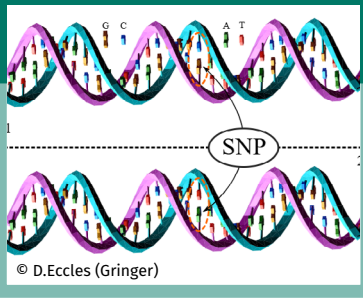
Technical Sheet for Solution Implementation

SNP (Single Nucleotide Polymorphisms) Genotyping



© D.Eccles (Gringer)

Thematic Area: Health and Welfare.

Priority: What practices can be implemented to promote biosecurity measures and prevent emergent diseases?

Need: Health of breeding horses: what are the solutions to improve the quality of breeding horses? (use of healthy horses with good temperament only; elimination of individuals with genetic disorders and diseases; good physical condition is also required).

Solution EU Number: HE-06.

Content of the Solution: SNP-based genotyping to support breeding decisions in horses.

Key Contacts:
- Breeding association, laboratories.

Reasons for Implementing this Solution

SNP genotyping provides an accurate, DNA-based method to evaluate breeding equines, enabling informed decisions and early detection of genetic risks, heritable diseases, or undesirable traits. Establishing this method on a breeding farm improves the efficiency, health, and sustainability of the breeding program.

Description of Solution Strategies

SNP genotyping (Single Nucleotide Polymorphism genotyping) is a modern molecular genetic technique that enables a highly detailed and reliable characterization of the equine genome. It allows the identification of genetic variation at thousands to hundreds of thousands of specific points on the chromosomes, helping breeders and researchers to understand individual genetic profiles in unprecedented detail. While traditionally reserved for research, SNP genotyping has become increasingly accessible and is now being used routinely in equine breeding programs across several countries to realize parentage verification.

Use of SNP Genotyping in Equine Breeding

SNP genotyping helps breeders make informed decisions based on objective, DNA-level information. It allows for the identification of carriers of inherited diseases, the detection of valuable traits, and better control of genetic diversity in breeding populations. Genotypic data supports parentage verification, individual identification, and the early estimation of breeding potential — even before performance testing or offspring data are available. In the long term, the integration of genomic data into breeding programs enhances selection accuracy and the sustainability of equine populations.

SNP (Single Nucleotide Polymorphisms) Genotyping

Methodology of SNP Genotyping in Horses

The process begins with the collection of biological material — usually hair root samples or blood — from the horse, pony or donkey. DNA is extracted and applied to a genotyping chip (SNP array), which scans thousands to hundreds of thousands of SNPs across the genome. The precision depends on the chip used: common platforms include arrays with 10,000, 50,000, 70,000 or up to 670,000 SNPs. Some platforms even allow whole-genome characterization. Laboratories then analyze the data bioinformatically, assigning genotypes (e.g., AA, AG, GG) to each SNP location and interpreting them in relation to known traits, mutations, or population patterns. This method detects both functional variants (e.g. in performance or disease genes) and neutral variants, which are useful for genetic diversity analysis. As the cost of high-density chips decreases, SNP genotyping is becoming more cost-effective for practical use on breeding farms.

Until recently, microsatellite genotyping (using ~14 STR markers) was the standard for identification and parentage verification in horses. This method, regulated by ISAG (International Society for Animal Genetics), is still widely used. However, SNP genotyping offers several advantages:

FEATURE	MICROSATELLITES (STR)	SNP GENOTYPING
Number of markers	~14	150 to >600,000
Accuracy	Moderate	Very high
Automation & scalability	Limited	Highly automated
Data reuse potential	Low	High (used for multiple analyses)
Genomic selection compatibility	Not possible	Fully supported

SNP (Single Nucleotide Polymorphisms) Genotyping

Applications of SNP in Genotyping in Equine Breeding

SNP genotyping has multiple practical uses in modern horse breeding:

1. **Parentage and Identity Verification**
   More accurate than traditional STRs, SNPs ensure reliable identification and pedigree control.
2. **Health and Trait Testing**
   Detection of inherited diseases (e.g. PSSM1, WFFS) and important traits like gait ability (DMRT3), muscle type (MSTN), or coat color genes.
3. **Genomic Breeding Values (gEBVs)**
   Enables early and precise estimation of genetic potential, even before performance data is available.
4. **Managing Genetic Diversity**
   Calculation of real genomic inbreeding and better population management.
5. **Optimized Mating Decisions**
   Helps avoid risk matings and improves selection efficiency by combining genomic and phenotypic data.

SNP Genotyping Services

Several laboratories or organisations in Europe and worldwide offer SNP genotyping for horses, including:

- Laboklin (Germany).
- Van Haeringen Laboratorium (Netherlands).
- UC Davis Veterinary Genetics Laboratory (USA).
- Various national breeding associations and labs.

Breeders should consult their studbook or national breeding organization to ensure compatibility with official programs and national databases.

SNP (Single Nucleotide Polymorphisms) Genotyping

Implementation Steps

The implementation steps will depend on the actual process of DNA control of your breeding association in your country.
If your breeding association is using SNP technology, follow their implementation steps. If not you can follow the following ones:

1. **Gather Information & Seek Advice**
   - Contact breeding associations, veterinary geneticists, or specialized laboratories.
   - Clarify which SNP chips or specific genetic markers are relevant for your breed and breeding goals.
2. **Organize Sample Collection**
   - Select appropriate horses (e.g., breeding stock, young horses).
   - Collect hair root or blood samples according to the laboratory's guidelines.
3. **Submit Samples for Genotyping**
   - Send samples to an accredited genetic testing lab.
   - Choose the desired level of analysis (basic SNP profile, genomic breeding values (if possible), trait-specific tests).
4. **Interpretation of Results**
   - Discuss results with a breeding advisor or veterinarian.
   - Analyze SNP profiles in the context of breeding strategy and genetic diversity.
5. **Adapt Breeding Decisions**
   - Select breeding animals based on genetic values and disease markers.
   - Exclude carriers of harmful recessive traits from breeding.
   - Optimize pairings to reduce inbreeding and target desired genetic traits.
6. **Long-term Data Use & Integration**
   - Store SNP data for future analyses (parentage testing or reading of other information).
   - Integrate genotyping results with performance, conformation, and pedigree data.

SNP (Single Nucleotide Polymorphisms) Genotyping

How Will this Solution Impact the Performance of your Farm ?

TOPIC	SCORE
Social	1.00
Economics	1.25
Welfare	1.00
Health	2.00
Environmental	0
Land access and management	0
Global	0.88

Socioeconomics: This solution will support the social performance of the farm because it promotes responsible breeding practices, improves animal health, and enhances public perception by contributing to the management of genetic variability and reduction of hereditary disorders.

This solution will support the economic performance of the farm because it enables more strategic breeding decisions that can reduce long-term veterinary costs and increase the commercial value of foals—though these gains depend on careful planning to offset the additional costs of genetic testing.

Health & Welfare: This solution will enhance the health performance of the farm, particularly breeding operations, by potentially providing certification for genetically transmitted diseases. It will also support the welfare performance of the farm by promoting the breeding of healthier horses and reducing animal suffering.

SNP (Single Nucleotide Polymorphisms) Genotyping

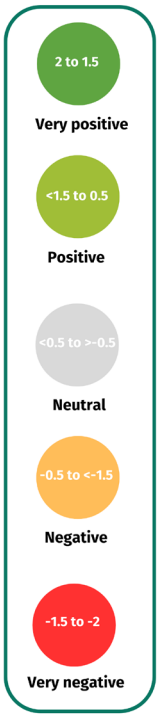
How Will this Solution Impact the Performance of your Farm ?

Environmental Sustainability: This solution has a neutral effect on farm performance related to environmental sustainability and grassland management. However, this solution has different counter-effects, which is why the overall effectiveness is neutral. Positive effects include SNP help to manage biodiversity within a breed and can help to protect endangered breeds. With genomics we could choose individuals that would adapt better to extreme weather. Negative effects include increased energy consumption due to large data generated and which is stored, and increased use of water to be able to cool down the servers. In addition, there is a risk of increased loss of biodiversity, if selection moves too much towards 'sports only' performance criteria.

Globally, this solution will support the performance of the farm.

How Will this Solution Impact the Resilience of your Farm?

TOPIC	SCORE
Social	0.50
Economics	0.46
Welfare	0.17
Health	1.25
Environmental	0.06
Land access and management	0
Global	0.41



SNP (Single Nucleotide Polymorphisms) Genotyping

How Will this Solution Impact the Resilience of your Farm?

Socioeconomics: This solution will support social performance of the farm facing external challenges assessed because it promotes responsible breeding, improves animal welfare, and contributes to biodiversity management—qualities valued by the public and sector stakeholders, while also fostering resilience through healthier, more manageable horses during crises.

This solution will not impact economic performance of the farm facing external challenges assessed because the potential long-term savings in veterinary care and maintenance are counterbalanced by recurring genotyping costs and limited short-term financial returns.

Health & Welfare: This solution will significantly enhance the health performance of the farm when facing external challenges. By reducing pain and fatal outcomes related to genetic diseases, and minimizing treatment side effects, horses are likely to remain healthier for longer. With improved animal health, the farm can more effectively allocate resources to manage other external pressures.

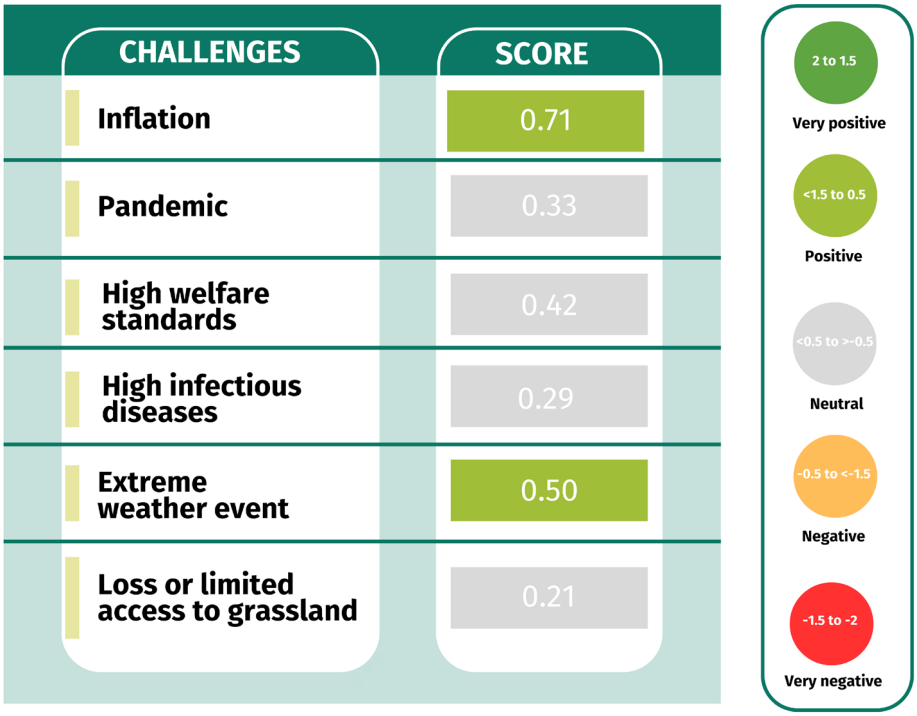
The solution will also have a modest positive impact on welfare performance by supporting positive emotional states in healthy horses. This is achieved through the prevention of discomfort associated with genetic conditions. Maintaining disease-free animals allows the farm to focus more efficiently on other operational challenges.

Environmental Sustainability: This solution has neutral effect on resilience related to environmental sustainability and land access /grassland management.

So globally, facing the following external challenges, this solution can help to support social and health performance.

SNP (Single Nucleotide Polymorphisms) Genotyping

How Can this Solution Help your Farm Cope with Specific External Challenges to Become More Resilient?



Inflation & Social Crises: This solution will support the global performance of the farm facing inflation because genetic selection contributes to long-term cost reduction by improving horse health and reducing veterinary expenses, while also increasing the commercial value of animals and production efficiency; although annual genotyping may raise short-term costs, this is offset by more strategic breeding and indirect environmental benefits managed at the breed level, such as biodiversity preservation.

This solution will not impact the global performance of the farm, in the short term, facing pandemics because it does not directly influence daily operations, animal care, or labor availability—key challenges during such crises—though in the long term, it may support resilience by enabling farmers to reduce herd size and focus on breeding more robust, resource-efficient horses better suited to constrained conditions.

Welfare & Diseases: This solution will have a modest impact on the global performance of the farm in the face of infectious disease outbreaks. However, it supports animal health and enhances horses' overall resistance to other health issues, thereby reducing the need for medication and associated costs.

SNP (Single Nucleotide Polymorphisms) Genotyping

How Can this Solution Help your Farm Cope with Specific External Challenges to Become More Resilient?

Welfare & Diseases:
Although this solution is related to health and may have some environmental benefits, it does not significantly contribute to the farm's global performance in adapting to high welfare standards. This is likely due to the relatively low prevalence of genetic diseases in the general horse population, and genetic testing may not be considered as a tool for meeting high welfare requirements.

Climate Change & Access to Land: This solution has a positive effect on farms' ability to recover from abnormally high temperatures and drought. Currently the effect is somewhat neutral but in the future, it could be positive if we identify genes of resilience related to high temperatures, for instance. Genomics has been used in bovines to find tick/mosquito resistant breeds. Similar analysis could be done within the equine population.

So in short term perspective, this solution can help the farm to be more resilient in case of inflation and in long term perspective, thanks to research we can hope that some genes will be identified to help equines to be more resilient in case of high infectious diseases or extreme weather even.

SNP (Single Nucleotide Polymorphisms) Genotyping

Cost-Benefit Analysis

Costs

Socioeconomics:

- **Genotyping fees per horse** (depending on chip density): Initial investment, particularly for larger herds.
- **Commercial risks:** If genotyping reveals unfavorable traits, saleability or stud value may decrease.
- **Training requirement:** Some breeders may need education or guidance to interpret results correctly.
- **Data handling:** Risk of misinterpretation or over-interpretation of results by untrained individuals.
- **Privacy vs. transparency:** Full disclosure of negative findings (e.g. genetic disorders) might be resisted by some breeders.
- Withholding genetic information could raise **ethical or legal concerns,** especially for breeding animals.

Benefits

- **Cost-effective in the long term:** Reduces losses from genetically unfit equines and poor matings.
- **Transparency for clients:** Buyers can better assess genetic quality before purchasing.
- **Data-driven marketing:** Breeders can tailor commercial strategies based on individual horses' genetic profiles.
- **Bundled information:** One sample provides insights into parentage, disease risk, performance potential, etc., reducing vet visits and repeated sampling.
- **Enhanced competitiveness:** Breeders with SNP-typed horses/donkeys may gain **market credibility** and international access.
- **Valuable for Research & Development:** Genotyped populations enable **research into new traits,** aiding breed development.

Health & Welfare:

- No significant direct costs in terms of animal welfare (non-invasive procedure).

- **Earlier detection** of inherited diseases, even in foals.
- **Improved animal health:** Genomic data supports **preventive care**, including veterinary planning (e.g., allergy risk, metabolic predisposition).
- Reduces the inheritance of diseases such as WFFS or PSSM1.
- Supports **breeding of healthier and more suitable animals,** decreasing reliance on medication or treatments.
- Aligns with modern welfare standards by minimizing avoidable suffering.

SNP (Single Nucleotide Polymorphisms) Genotyping

Cost-Benefit Analysis

Costs

Environmental Sustainability:

- **Data processing infrastructure** (servers, storage) has some environmental footprint – however, considered **negligible** in the context of a breeding program.

Cooperation between farms:

- Concerns around **data ownership** and **information sharing** may lead to reluctance in collaboration.
- If SNP results are made public by studbooks, breeders might fear competitive disadvantages.

Benefits

- **Fewer wasted resources** on raising unfit or unsellable horses/donkeys.
- **Genomic selection**: Healthier animals require **fewer interventions**, reducing chemical and medical input.
- Can contribute to **wild horse management** by improving inbreeding control and maintaining genetic diversity.

- **Shared genomic databases** foster better **stallion sharing and selection**.
- Facilitates **cross-breeding strategies,** rare allele preservation, and collaborative conservation.
- **Genomic breeding value estimation (gEBVs)** makes performance prediction possible even across farms and countries.
- **DNA "identity cards"** allow consistent identification, planning, and transparency between breeders and owners.

SNP (Single Nucleotide Polymorphisms) Genotyping

Additional Resources

Websites

- https://www.eurofins.com/genomic-services/our-services/genotyping-gene-expression

Publications

- Blott, S.C., Swinburne, J.E., Sibbons, C. et al. A genome-wide association study demonstrates significant genetic variation for fracture risk in Thoroughbred racehorses. BMC Genomics 15, 147 (2014). https://doi.org/10.1186/1471-2164-15-147
- Haberland, A. M., König von Borstel, U., Simianer, H., & König, S. (2012). Integration of genomic information into sport horse breeding programs for optimization of accuracy of selection. Animal : an international journal of animal bioscience, 6(9), 1369–1376. https://doi.org/10.1017/S1751731112000626
- McCue, M. E., Bannasch, D. L., Petersen, J. L., Gurr, J., Bailey, E., Binns, M. M., Distl, O., Guérin, G., Hasegawa, T., Hill, E. W., Leeb, T., Lindgren, G., Penedo, M. C., Røed, K. H., Ryder, O. A., Swinburne, J. E., Tozaki, T., Valberg, S. J., Vaudin, M., Lindblad-Toh, K., ... Mickelson, J. R. (2012). A high density SNP array for the domestic horse and extant Perissodactyla: utility for association mapping, genetic diversity, and phylogeny studies. PLoS genetics, 8(1), e1002451. https://doi.org/10.1371/journal.pgen.1002451
- Schaefer, R.J., Schubert, M., Bailey, E. et al. Developing a 670k genotyping array to tag ~2M SNPs across 24 horse breeds. BMC Genomics 18, 565 (2017). https://doi.org/10.1186/s12864-017-3943-8

Model Companies

- https://www.neogen.com/de/categories/parentage/equine-snp-parentage

Funded by the European Union

This project has received funding from the European Union under Grant Agreement No. 101086551.

Technical Sheet for Solution Implementation

SNP (Single Nucleotide Polymorphisms) Genotyping

Annex

Ideas to Ideas to Animate a Workshop about the Solution

- Invite a **breeding association, genetics laboratory, or biotech company** (e.g. SNP chip or breeding software provider) to sponsor the event.
- Find a **model farm or stud** already using SNP genotyping or willing to test it for demonstration.
- Complete the required tasks and let the participants take part in these demonstration tasks so that they can get to know the system by **practical activities** such as:
  - Collecting hair samples.
  - Simulating data evaluation.
  - Interpreting sample SNP reports.
  - Planning matings based on genetic profiles.

Proposed structure for the workshop on SNP Genotyping in Horse Breeding

1. Introduction to SNP Genotyping

- **What is SNP genotyping?**
  - Basics of Single Nucleotide Polymorphisms, markers, genome mapping.
  - Difference from microsatellites or full sequencing.
- **Key components & providers:**
  - Different SNP chip sizes (e.g. 54k, 70k, 600k), lab options, software tools.
- **Examples of systems on the market:**
  - Collaborations with universities, laboratories (Eurofins, Laboklin, etc.).

2. Benefits of SNP Genotyping in Horse Breeding

- **More accurate selection:** Early identification of suitable breeding animals.
- **Disease prevention:** Detection of carriers for inherited diseases (e.g., WFFS).
- **Economic efficiency:** Fewer veterinary costs, higher breeding success.
- **Transparency:** Genetic “ID cards” increase buyer confidence.
- **Inbreeding avoidance:** Better pairing decisions using genomic data.

3. Practical Applications on Horse Farms

- Integration into **breeding plans**, e.g., for selecting sires or matching mares.
- Support during **foal evaluations** with early predictions on performance or health.
- Cooperation with **breeding associations** to manage diversity and monitor populations.

4. How to Choose the most suitable provider

- **Farm needs assessment:** What data is relevant (health, performance, pedigree)?
- Choosing the right provider (chip size, trait coverage, reporting system).
- Consideration of **data privacy and publication.**
- Comparison of costs and support services.

5. Hands-On Demonstration
- **Live demonstration:** Hair sample collection, proper storage, and shipping.
- **Reading and interpreting reports:** Real-life examples with performance or health traits.
- **Interactive exercise:** Plan a mating using two horses' genotyping profiles.

6. Maintenance and Troubleshooting
- What to do if results are unclear or contradictory?
- Handling **sensitive outcomes** like carrier status.
- Secure **data storage and GDPR-compliant use.**

7. Case Studies and Real-World Examples
- **Interview with a breeder** who uses SNP genotyping.
- Before-and-after results: how has their selection success changed?
- Practical tips for working with labs and using results effectively.

8. Cost Analysis and Return on Investment (ROI)
- **Comparison:** Genotyping costs vs. traditional diagnostics and misused rearing resources.
- Savings on healthcare, selection errors, and unsuccessful matings.
- ROI calculations for small, medium, and large operations.

9. Q&A Session
- Open discussion of participant questions and challenges.
- Common topics:
  - "What if a top stallion turns out to be a carrier?"
  - "What are my legal obligations when publishing results?"

10. Wrap-Up and Resources
- Recap: key benefits, risks, and next steps.
- **Provide resources**: provider links, sample reports, interpretation guides.
- Share **discount codes or free consultations** if offered by sponsors.