal immunoglobulin A concentration **(fecal IgA)**

→ ELISA

→ No data from year 2021

SAMPLING, GENO- & PHENOTYPING



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Blood sample

- Plasma immunoglobulin A concentration **(plasma IgA)**

→ ELISA

- **Ovine 50K SNP Chip genotyping** (Illumina, San Diego, USA)

Fecal sample

- FEC of Trichostrongylides (**FECt**)
- FEC of Nematodirus spp. (**FECn**)

→ modified sedimentation-flotation method (sensitivity 10 epg) (Sargison, 2008)

- Fecal immunoglobulin A concentration **(fecal IgA)**

→ ELISA

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DATASET & DESCRIPTIVE STATISTICS

Trait	Unit[1]	n	Mean	Median	Minimum	Maximum
plasma IgA	AU/ml	1,135	12,719.5	10,587.3	1,297.1	111,528.3
fecal IgA	AU/ml per g TP	492	2,537.4	1,390.1	91.3	30,152.1
FECt	epg	1,135	129.9	50.0	0.0	3,060.0
FECn	epg	1,135	51.5	20.0	0.0	1,270.0

[1]Arbitrary units per mililiter (AU/ml); Arbitrary units per mililiter per gram total protein (quantified in Bradford Assay) (AU/g TP), eggs per gram (epg)

- **Phenotypic variation** in all traits
- **Intermediate infection level** (moderate mean FEC)
- GIN infection **prevalence:~79%** (FECt > 0), **~62%** (FECn > 0), ~16% (FEC = 0)

MULTIVARIATE ANIMAL MODEL

- RStudio (Allaire, 2012)
- asreml-R (Butler et al., 2023)

$$\boldsymbol{y} = \boldsymbol{X_b b} + \boldsymbol{Z_a a} + \boldsymbol{e}$$

- y observations (trait phenotypes)

Box-Cox transformed & standardized (mean = 0; sd = 1)

- b, X_b fixed effects with design matrix X_b
- a, Z_a random animal effect ($a \sim N(0, G\sigma_a^2)$, with SNP-based relationship matrix G and design matrix Z_a
- e heterogeneous residual variances per cross

Heritability across all crosses: $\overline{h^2} = \frac{n_1 h_1^2 + \cdots + n_5 h_5^2}{n_1 + \cdots + n_5}$ (number of lambs n of cross 1 to 5)

WALD TESTS REVEALD A SIGNIFICANT IMPACT OF HERD ENVIRONMENT ON ALL TRAITS

Trait	Sire breed	Sex	Birth type	Farm:year:grazing system	Age at sampling
plasma IgA	n.s.	n.s.	<0,001	<0,001	n.s.
fecal IgA	n.s.	n.s.	n.s.	<0,001*	<0,001
FECt	n.s.	n.s.	n.s.	<0,001	n.s.
FECn	n.s.	n.s.	n.s.	<0,001	n.s.

Wald tests based on univariate models; significance level p=0.05; n.s.: not significant; *farm:grazing system, no data from 2021

- **Sex effect**: sampling before puberty → **too young?!**
- **Sire breed effect** rather detectable
    - between animals of different sire breeds (**not between crosses**)

SIGNIFICANT HERITABLE VARIATION FOUND IN ALL TRAITS

	plasma IgA	fecal IgA	FECt	FECn
plasma IgA	**0.59 (0.03)**	-0.03 (0.05)	0.10 (0.03)	0.23 (0.03)
fecal IgA	-0.17 (0.23)	**0.14 (0.05)**	-0.08 (0.05)	-0.19 (0.04)
FECt	-0.18 (0.24)	0.30 (0.57)	**0.09 (0.03)**	0.43 (0.03)
FECn	0.44 (0.21)	0.41 (0.43)	-0.24 (0.48)	**0.09 (0.02)**

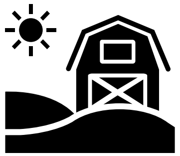
- Estimates with standard errors (SE) in parentheses
- Diagonals: heritabilities
- Below diagonals: genetic correlations
- Above diagonals: phenotypic correlations

- Heritabilities comparable with other studies (Davies et al., 2005; Gauly et al., 2002; Zhao et al., 2019)
- Low to moderate phenotypic & genetic correlations between traits

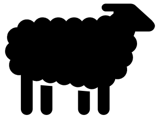
→ SE too high to draw inferences

IMPLICATIONS

MANAGEMENT + BREEDING = SUCCESS IN COMBATING GIN

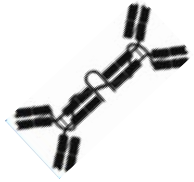


Significant impact of management & weather conditions (farm, grazing system, year)



No preferable crossing partner for Merino identified

Worth to generate more data & breed for improved GIN resistance
→ **Sufficient h^2 for parasite load** (FECt & FECn)



Immune traits are interesting & promising for breeding
→ Direct measure of host immune competence against GIN
→ Moderate to high heritabilities of IgA

MANY THANKS TO...

... farm staff members, colleagues & project partners who contributed to this study

... PhD candidate **Rebecca Martin**
(see Session 2, Book of Abstracts p. 178)

... EIP-agri for funding parts of the study

INTERESTED IN OUR FURTHER RESEARCH? CONTACT ME!

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