From genotyping to mating plan: application of genomic data in future breeding programs of Istrian goat

M. Špehar[1], J. Ramljak[2], G. Šubara [3], E. Šuran [3], Z. Barać [4], A. Kasap[2]

[1] Croatian Agency for Agriculture and Food, Svetošimunska cesta 25, 10000 Zagreb, Croatia
[2] University of Zagreb, Faculty of Agriculture, Department of Animal Science and Technology, Svetošimunska 25, 10000 Zagreb, Croatia
[3] Agency for Rural Development of Istria (AZRRI)
[4] Croatian Association of Sheep and Goat Breeders

Breeding program for Istrian goat

HAPIH Hrvatska agencija za poljoprivredu i hranu | Croatian Agency for Agriculture and Food

Tablica 31. Pasminski sastav uzgojno valjanih koza
Breed structure of herdbook goats

Pasmina	2024. Grla Heads	2024. Uzgajivači Breeders	2025. Koze Does	2025. Jarica Yearlings	2025. Jarčevi Bucks	2025. Sva grla All heads	2025. Uzgajivači Breeders
Alpina	4.166	36	2.813	758	89	3.660	33
Sanska	621	8	463	141	28	632	8
Burska koza	41	3	33	0	4	37	3
Hrvatska bijela koza	297	7	226	56	13	295	6
Hrvatska šarena koza	2.144	23	1.608	441	74	2.123	22
Istarska koza	173	8	146	67	8	221	9
Murciano-Granadina	55	2	9	2	3	14	2
Sve / All	**7.497**	**87**	**5.298**	**1.465**	**219**	**6.982**	**83**

Izvor / *Source*: HAPIH

Tablica 34. Brojčani pokazatelji istarske koze
The numerical indicators in Istrian breed

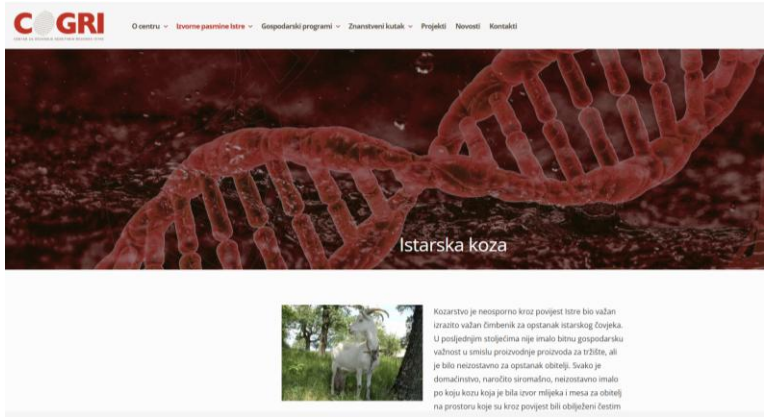
Istarska koza	**2025.**
Ugojno valjana grla / Herdbook goats	221
Uzgajivači / Breeders	9
Prosječna veličina stada / Average herd size	25

Izvor / *Source*: HAPIH





AZRRI agencija za ruralni razvoj Istre



https://www.hapih.hr/wp-content/uploads/2026/06/Ovcarstvo-kozarstvo-i-male-zivotinje-Godisnje-2025-1.pdf

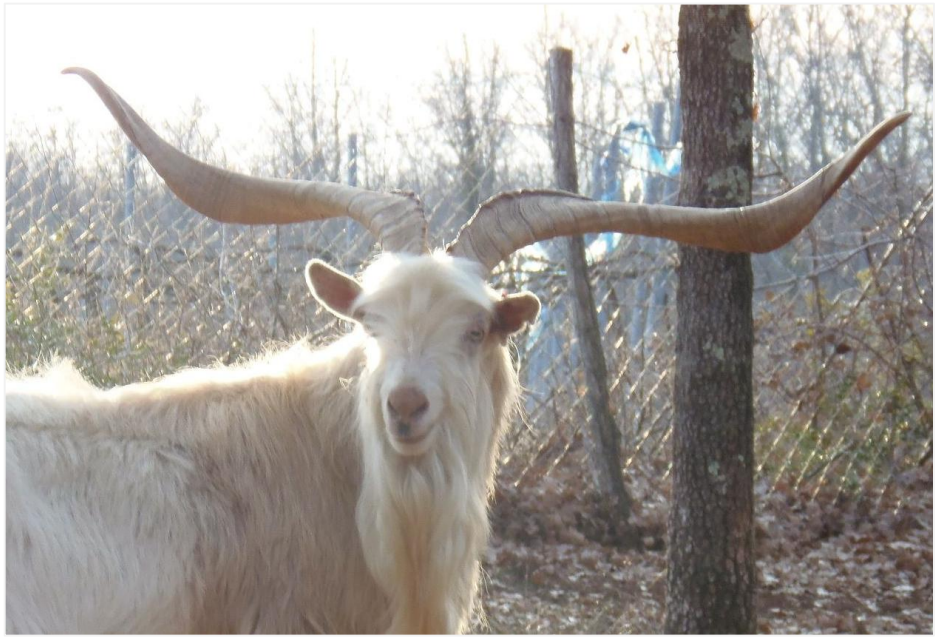
https://www.ovce-koze.hr/ovcarstvo-kozarstvo/ovcarstvo-i-kozarstvo-u-rh/kozarstvo-u-rh/pasmine-koza/istarska-koza/

https://cogri.azrri.hr/hr/izvorne-pasmine-istre/o-istarskim-autohtonim-pasminama/istarska-koza/

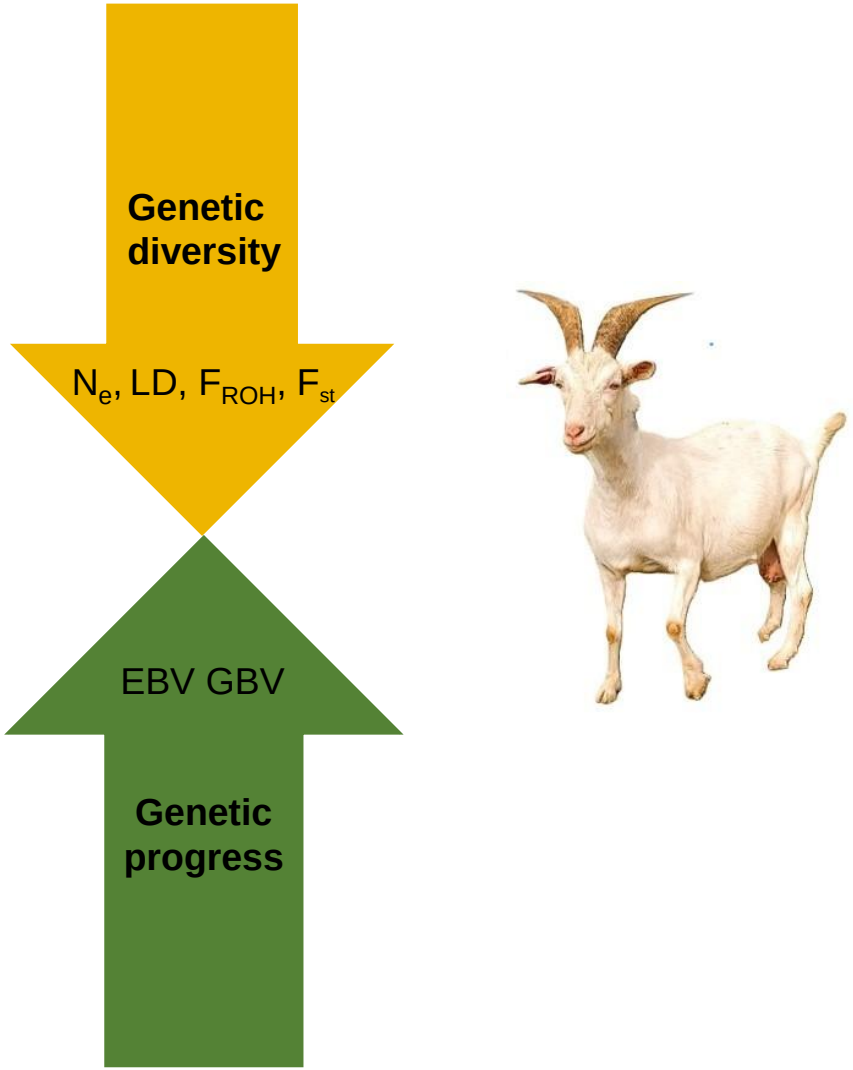
State of art

- Breeding program
- Challenges
- Solutions



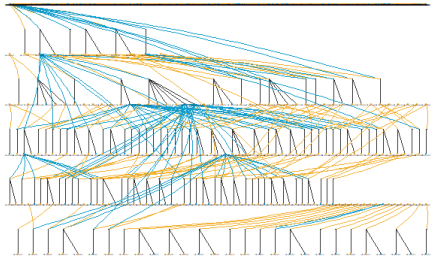


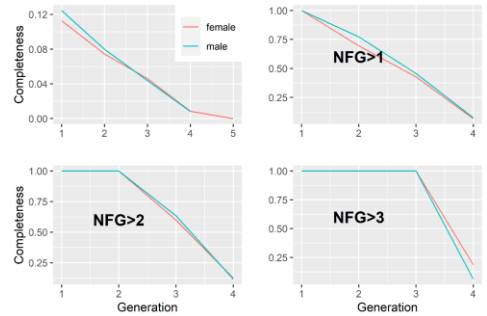
How to upgrade breeding program?



Challenges

- Lack of **pedigree records**
  - (Un)informative pedigree
- Lack of **phenotypic records**
  - Limited number

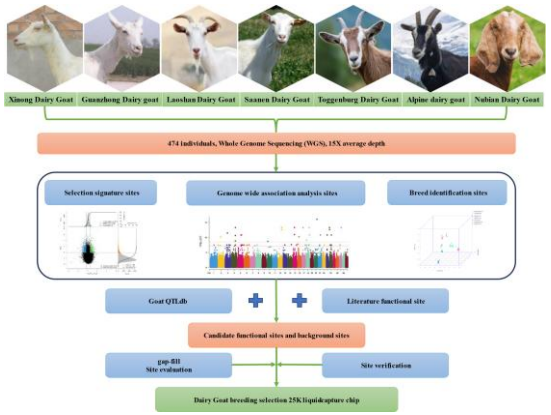


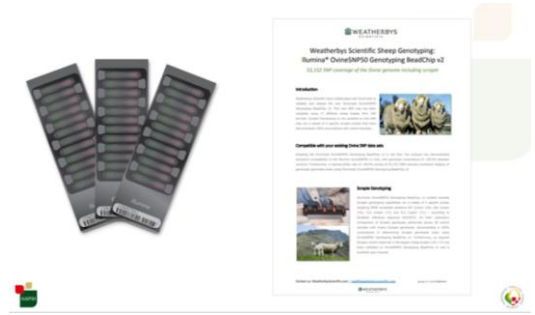


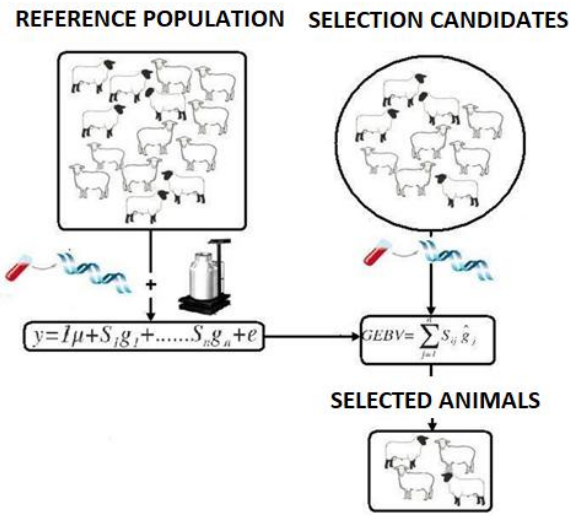


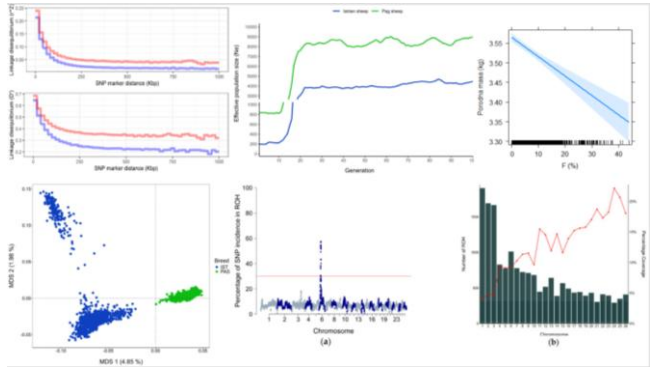
Challenges

- How to select & breed
- Genomics
  - Better selection decisions?









Genotyping (financing)



- Agency for Rural Development of Istria (AZRRI)
  - **312 genotyped animals**
    - 60 males, 252 females

- *Genomic characterization, preservation, and optimum contribution selection of Croatian dairy sheep (OPTI-SHEEP)*
- *Integration of genomic selection into the existing system of genetic evaluation of dairy goats (GEN-UP GOAT)*
- *Support for conservation, sustainable use and development of genetic resources in agriculture (SubMeasure 70.05.)*
- **Increasing sheep herd heat resistance score by developing and implementing selection index towards higher individual heat resistance (SheepHeatIT)**

Why genomics?

- Genomic selection

  → Accuracy
- Finding pedigree errors

  → Reconstruction
- Better estimation of relationship

  → Genetic parameters
- Conservation

  → Mating





Genetic parameters



Inbreeding (F_{ROH}) & genetic variability

N	N_{ROH}	F_{ROH1_2}	F_{ROH2_4}	F_{ROH4_8}	F_{ROH8_16}	**$F_{ROH>16}$**	**F_{ROH}**	Het(%)
214	3119	0.03	0.43	0.92	1.57	**4.37**	**7.31**	39.88

1) F_{ROH} (~7.3%) → **High genomic inbreeding**

2) $F_{ROH>16}$ (~4.4%)→ **Prevalence of recent inbreeding**

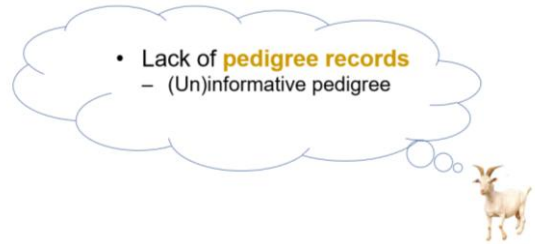
3) Het (~40%)→ **Moderately low heterozygosity**

Prevalence of recent inbreeding

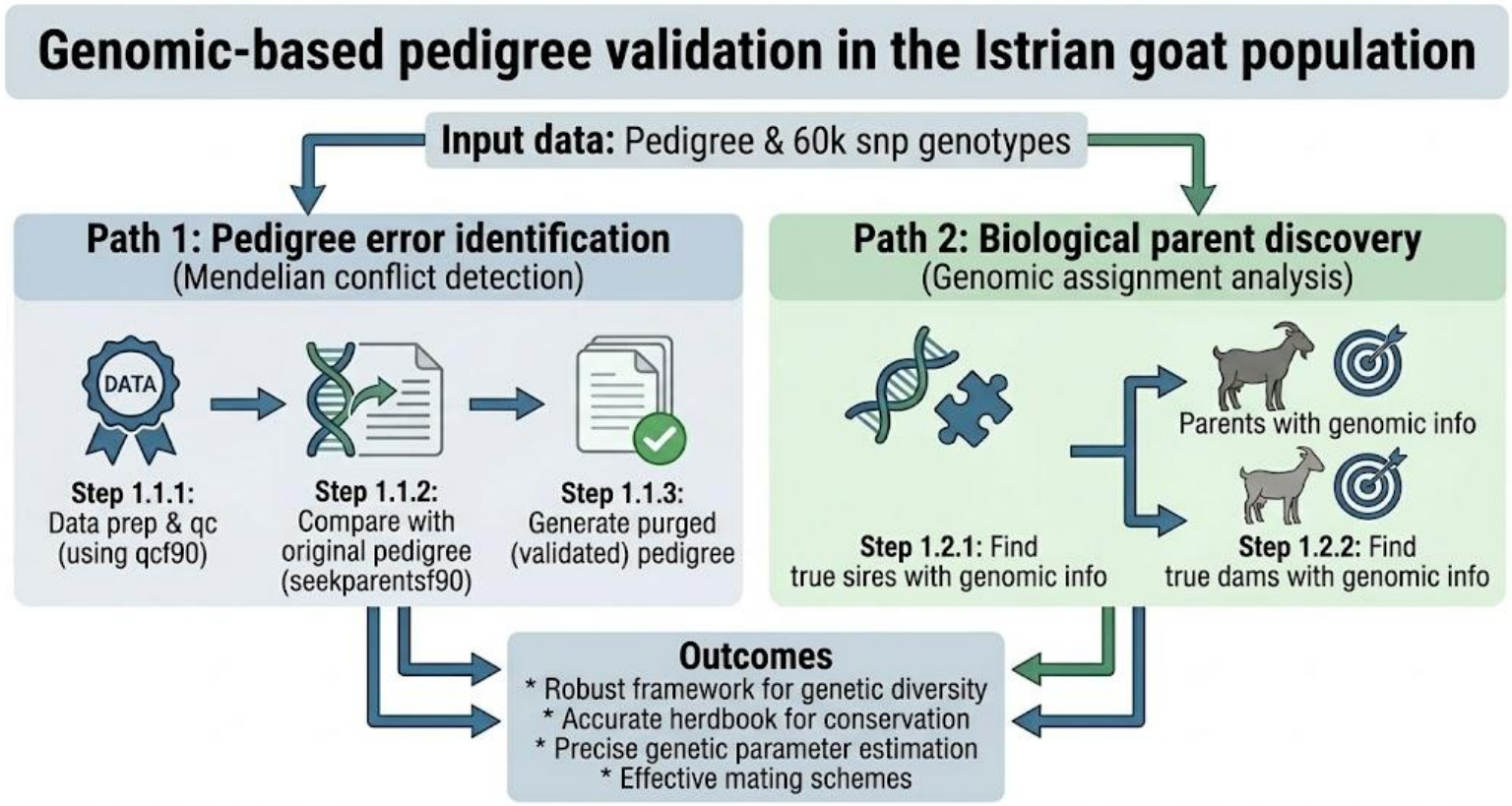
- Elevated risk of expressing deleterious recessive alleles
- Reduced adaptive potential (environment/diseases)

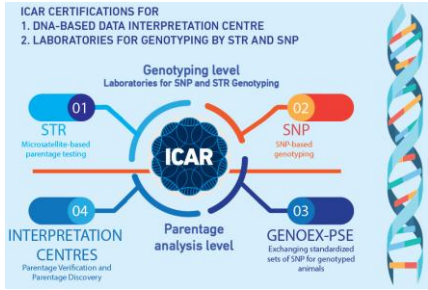
Conservation strategy (avoidance of mating highly related individuals to mitigate further increases in homozygosity)

Inconsistencies in the pedigree



- If the pedigree lies, the **DNA does not**





Results

- **Genotyping:** 307 individuals (60K & 80K SNP)
  - 5 animals with low call rate < 0.90

- **Validation Sample**
  - Sire-progeny tested
  - Dam-progeny tested: 211

- **Filtering Thresholds (Mendelian conflicts)**
  - > 1.0% MC to exclude false parents
  - < 0.5% MC to assign true parents (pedigree reconstruction)

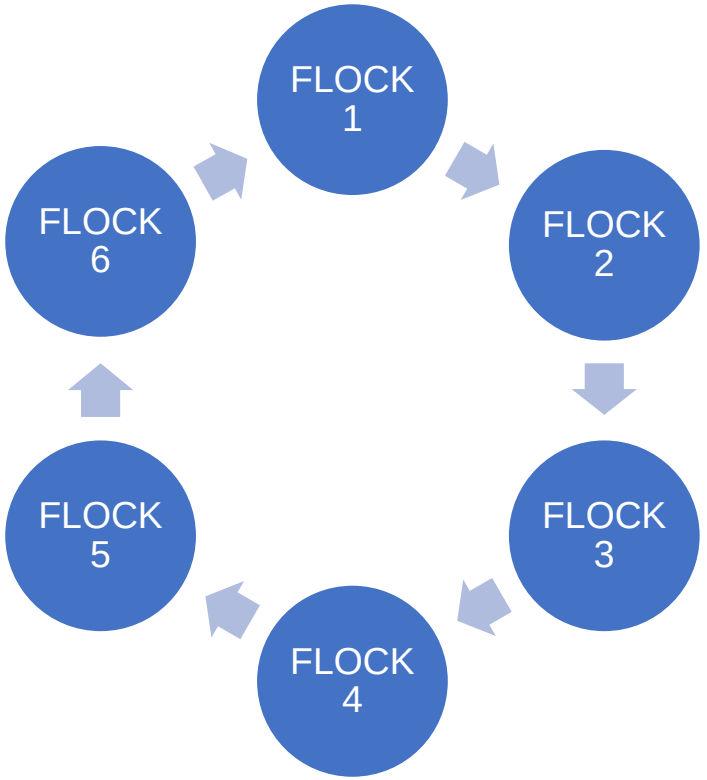
- **Discovered error rates**
  - Paternity error: 11.6% (18/155)
  - Maternity error: 18.5% (39/211)

- **Pedigree correction:** Successfully identified and assigned
  - 16 sires
  - 25 dams

Mating plan

GENOTYPING
(60-80K SNPs)

(*in situ conservation*)



Genomic relationship
ALL INDIVIDUALS





BUCKS ←→ DOES (herd-wise)

Genomic relationship between bucks and does (herd-wise)

HERD (owner)	BUCK 1	BUCK 2	BUCK 3	BUCK 4	BUCK 5
Bencic	HR440064895 (Trento) [-0.1466]	HR740499202 (Trento) [-0.1443]	HR940297789 (Pavlakovic) [-0.115]	HR640499201 (Trento) [-0.0962]	HR440500131 (Brcic) [-0.091]
Brcic	HR440500131 (Brcic) [-0.1091]	HR440064895 (Trento) [-0.1066]	HR940484916 (Ruzic) [-0.0697]	HR740499202 (Trento) [-0.0509]	HR640499201 (Trento) [-0.0502]
Buic	HR940484940 (Buic) [-0.0855]	HR240484942 (Buic) [-0.075]	HR940297789 (Pavlakovic) [-0.0744]	HR840484873 (Jelenkovic) [-0.0302]	HR140484999 (Solic) [-0.0091]
Jelenkovic	HR440297784 (Solic) [-0.0529]	HR440297917 (Solic) [-0.0489]	HR840484873 (Jelenkovic) [-0.0463]	HR440499216 (Jelenkovic) [-0.045]	HR140484999 (Solic) [-0.0433]
Milohanic	HR440064895 (Trento) [-0.0989]	HR140294192 (Milohanic) [-0.0875]	HR840499013 (Milohanic) [-0.0639]	HR540294221 (AZRRI) [-0.0307]	HR440500131 (Brcic) [-0.0222]
Pavlakovic	HR940297789 (Pavlakovic) [-0.1468]	HR540294221 (AZRRI) [-0.1462]	HR240484942 (Buic) [-0.1026]	HR940484940 (Buic) [-0.0962]	HR440297784 (Solic) [-0.0844]
Ruzic	HR940484916 (Ruzic) [-0.2676]	HR440500131 (Brcic) [-0.0516]	HR440064895 (Trento) [-0.0033]	HR640499201 (Trento) [0.0184]	HR740499202 (Trento) [0.0195]
Solic	HR440297917 (Solic) [-0.2545]	HR640484962 (Solic) [-0.203]	HR140484999 (Solic) [-0.1182]	HR440499216 (Jelenkovic) [-0.0631]	HR540294221 (AZRRI) [-0.0362]
Sverko	HR940297789 (Pavlakovic) [-0.0989]	HR440064895 (Trento) [-0.0704]	HR440500131 (Brcic) [-0.0422]	HR740499202 (Trento) [-0.0401]	HR640499201 (Trento) [-0.0327]
Trento	HR440297917 (Solic) [-0.0263]	HR640484962 (Solic) [-0.0235]	HR140484999 (Solic) [0.0022]	HR640499201 (Trento) [0.0023]	HR740499202 (Trento) [0.0094]

Genetic evaluation

- Phenotyping (ICAR standards)
- Genetic evaluation (BLUP)
- Repeatability animal model

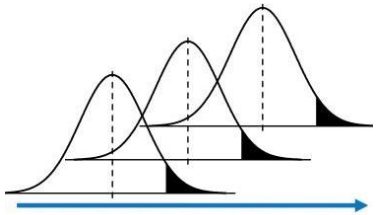


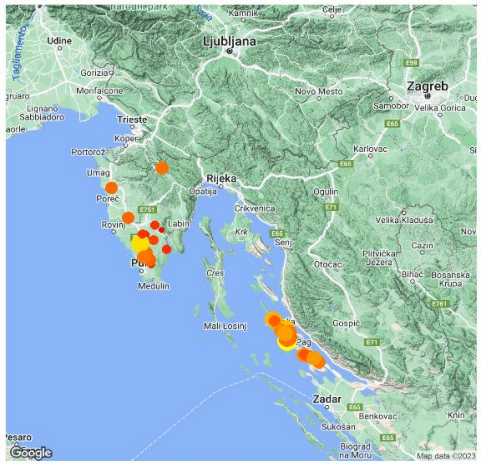



$$\begin{bmatrix} \hat{\mathbf{b}} \\ \hat{\mathbf{a}} \\ \hat{\mathbf{pe}} \end{bmatrix} = \begin{bmatrix} \mathbf{X}'\mathbf{X} & \mathbf{X}'\mathbf{Z} & \mathbf{X}'\mathbf{W} \\ \mathbf{Z}'\mathbf{X} & \mathbf{Z}'\mathbf{Z} + \mathbf{A}^{-1}\alpha_1 & \mathbf{Z}'\mathbf{W} \\ \mathbf{W}'\mathbf{X} & \mathbf{W}'\mathbf{Z} & \mathbf{W}'\mathbf{W} + \mathbf{I}\alpha_2 \end{bmatrix}^{-1} \begin{bmatrix} \mathbf{X}'\mathbf{y} \\ \mathbf{Z}'\mathbf{y} \\ \mathbf{W}'\mathbf{y} \end{bmatrix}$$

$$\mathbf{H} = \begin{bmatrix} \mathbf{H}_{11} & \mathbf{H}_{12} \\ \mathbf{H}_{21} & \mathbf{H}_{22} \end{bmatrix} = \begin{bmatrix} \mathbf{A}_{11} + \mathbf{A}_{12}\mathbf{A}_{22}^{-1}(\mathbf{G} - \mathbf{A}_{22})\mathbf{A}_{22}^{-1}\mathbf{A}_{21} & \mathbf{A}_{12}\mathbf{A}_{22}^{-1}\mathbf{G} \\ \mathbf{G}\mathbf{A}_{22}^{-1}\mathbf{A}_{21} & \mathbf{G} \end{bmatrix}$$

OCS







Breeders

Croatian Agency for Agriculture and Food

Croatian Association of Sheep ang Goat Breeders

Faculty of Agriculture, Department of Animal Science and Technology

Agency for Rural Development of Istria Region

Regular communication with breeders (field work)










Regular communication with breeders (field work)













SheepHeatIT

Funded by
the European Union



WHAT IS SHEEPHEATIT?

SheepHeatIT is an international research and innovation project funded through Horizon Europe.

The project aims to create practical solutions for heat-resilient sheep farming by combining:

- Animal genetics
- Genomics
- Information technologies
- Multi-omics science
- Breeding innovation

The project will generate one of the largest international datasets on heat resilience in sheep, covering:

~18,000 animals | **24 breeds** | **8 geographic regions**

WHY IS SHEEPHEATIT NEEDED?

Climate change is becoming one of the biggest threats to global livestock production. Rising temperatures and more frequent heatwaves directly affect sheep health, fertility, growth, milk production, and survival.

Traditional cooling infrastructure is often expensive, inaccessible, or unsustainable for many farming systems. Farmers need long-term solutions that allow sheep to naturally adapt to hotter environments.

SheepHeatIT responds to this challenge through innovative breeding technologies and digital tools designed specifically for future climate conditions.

Funded by the European Union

COORDINATOR

Yehoshav Ben Meir, Ph.D
Researcher, Cattle and Sheep Research
The Agricultural Research Organisation of Israel – Volcani Centre
yehoshav@volcani.agri.gov.il

PROJECT PARTNERS

IN-KIND CONTRIBUTIONS

SheepHeatIT

Harnessing Information Technologies for Heat Resilient Sheep Breeding

Breeding climate-resilient sheep for a sustainable future.



sheepheatit.eu

Conclusion

- Implemented **mating strategies** should minimize inbreeding and further loss of genetic diversity
- Performance recording that has been initiated should establish a foundation for future selection
- Long-term selection strategy should rely on **OCS** in order to provide selection gain with minimal loss of genetic variability

- Obstacles - tourism, lack of agricultural land