Conservation genetics of domestic Bovidae (cattle, sheep, goats)

or

Are cattle, sheep, and goats endangered species?

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Are cattle, sheep, and goats endangered species?

• Introduction
• Historical aspects
  – The domestication process
  – The breed concept
  – Recent selection pressures
• Threats to industrial breeds
• Threats to traditional breeds
• Conclusions and management guidelines
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### Current status

<table>
<thead>
<tr>
<th></th>
<th>Cattle</th>
<th>Sheep</th>
<th>Goats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population size (billion)</td>
<td>1.4</td>
<td>1.1</td>
<td>0.7</td>
</tr>
<tr>
<td>Current number of breeds</td>
<td>1224</td>
<td>1313</td>
<td>570</td>
</tr>
<tr>
<td>Number of extinct breeds</td>
<td>254</td>
<td>181</td>
<td>17</td>
</tr>
<tr>
<td>% of extinct breeds</td>
<td>17</td>
<td>12</td>
<td>3</td>
</tr>
</tbody>
</table>

From FAOSTAT; Scherf (2000)

- Effective population size of the Japanese Black cattle: 17.2 (N=530 000) (Nomura et al. 2001)
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Cattle domestication (1)

- Wild ancestor now extinct: auroch (*Bos primigenius*)
- Domestication: 8800 to 8300 BC (Helmer *et al.* 2005)
- For domestic cattle, the common usage accepts two taxa (*Bos taurus*, *B. indicus*)
- Mitochondrial DNA polymorphism: two main lineages corresponding to two domestication events (Loftus *et al.* 1994; Bradley *et al.* 1996)
- Eighty four percent of the mtDNA variation is partitioned among continents (Bradley *et al.* 1996)
Cattle domestication (2)

Mitochondrial DNA polymorphism

85% among continents

Bos indicus

Bos taurus
Sheep domestication (1)

- Wild ancestor(s): *Ovis gmelini*, *O. vignei*, *O. ammon*
- Domestication: 8500 BC (Peters *et al.* 2005)
- Domestic species: *O. aries*
- Mitochondrial DNA polymorphism: four main lineages (Tapio *et al.* 2006)
- Thirty five percent of the mtDNA variation is partitioned among continents (Townsend 2000)
Sheep domestication (2)

Mitochondrial DNA polymorphism
35% among continents
No relationship with breeds
Goat domestication (1)

• Wild ancestor: Bezoar (*Capra aegagrus*)
• Domestication: 8500-7900 BC (Zeder 2005)
• Domestic species: *Capra hircus*
• Mitochondrial DNA polymorphism: four main lineages (Tapio *et al.* 2006)
• Ten percent of the mtDNA variation is partitioned among continents (Luikart *et al.* 2001)
Goat domestication (2)

Mitochondrial DNA polymorphism
10% among continents
No relationship with breeds
Domestication in the Fertile Crescent, about 10,500 years ago
Dispersal from the domestication centers

Danubian route:
- 7,400
- 7,600
- 7,100
- 7,500

Mediterranean route:
- 7,400
- 8,000
- 8,200
- 10,500
Domestication of cattle, sheep, and goats

- Multiple maternal origins
- High level of nuclear DNA polymorphism
- No evidence of bottleneck during the domestication
- Very large gene pools on which human induced-selection was acting to produce the diversity of breeds we observe today
Rosa Bonheur (1822-1899): 1849

Paulus Potter (1625-1654)

Anthonie van Borssum (1630/31-1677)
Recent history: the breed concept

• About 10000 years ago: farmers started to control the reproduction of their farm animals in a traditional way
• About 200 years ago: standardization of the colour, morphology, and performance
• Reproduction among different phenotypes was seriously reduced
• About 50 years ago: the selection pressures strongly increased
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Threats on industrial breeds (1)

- Artificial insemination strongly decreases the genetic diversity
- Germany: $N_e = 52$ for Holstein
- France: $N_e = 46$ for Holstein
- France: $N_e = 27$ for Tarentaise
- Japan: $N_e = 17$ for Japanese Black
Threats on industrial breeds (2)

- Emergence of new genetic diseases
  - Bovine leukocyte adhesion deficiency
  - Achondroplasia
  - Complex vertebral malformation (CVM)

- Rapid decline in fertility
  - USA, 1951: 65%
  - USA, 1996: 40%
Threats on industrial breeds (3)

• Introgression from highly productive breeds

• New selection pressures (e.g. on coat colour)
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Threats on traditional breeds

• Already extinct: 17% of cattle breed and 12% of sheep breed

• Often low population size, with problem of inbreeding

• Competition with industrial breeds

• Crossbreeding with industrial breeds
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The same threats on domestic and wild species

- **Fragmentation** (highly reduced gene flow among breeds)
- **Low population size**
  - Industrial breeds: due to the current selection schemes
  - Traditional breeds: due to competition with industrial breeds
- **Economic constraints** for preserving traditional breeds
Are cattle, sheep, and goats endangered species?

• Cattle, sheep, and goats cannot be considered as endangered species, but…
  • Many breeds are already extinct
  • Many breeds are highly endangered
  • We are losing irreplaceable genetic resources
Problem with the public perception

- The preservation of genetic resources in domestic animals does not have the same image for the public as preserving the giant panda or whales
- Domestic animals have been selected and modified by humans
- Domestic animals do not bear the same "natural" perception that wild species have for the public, despite being our food
Management guidelines

• Change the public perception about domestic animals
• Preserve the traditional breeds for preserving the genetic resources
• Restore the genetic diversity of industrial breeds
• Protect the wild relatives of domestic species
In a few decades, we might lose most of the highly valuable genetic resources that humanity has gradually selected over the past 10,000 years.
Thank you for your attention