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Management strategies for inbreeding control in unselected and selected populations

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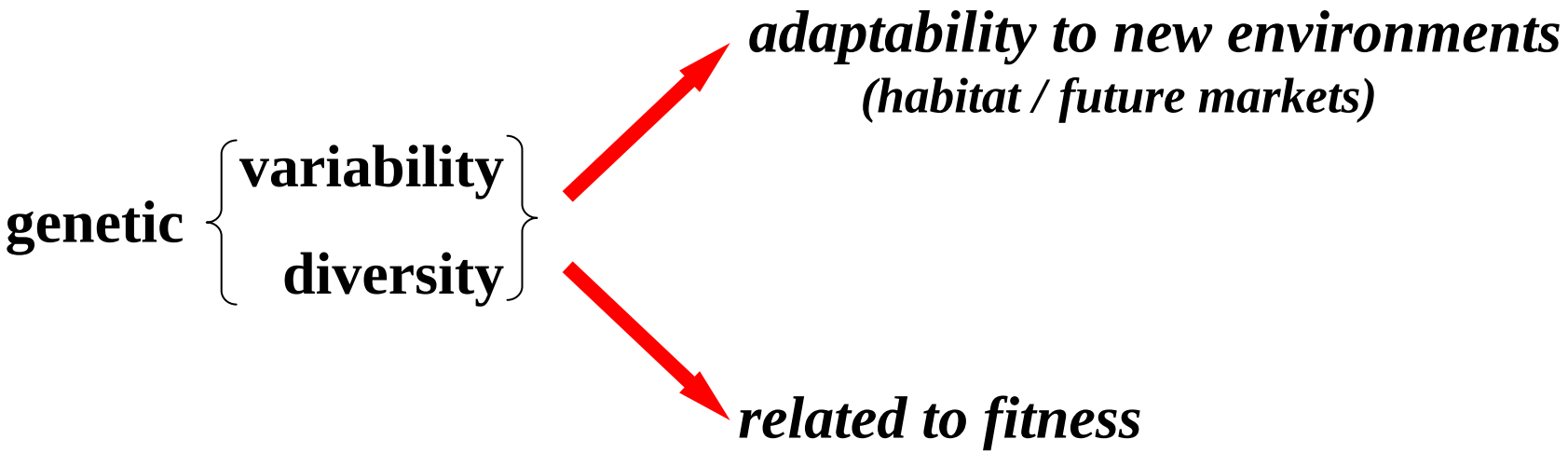
EuReCa
Towards self-sustainable European Regional Cattle breeds


Preserve
NATURAL RESERVE
ZOO
Gary Larson



short-term: inbreeding depression

long-term: accumulation of deleterious mutations
loss of evolutionary potential

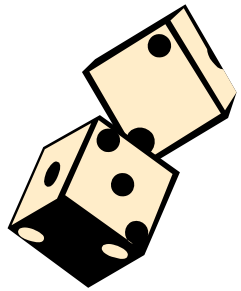
selection $\Rightarrow$ ***loss of detrimental alleles***

loss of variability

drift $\Rightarrow$ ***random sampling***

random sampling

parents → **different alleles**



gametes → **heterozygotes**

Genetic drift

Variation of allelic frequencies

$\propto 1/N$

Increase of inbreeding (*F*)

Effective population size (*Ne*)

$$\Rightarrow \text{ideal population with the same} \begin{cases} \Delta F \\ \Delta V(q) \end{cases}$$

fluctuating population size

$$\frac{1}{Ne} \approx \frac{1}{t}\sum_{i=1}^{n}\frac{1}{N_i}$$

biased sex ratio

$$\frac{1}{Ne} = \frac{1}{4N_f} + \frac{1}{4N_m}$$

differential contributions

$$Ne \approx \frac{4N}{2 + S_k^2}$$

Recommendations:

- keep constant census
- 1:1 sex ratios
- equalise contributions

ESTIMATION OF *Ne*

- ✓ **demographic data**
- ✓ **pedigree analysis** $\Delta F = \frac{1}{2Ne}$
- ✓ **molecular data**
  - ➢ ***fluctuation of allelic frequencies***
  - ➢ ***decrease in heterozygosity***
  - ➢ ***amount of linkage disequilibrium***

Genetic management of a population

- **two decisions to take:**
  - ✓ ***which individuals reproduce?*** **1**
  - ✓ ***how they mate?***

SELECTION

CONTRIBUTIONS

➢ **maximise *Ne***

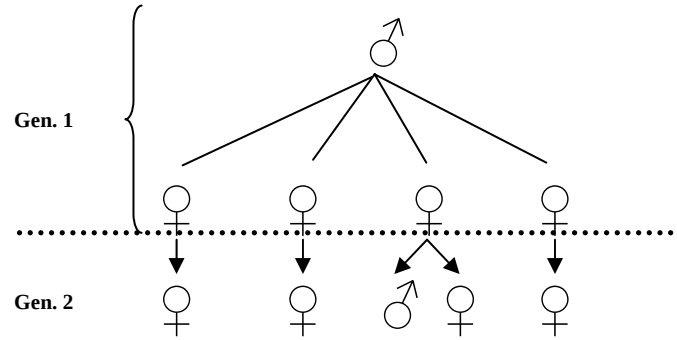
keep constant census

1:1 sex ratios

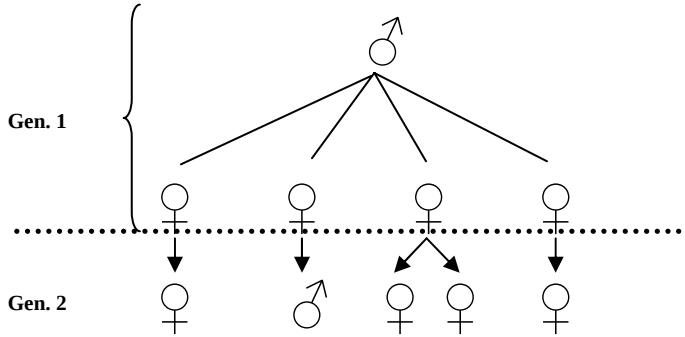
equalise contributions

Hierarchical regular methods

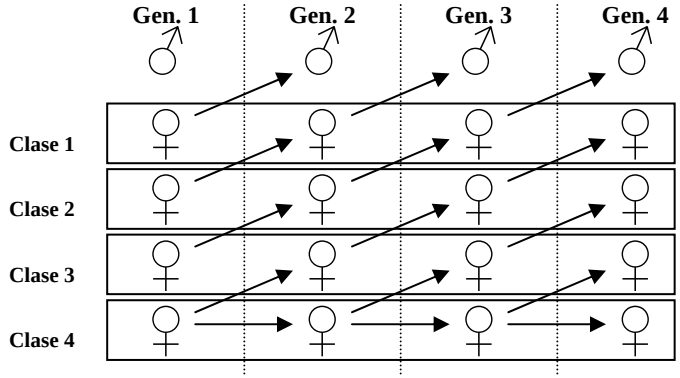
Gowe et al. (1959)



Wang (1997)



Sánchez-Rodríguez et al. (2003)



close relatives

share genetic information

low diversity

mating between relatives

increase of inbreeding

inbreeding depression

Let's minimise coancestry !!!

f_{ij} = coancestry coefficient

> ***… probability of two individuals carrying alleles identical by descent in a random locus ...***
>
> ***Malecot (1948)***

⇒ **from pedigrees or from markers**

OPTIMAL CONTRIBUTIONS

→ **overrepresented individuals are penalised**

→ **loosely related individuals are favoured**

Ballou & Lacy (1995)

$$\min \sum_{i=1}^{N}\sum_{j=1}^{N} c_i c_j f_{ij}$$

- ✓ **equalises ancestral contributions**
- ✓ **maximises *Ne***
- ✓ **maximises gene diversity (Exp. Het.)** $\bar{f} = 1 - GD$
- ✓ **minimises *ΔF*** $\Delta F = \frac{1}{2Ne}$
- ✓ **flexible and robust**

Animal Breeding ⇒ selection

⇒ *improving a particular trait*

$$\Delta G = i\, \rho_{AC}\, \sigma_A$$

$$\uparrow i \Rightarrow \uparrow \Delta G\,,\uparrow \Delta F$$

$$\uparrow \rho \Rightarrow \uparrow \Delta G\,,\uparrow \Delta F$$

Response / Gain

Inbreeding / Genetic diversity

- **Decrease importance of relatives' information**
  - ✓ **Inflated heritability**
  - ✓ **Suboptimal familiar indices**
- **Allow for differential contributions**
  - ✓ **proportional to breeding value**
  - ✓ **more selected ⇒ same *i* with more *Ne***

OPTIMAL CONTRIBUTIONS

(Wray & Goddard 1994, Meuwissen 1997)

$$\max \left(\sum_{i=1}^{N} c_i \, EBV_i \right)$$

contributions proportional to breeding value …

$$s.t. \left(\sum_{i=1}^{N} \sum_{j=1}^{N} c_i c_j f_{ij} \right) \leq F_{t+1}$$

… but also to average relationship

Genetic management of a population

- **two decisions to take:**
  - ✓ ***which individuals reproduce?***
  - ✓ ***how they mate?*** **2**

- **less important than selection**

  ⇒ ***little margin for improvement***

➢ Factorial mating

- ✓ several partners per individual
- ✓ HS families instead of FS families

➢ Compensatory mating

- ✓ mix overrepresented lineages with rare ones

➢ Minimum coancestry mating

- ✓ avoid mating between close relatives
- ✓ delays inbreeding (but not ΔF)

CRYOCONSERVATION

- ✓ use of post-reproductive individuals
- ✓ increases census
- ✓ increases generation interval 
- ✓ reduces drift

TO TAKE HOME

✓ ***Ne*** **is a key parameter**

⇒ **management and monitoring**

✓ **OC controls the rise of inbreeding**

⇒ **with and without selection**

⇒ **also reduces loss of diversity**

✓ **mating less important than selection**

⇒ **but *mcm* could be advisable**