Genetic and genomic study for milk production traits in the Cyprus Chios sheep

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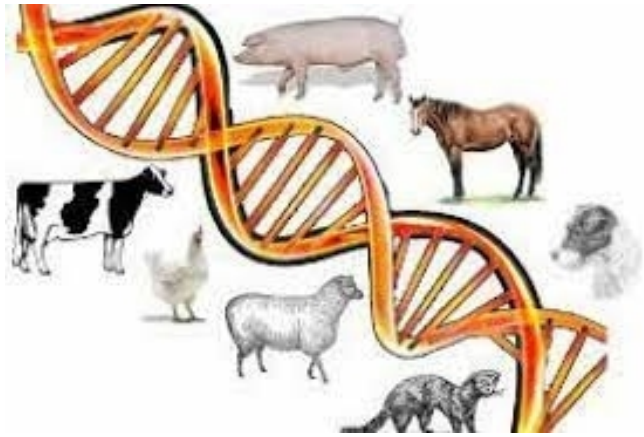
Introduction

- Mediterranean countries host approximately 46% of the total world **sheep milk production**
- The dairy sheep industry is usually based on local breeds, which are very well adapted to their production systems and environments
- **Animal breeding & identification of genetic markers** affecting traits of economic interest such as milk performance, provide practical benefits for the dairy sheep industry



Introduction

Agricultural Research Institute (ARI) conducts research aiming to create and transfer knowledge for**:**

- Development of the primary sector and solving problems in farms

- Transfer of knowledge to stakeholders through modern educational programs
  - **Animal breeding:** Genetic and genomic improvement of Cyprus Chios sheep
  - **Genetic research and management of the Scrapie disease**

Introduction

- Chios Sheep originates from the Greek island of Chios and were imported into Cyprus in 1954.

- The Chios sheep breed is widely known for its responsible for the livestock genetic improvement, high milk production and prolificacy.

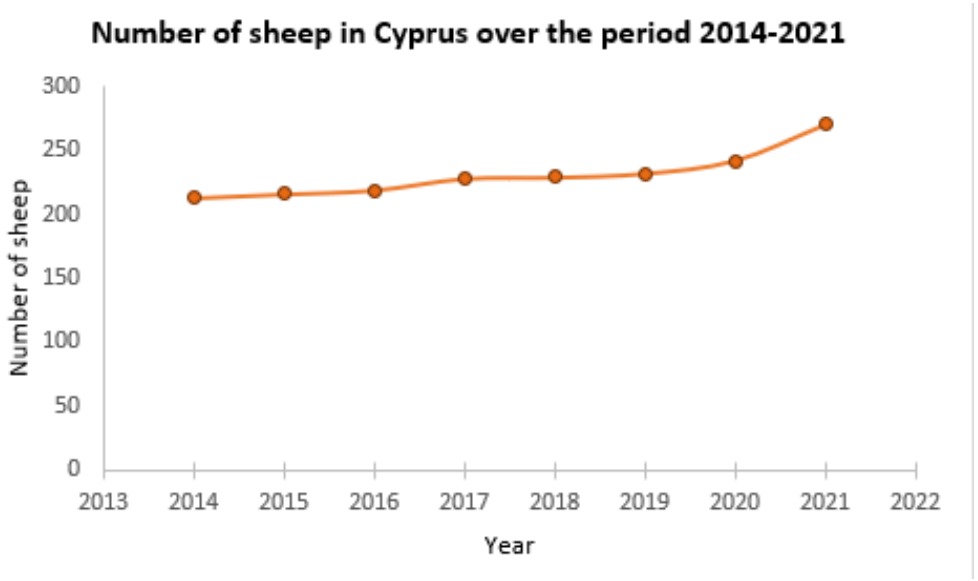
- They have been kept in pure bred flocks and genetically contributed in cross-bred sheep population.

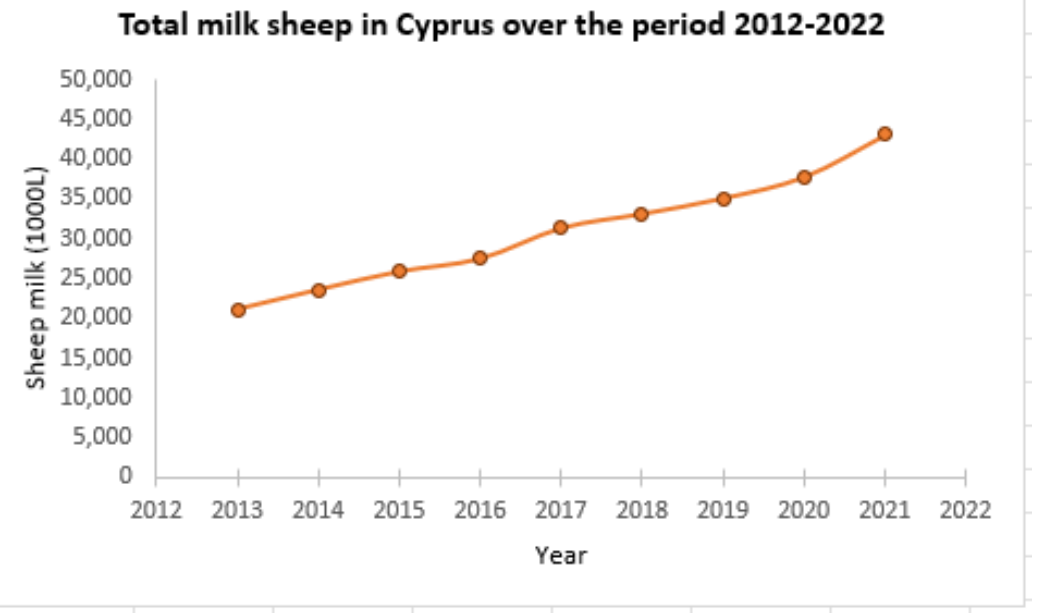
Introduction

- Cyprus' traditional cheese "Halloumi" is officially registered as a Protected Designation of Origin (PDO) foodstuff with the European Union.

- The demand for goats' and sheep's milk is increased.

- The goal is to genetically enhance livestock to meet the demands for "halloumi".





Aim of the study

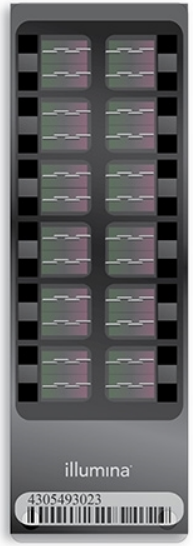
Genetic and genomic characterization of milk production traits in Cyprus Chios sheep using the below methods:

- BLUP (Best Linear unbiased prediction)
- ssGBLUP (single-step Genomic Best Linear unbiased prediction)
- GWAS (Genome Wide Association Study)

Methods

Recording for ~3,000 1st lactation ewes of:

- basic characteristics
  - birthdate
  - lambing age
  - gestation length
- milk performance
  - total milk yield
  - fat percentage
  - protein percentage & full pedigree
- Blood collection and genotyping of ~1,000 sheep (>54,000 SNPs were genotyped with OvineSNP50 BeadChip array)
- 383 ewes with genotypes had phenotypic records (293 from Athalassa farm & 90 from Achellia farm)



Methods

ASReml-R statistical analysis software was used for:

- BLUP and ssGBLUP analysis (asreml & ASRgenomics packages)

Equation for the pedigree-based mixed animal model

$$y = \mu + Xb + Z2p + e$$

Where:
y is the vector of phenotypes
X is the incidence matrix
b is the vector of **fixed** effects to be **estimated**
Z is the **incidence** matrix for **random** effects (pedigree for BLUP / pedigree + genomic data for ssGBLUP)
e is the vector of residuals

- GWAS analysis (ASRgenomics package)

Dataset

Variable	N
Total number of ewes	3,140
Recording period	1984-2021
Rounds of lactation	1-10
Number of ewes with full pedigree	3,040
Popularity of each lactation	
Lactation 1	3,055
Lactation 2	2,436
Lactation 3	1,735
Lactation 4	1,122
Lactation 5	687
Lactation 6	381
Lactation 7 - 10	300

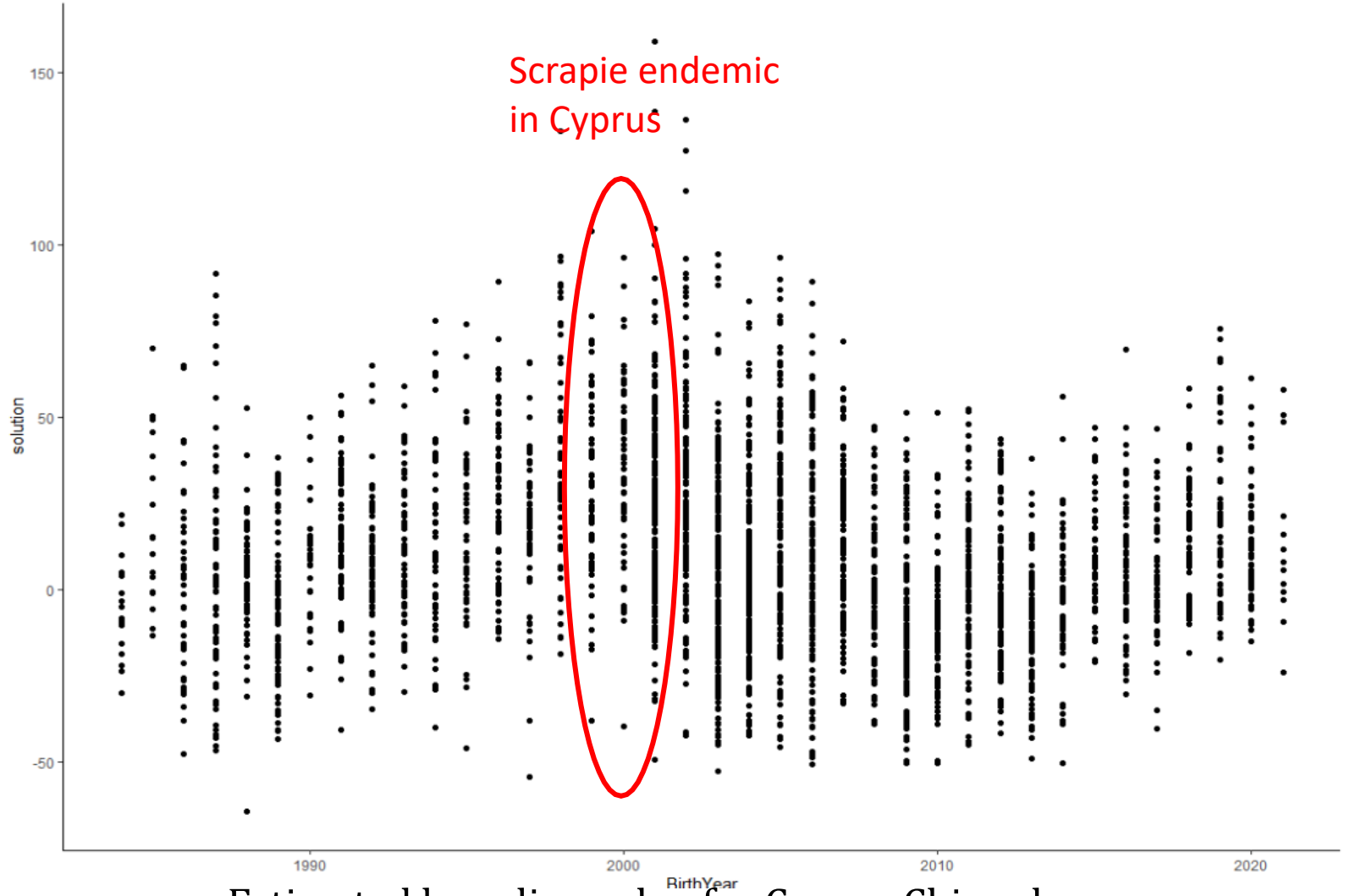
BLUP – fixed effects fitted & heritability for total milk yield

N_{ewes}= 3,040

Variable	Sum of square	P-value
Lactation Number	0.05	0.82
Lambing age	0.01	0.92
Gestation length	8.58	**0.003**
Fat percentage	78.25	**2.2 E-16**

Heritability	Standard error
0.32	0.03

Results – EBV for total milk yield



Estimated breeding value for Cyprus Chios sheep

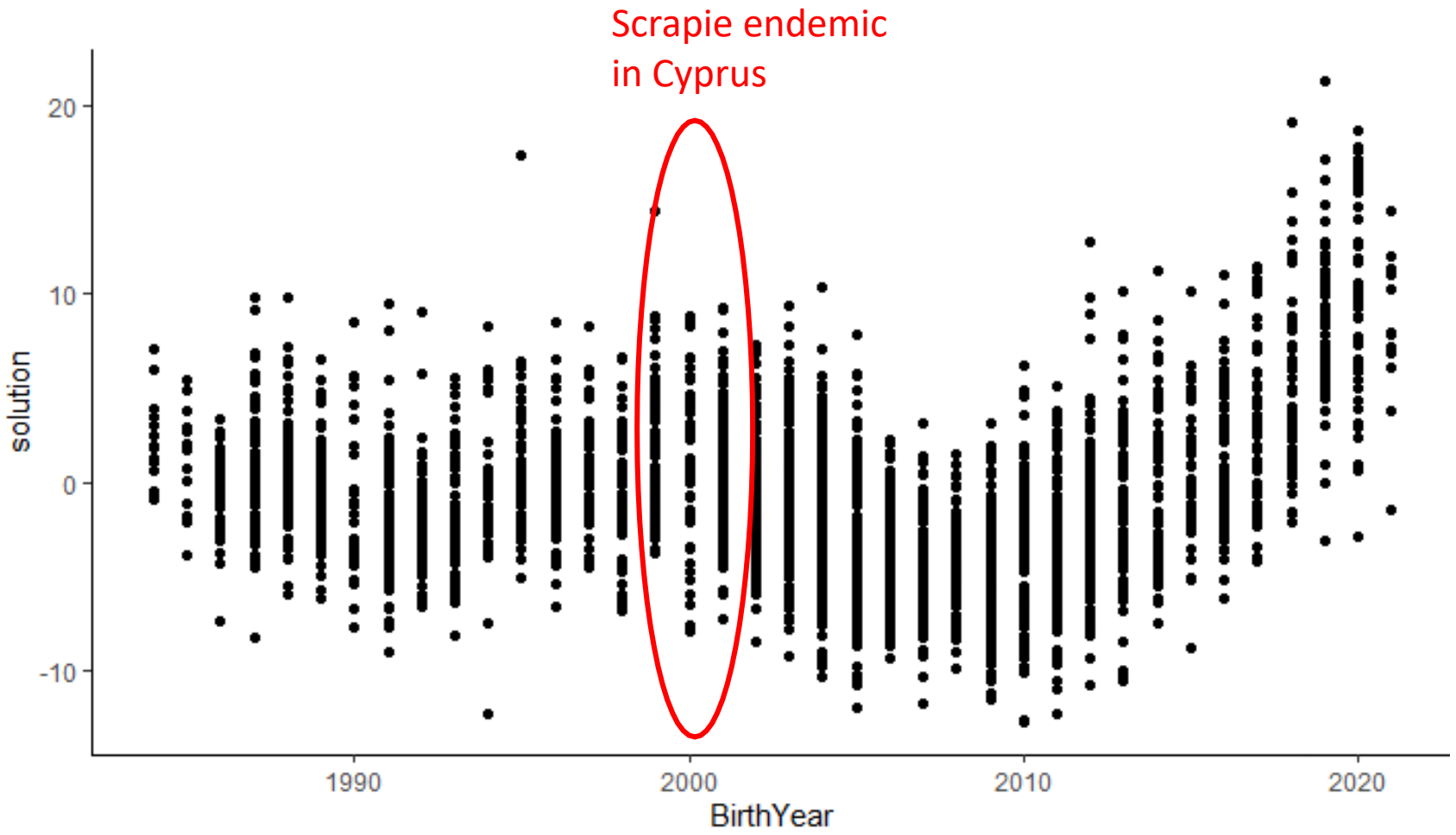
BLUP – fixed effects fitted & heritability for fat percentage of milk

N_{ewes}= 3,040

Variable	Sum of square	P-value
Lactation Number	42.0	**9.3×10^{-11}**
Lambing age	62.7	**2.3×10^{-15}**
Gestation length	9.0	**0.003**
Total milk yield	78.2	**2.2×10^{-16}**

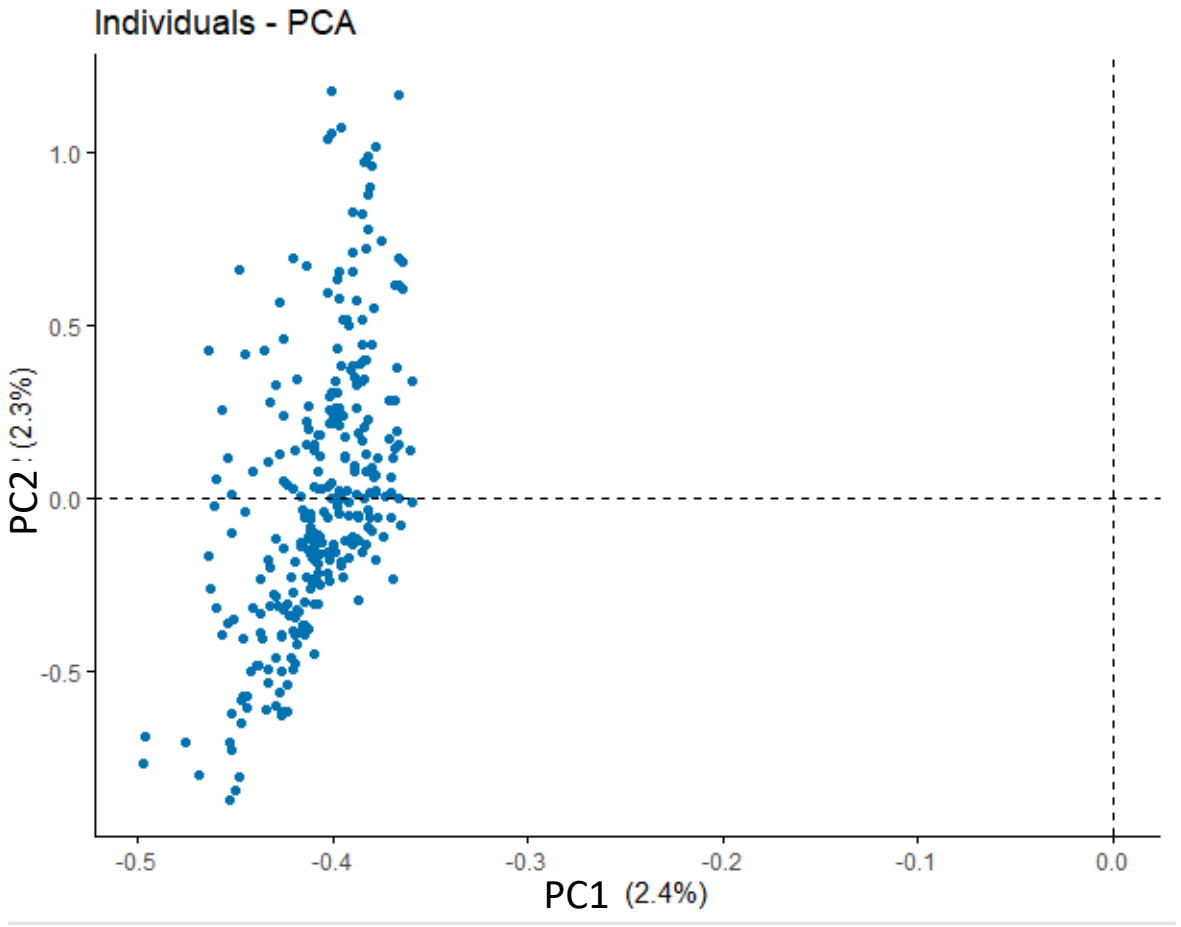
Heritability	Standard error
0.48	0.04

Results – EBV for fat percentage in milk



Estimated breeding value for Cyprus Chios sheep

Principal component analysis for Cyprus Chios sheep



Preliminary results – ssGBLUP

fixed effects fitted & heritability for total milk yield

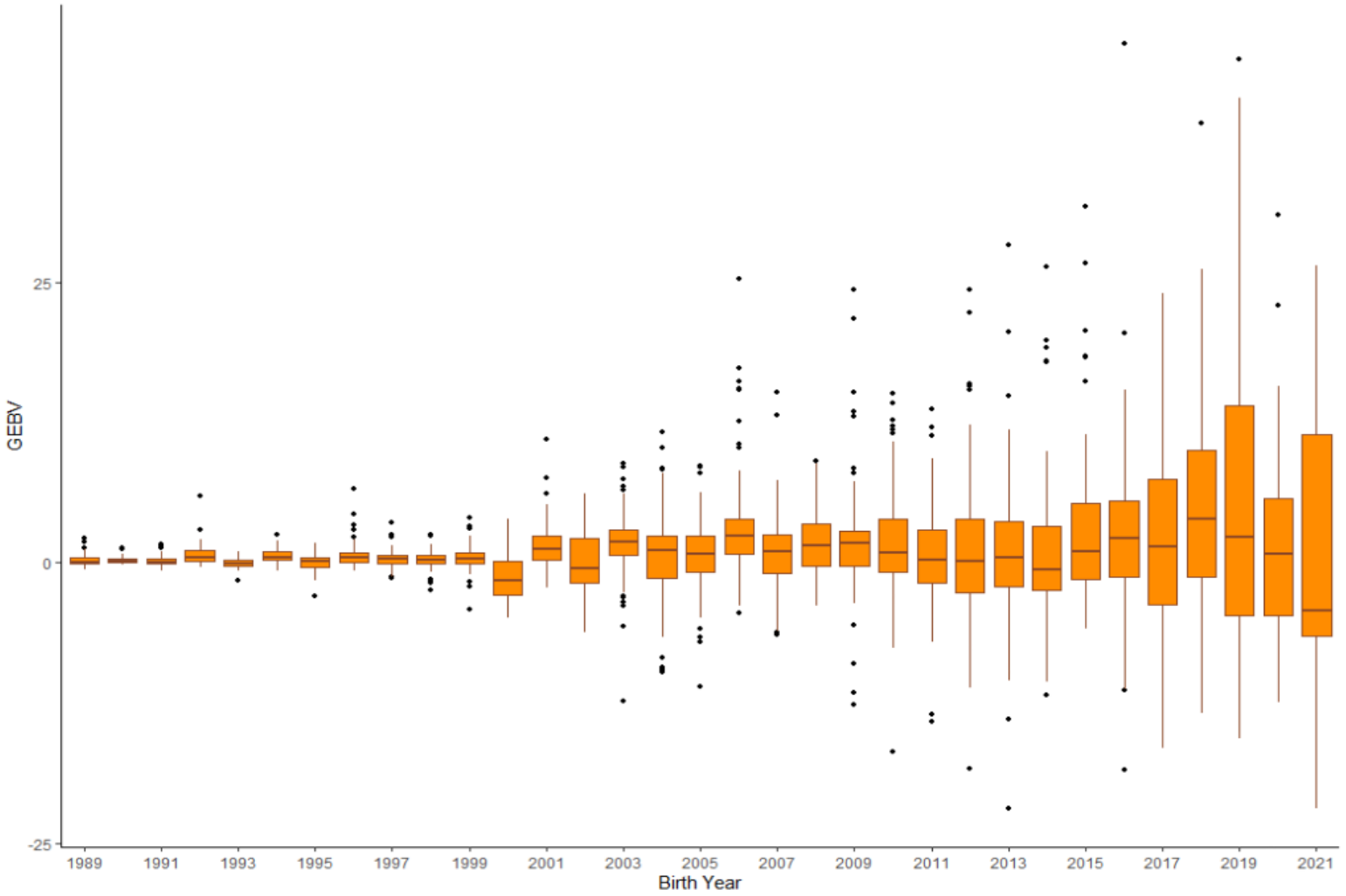
$N_{ewes\_phenotypes}$= 3,040

$N_{ewes\_genotypes}$= 293

Variable	Sum of square	P-value
Lactation Number	0.34	0.56
Lambing age	7.62	**0.006**
Gestation length	3.31	0.07
Fat percentage	3.62	0.052

Heritability	Standard error
0.19	0.13

Preliminary results – GEBV for total milk yield



Estimated genomic breeding value for total milk yield in Cyprus Chios sheep

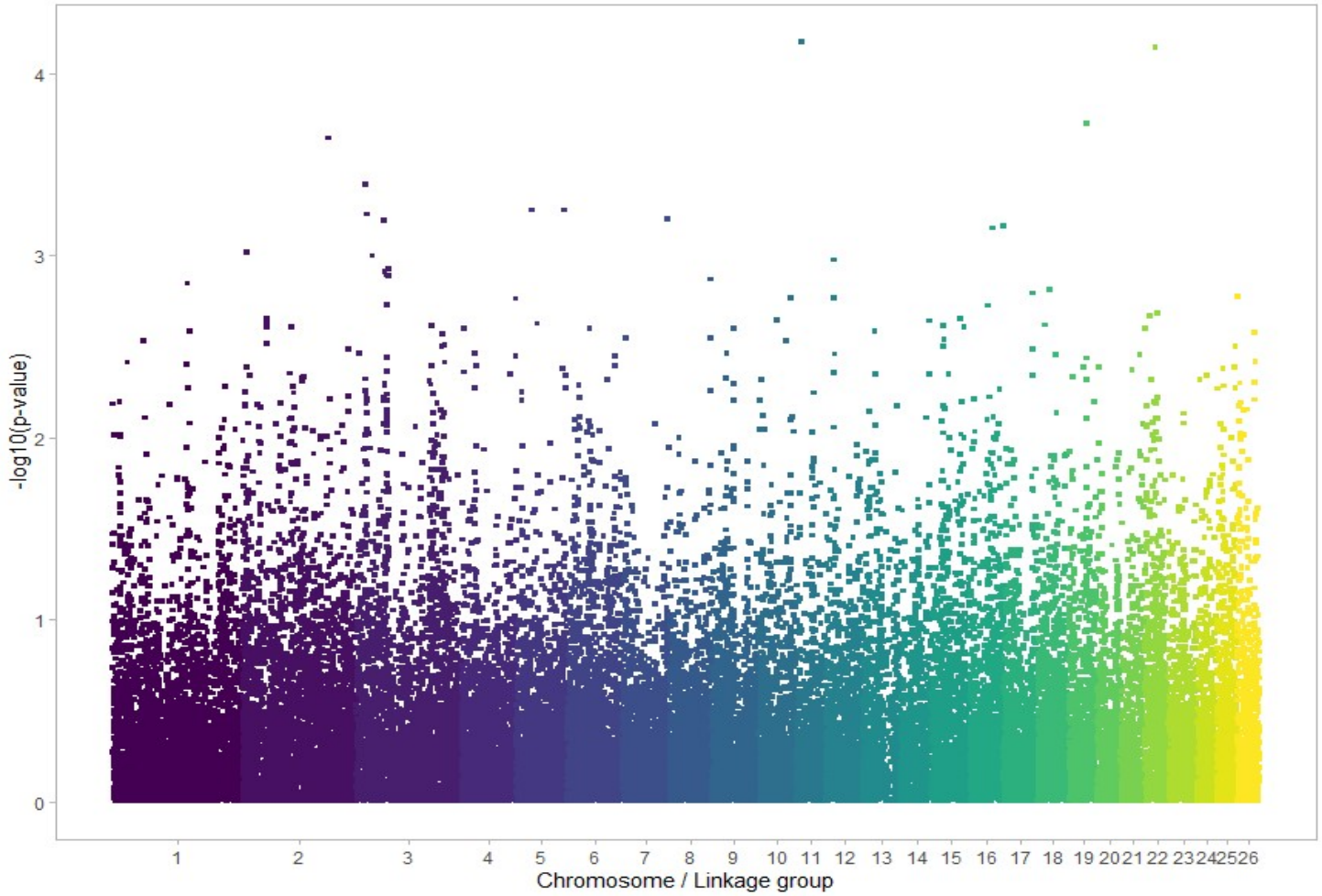
Preliminary results
GWAS analysis for total milk yield

N_{ewes}= 287

Chr: Position	MAF	Effect	SE	P-value
2:197417307	0.13	-40.60	10.26	$2.3x10^{-4}$
3:21980068	0.30	-24.41	6.47	$4.1x10^{-4}$
11:10177509	0.07	87.22	20.17	$6.8x10^{-5}$
19:41862754	0.11	-68.17	16.98	$1.9x10^{-4}$
22:24014440	0.19	-59.16	13.74	$7.2x10^{-5}$

*Note: there were not detected any genome wide associated SNPs with milk performance. We used a more lenient p-value (<$1x10^{-4}$).

Preliminary results – GWAS for total milk yield



Manhattan plot of genome-wide association analysis of total milk yield in Chios sheep

Summary

- BLUP and GBLUP methods will enable the better genetic improvement of Cyprus Chios sheep.
- This is the first preliminary GWAS study conducted for milk traits in Cyprus Chios sheep.
- With sufficient number of genotype information, GWAS analysis will enable the identification of GWA SNPs for milk performance traits.

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