# Genomic diversity in the domestication process

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### **Questions:**

## Chapter 3: Genomic diversity in the domestication process

Tapio & Qanbari

- What is domestication
- Why is knowledge about domestication important
- What are approaches used to study domestication
- How is the domestication process
  visible in genomes
- What are the domestication pathways
- What are the main facts about domestication of cattle pigs, chicken sheep, goat, horse and dog.

## Chapter 4: Tracing domestication and selection in animal genomes

Qanbari & Tapio

- How did human intervention shape the genomes
- Why are domestic animals genetically diverse
- Which class of genes has been under the action of domestication
- How can domesticated species be tested for selection effects.
- How to relate selective sweeps to functional traits.



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### What is domestication?

- Independent emergence of co-operative relationship between human and another species:
  - Humans manage and adapt another species to fulfil human needs
  - Animal population prospers over their wild relatives.
- Does not happen to an individual animal.
- Introgression into existing stock is not domestication. •

#### A gradually intensifying relationship between human and animal species:



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### Domestication occurred in restricted areas.

• Required suitable 1) animals, 2) a society and 3) a need.



- Animals:
  - Male dominated permanent social structure,
  - Generalist feed preferences,
    - (herbivorous or omnivorous)
  - Suitability to captive breeding
  - Anthropic environment use.
- Need
  - Reduce variation in harvest
  - Coping with local over-hunting
  - Dealing with waste or pests

Society

- Sedentary society
- Resource rich area
- Cultivation
- Sustained activities to increase abundance
  of targeted wild species
- Suitable technology, skills and culture



## The initial domestications took at least tens of human generations

Table 3.1 The main domesticated species and their ancestors, domestication area, pathway type of domestication process and time. The list is ordered based on the estimated start of domestication and the current population estimates. Dating varies in literature and other domestication areas have been suggested. This table is based on Larson & Fuller (2014) and Larson *et al.* (2014).

Species	Ancestor	Area	Path*	Time (years ago)
dog	grey wolf	Eurasia	С	~30000**
cattle, taurine	aurochs	West Asia Africa	Ρ	10000-8000 7500-6500
pig	wild boar	West Asia East Asia	С	10 000-9000 8500-6000
sheep	Asian mouflon	West Asia	Ρ	10000-8000
goat	bezoar	West Asia	Ρ	10000-8000
cattle, zebu	aurochs	South Asia	Ρ	8000-6250
llama	guanaco	Andes	Ρ	6000-4000
horse	forest horse	Central Asia	D	5500-4000
donkev	Numibian wild ass	North-East	D	5500-3500

Domestication processes occurred in many locations, also outside the widely known "domestication centers"

















Larson and Fuller (2014)



## Humans domesticate everything suitable, but early domesticates are the most prominent

- ~40 terrestrial domesticates and ~100 terrestrial semi-domesticates
- Hundreds of marine and freshwater species domesticated
- Eight domestic animal species widely distributed: cow, sheep, goat, pig, chicken, horse, dog and cat.





## Three domestication pathways:

#### The commensal pathway:



TRENDS in Genetics

Long preadaptation and Larson, G. and Burger, J. (2013) extended connection between the wild and the predomesticated form.

- No drastic reduction expansion pattern expected during early domestication history
- dog (food remains, commensal prey), Eurasia, 30 000/16 000 YA

#### The prey pathway:

- Difficult to handle, population reduction expansion
- Often females more tightly controlled.
- Cattle, taurine, West Asia, 10000-8000 YA

#### The directed pathway (deliberate intention):

- Many used for transportation, or as pets or are special production insects.
- The most common path
- Horse, Central Asia, 5500-4000 YA



## Introgression and gene-flow is an important part of the domestication history

- Without a plan to change the species, admixture with wild types not seen harmful, maybe considered advantageous.
  - Accidental/opportunistic recruitment
  - Planned stocking (*e.g.* stallions)
  - Inbreeding management
  - Sex biased admixture e.g. in cattle
- Ever since breed diversity emerged, there has been a demand for improved types and novelty.
- Except when a trait or gene has a specific value, the source of gene flow is an improved stock.
- The imports may be successful when the imported breed fits the production system.
- In modern times the local populations have limited possibility to add on the imported.



Cinta Senese

Schäfer & Zárate 2006

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## Breed diversity is about *improvement traits*

#### **Domestication traits (essential for domestication):**

- behavioural calming,
- temperament related organ changes,
- reduced weaponry,
- reproduction changes, •
- reduced size, ۰
- dietary flexibility and adaptations to new diets, ۰
- social flexibility and, •
- tolerance or resistance against human-borne ۰ diseases.

#### **Improvement traits:**

- growth rate and pattern changes,
- body composition traits,
- variation in wool, hair or feather,
- fertility traits,
- milk traits. .
- alterations in colours. •
- external morphology traits with aesthetic value, ۰
- special adaptations and, •
- further behavioural changes. ۰



aurochs

neolithicum

Felius (1995)



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WHITE PARK

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PROFICER PRAIN OLD BELL FIRE BLERS FORD DEPENAN, NOR FOLK, 1823 487 WELLING HIS FORD ON

SUSSEX

## Intensifying management in the genomes



## 1) Local populations with gene-flow within the limited social networks of their keepers

- Informal selection with low off take (8-16%).
- Female more controlled (number maximized). Natural selection, artificial for major. Main changes!

### 2) 200 years ago, breed concept as a "certificate"

• Herd book & breed standards limited breeding In old breeds, animals are more related and share longer genome segments. Stabilizing selection based on phenotype.

#### 3) 1950s, efficient selection programmes.

- Data bases, statistical predictions, technologies
- Line breeding (poultry and pigs).

Quick trait changes, but diluted genomic impact. Reduced effective populations.



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## The domestication processes are directed by the needs of the society

- Early selection focused on complex characteristics involved in brain and neuronal development (no single gene consistently).
- Selection on morphology and production genes more consistently observed.
  - "Secondary product revolution"
    Some less important products became the primary products
- The demand of sustainably produced animal based food is likely to dominate in the near future.
- Multi-functional systems satisfying societal demands and generating addedvalue products may utilize otherwise less competitive environments or breeds.
  - "Tertiary product revolution"?
    - The animals take roles usually attributed to people or man made items (cultural objects, sensors, therapy).



## Management of diversity is a part of domestication history.

- Initially the focus of diversity management was at local level
  - Wild and comparable domestic genetic resources were available for recovery.
- Later, the breed differences and the increased transport emphasized managing the breed as a closed resource for approximately two centuries.
- Breeds importance began to weaken, when more pedigree control was introduced (incl. linebreeding and crossbreeding).
- Genomic selection and animal tracking methods, possibly combined with genome editing methods, create again a new situation, which might lead to new solutions.



## Thank you!





