Designing the conservation and use programme – Maintaining genetic variability

- **Our aim: avoid the extinction of endangered populations**
- **Survival depends on the levels of genetic diversity**
- **Correct management of small populations**
  - ***Causes of loss of diversity***
  - ***Measures of diversity***

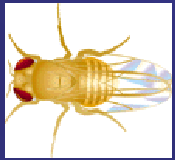
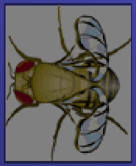
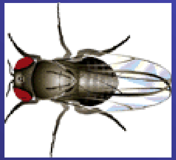
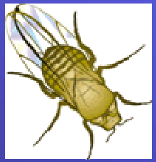
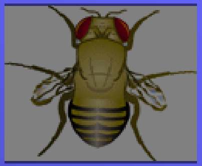
adaptability to new environments
(habitat / future markets)

variability
genetic
diversity

associated with fitness

short term: inbreeding depression

long term: accumulation of deleterious mutations


loss of variability

selection ⇒ ***loss of unfavourable alleles***

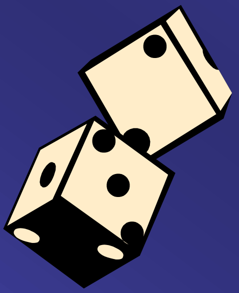
drift ⇒ ***random sampling***

finite census
(very small)

random sampling

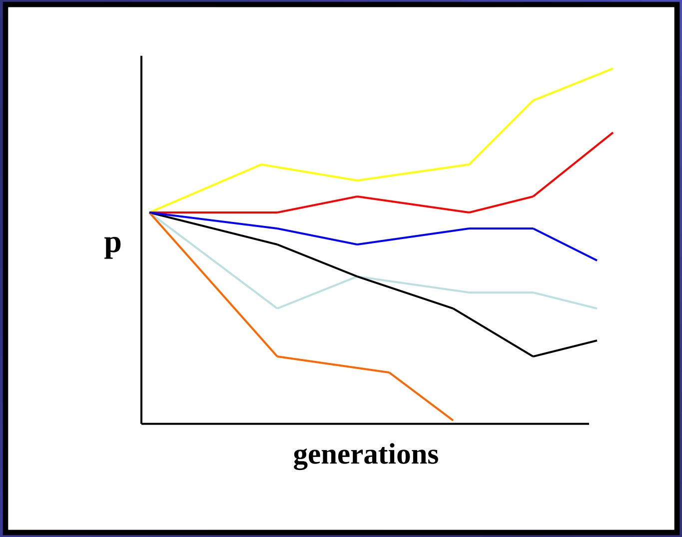
parents → **different alleles**

gametes → **heterozigotes**



Genetic drift

Infinite lines with the same allelic frequencies



Variance of allelic frequencies

Increase of inbreeding

Variance of allelic frequencies

⇒ in the long term all but one allele are lost

Increase of inbreeding

limited number of ancestors → **mating between relatives** → **increase of homozygosity**

Inbreeding depression

… the reduction in the expression of a trait as a consequence of the inbreeding …

fitness (viability, fertility, ...) or productive

deleterious genes ⇒ *recessives*

⇒ *do not expressed in heterozygous*

inbreeding ⇒ *increases the proportion of homozygous*

⇒ *deleterious genes express*

- **Use inbreeding coefficient (*F*) as a measure of diversity**

  - **if in generation *t* $N = \infty$** $F_t = F_{t-1}$

    $\Rightarrow$ ***inbreeding accumulates***

  - **depends on the reference population**

    $\Rightarrow$ ***rate of inbreeding***

$$\Delta F = \frac{F_t - F_{t-1}}{1 - F_{t-1}}$$

Deviations from ideal population

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

$$\Delta F = \frac{1}{2Ne}$$

- **Other important parameter is coancestry coefficient (*f*)**

- **in parents is the inbreeding of offspring**
- **related to expected heterozygosity ($He = 1 - f$)**
- **a measure of the 'redundancy' of genetic information**

Task 1. Adopt a general breeding strategy to maintain the conserved breed, based on a clear understanding of options for maintenance of genetic variability

Action 1: Include as many individuals as possible from the start, as drift depends on the number of individuals available

- **The initial variability is the highest possible**

- **Magnitude of drift only depends on the (effective) population size**

Action 2: Equalise the number of breeding males and females

- **Half of the diversity through each sex**

- **Less represented sex conditions *Ne***

$N_m = 2$
$N_f = 1000$
$Ne = 8$

Action 3: Prolong the generation interval

- ✓ **same rate of inbreeding per generation divided by more years**

Action 4: Equalise the contribution of each individual

- **provide the same opportunity to all individuals to transmit their genetic information**

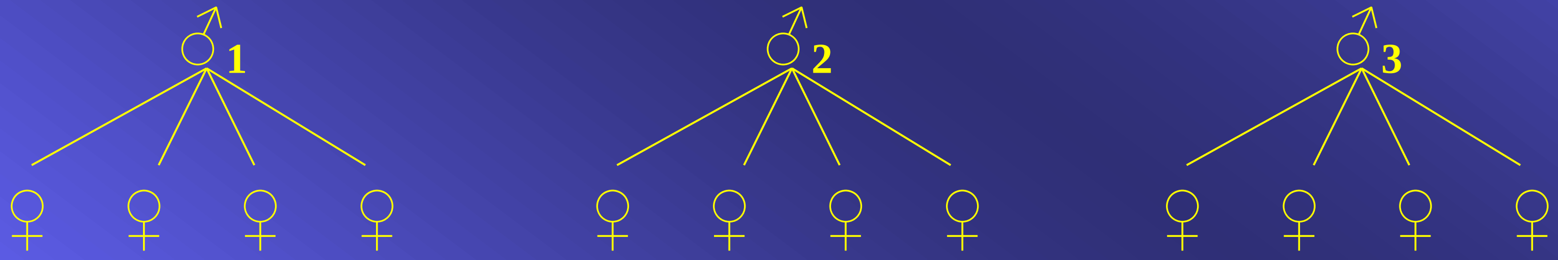
$$Ne \approx \frac{4N}{2 + S_k^2}$$

$$Ne \approx 2N$$

- ✓ **each male leaves a son and each female a daughter**

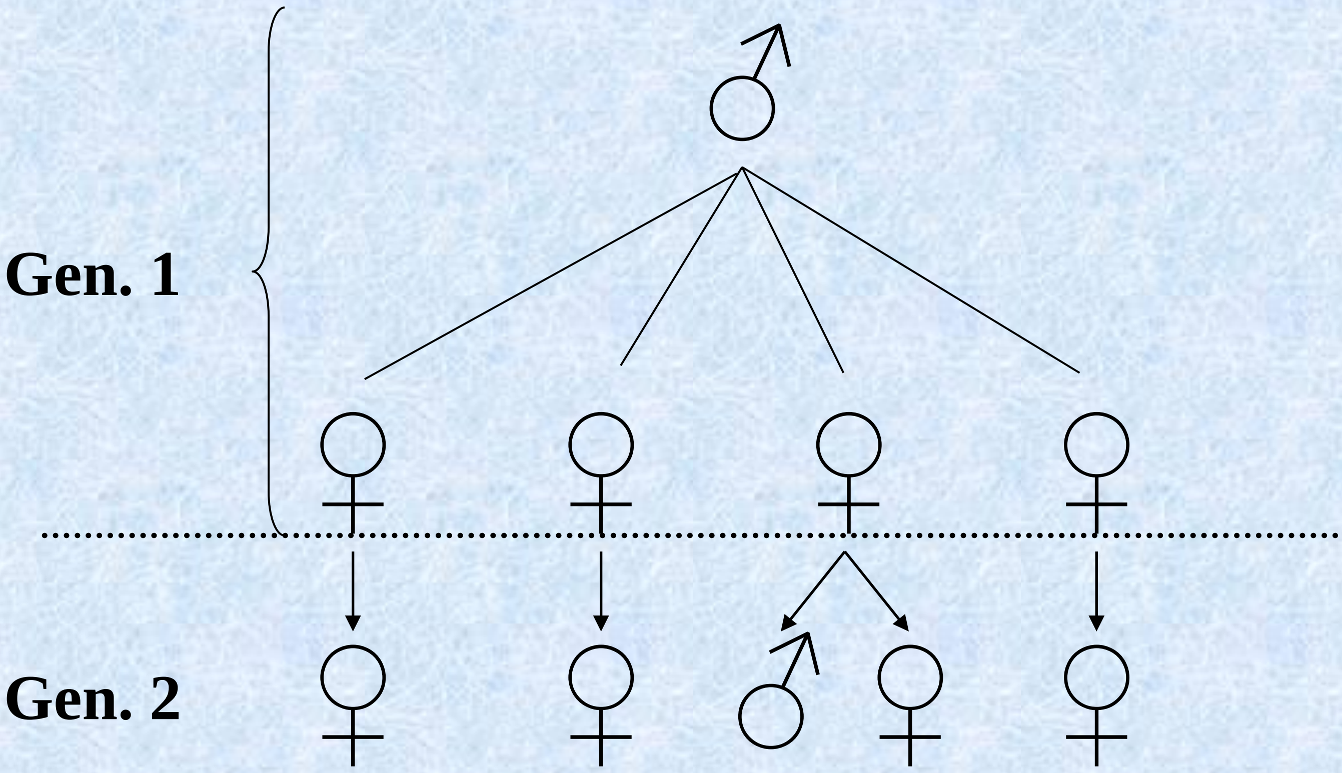
HIERARCHICAL REGULAR SCHEMES

Different number of males and females

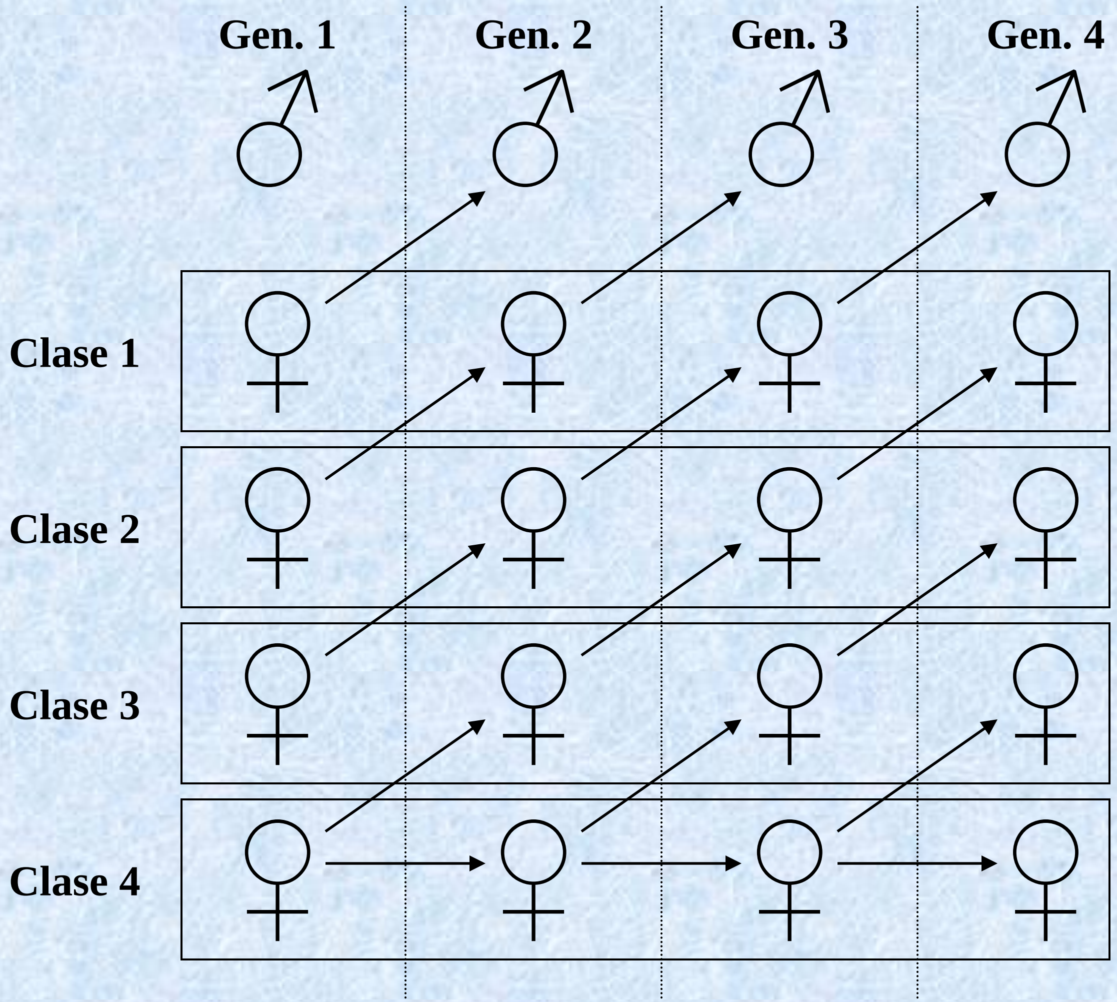


$$\frac{N_f}{N_m} = r$$ ⇒ *mating ratio*

Gowe et al. (1959)



Sánchez-Rodríguez et al. (2003)

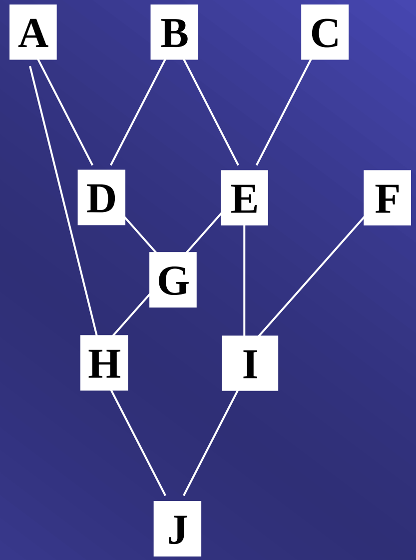


- **Some kind of within-family selection**

- **Lower ΔF than with random selection**

- **Correct for unintentional selection**

PEDIGREES



close relatives

↓

share genetic information

↓

low variability

Let's minimise coancestry!!!

Caballero and Toro (2000)

1) Maximise expected heterozygosity

2) Non related $\Rightarrow$ equalise contributions

3) Related $\Rightarrow$ equalise contributions from ancestors

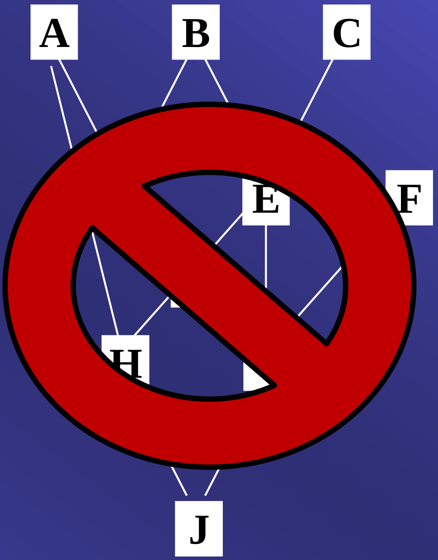
4) Minimise rate of inbreeding in the short-term

- **Require tight control of population**
- **Computationally demanding**

- **Robust against deviations**
- **Allows for imposing restrictions**

Absence of

PEDIGREES



USE OF MOLECULAR MARKERS

(allozymes, DNA markers, etc)

- **Reconstruct/complete the pedigree**
- **Estimate pedigree relationships from molecular similarity**
- **Replace directly with molecular coancestry**

Action 5: Consider the use of embryo transfer in species with low reproductive rates

- **MOET increase the number of offspring per female**
  - ✓ **rapid increase of census number**
  - ✓ **equilibrate the ratio between male and female**
  - ✓ **allows for factorial matings**

Task 2. Adopt a mating strategy to decrease inbreeding

MATING SCHEME

- ✓ **Does not affect ammount of transmitted diversity**

  ⇒ ***(at least in one generation)***

- ✓ **Important in the increase of inbreeding**

- ✓ **coancestry of parents = inbreeding of offspring**

↓

avoid mating between relatives

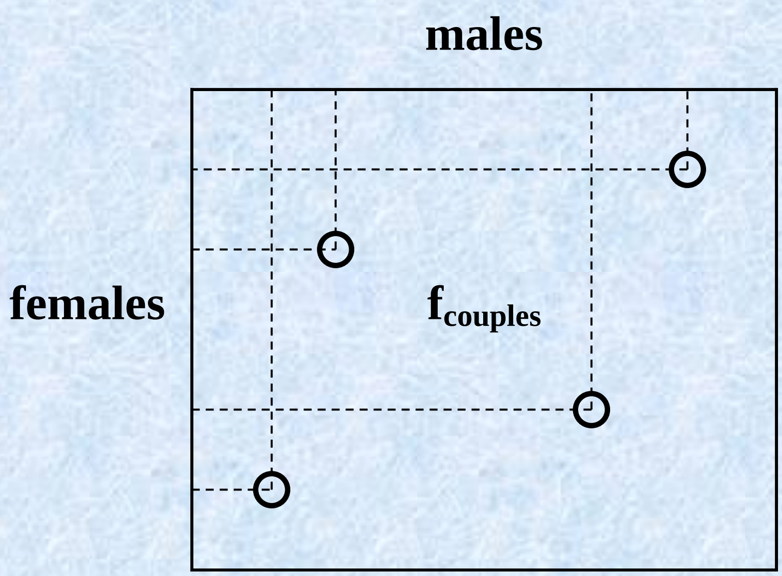
Action 1: Set a limit on the level of relationship between mates

- **Avoid a certain degree of relationship (e.g. full sibs)**

- **Determine a threshold for the coancestry of anybody's couple**

Action 2: Establish the ideal set of matings for the entire population

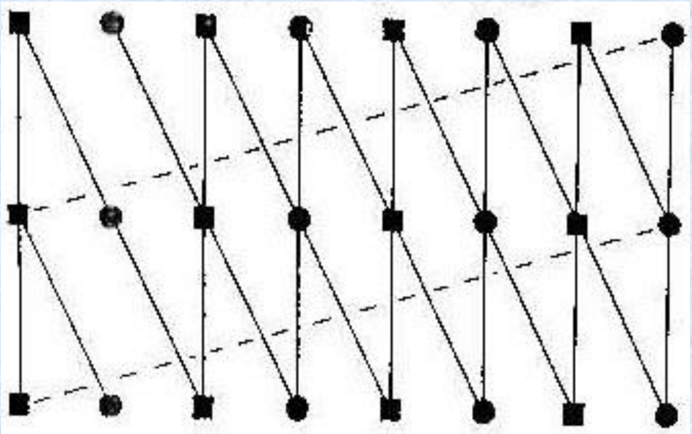
Minimum coancestry mating

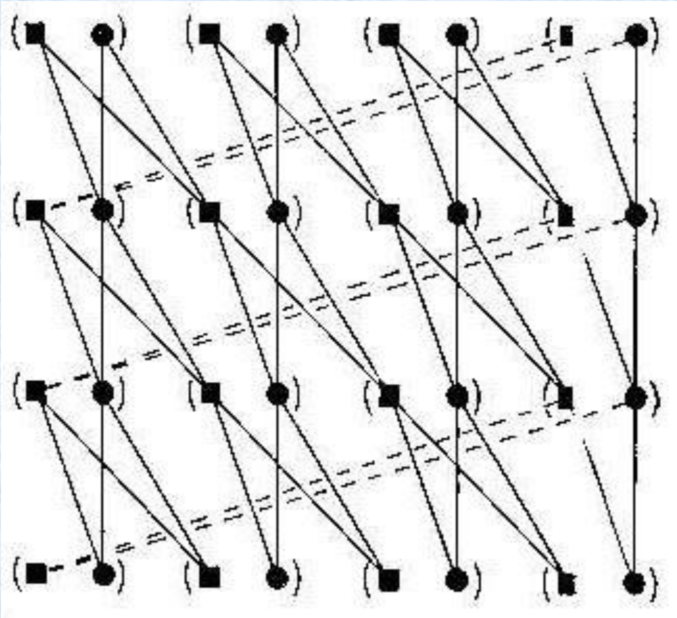


Action 3: Apply simple methods that do not require pedigree information

Circular Mating

Kimura and Crow (1963)





✓ **circular mating induces subdivision**

⇒ ***rise of inbreeding (in the short-term)***

⇒ ***inbreeding depression***

⇒ ***lower ΔF (long-term)***

✓ **keeps higher diversity (long-term)**

⇒ ***more homozygotes = less drift***

SELECTION

MATING

"mate selection"

⇒ account for reproductive's restrictions

⇒ impose conditions

(e.g.: no FS generated)

Task 3. Incorporate cryoconservation in the management of genetic variation in the in vivo programme

CRYOCONSERVATION

- ✓ **use of post-reproductive individuals**
- ✓ **increases census**
- ✓ **increases generation interval**
- ✓ **‘stops’ drift**

Action 1: Store genetic material from all animals at the start of the conservation programme

- ✓ **recreation of the population**
  - ⇒ **‘back up’**
  - ⇒ **critically endangered breeds**

Action 2: Use cryoconserved material continually for management of the genetic diversity

- ✓ **Reinforcement of *in vivo* programs**
  - ⇒ **recovery from a punctual problem**
  - ⇒ **continuous use of the material**

Options for breeding programmes combining conservation and sustainable use

6.1 Improvements through breeding

- **success is more likely if breed is productive**

- **enhance production on well adapted population**

- **larger populations needed for selection**

Task. Implementation of a breeding program with selection for production

Action 1: Analyse history of selection within breed

- ✓ did tradition made well in the past?

Action 2: Decide on the production and potential breeding goal traits that should be improved by breeding

- ✓ maintain traits of interest
- ✓ look for niche markets
- ✓ keep simple and realistic

Action 3: Implement identification, registration and performance recording

- ✓ can’t improve what can’t be measured
- ✓ wrong consequences form wrong data

Action 4: Select for type, production and fitness traits should be recorded and implemented in relevant environments

- ✓ stress the particular adaptations (low input)

Action 5: Decide on the selection and breeding strategy that is most likely to succeed in improving production

- ✓ again ... be realistic!

6.2 Optimising selection response and genetic variability within small populations

- **genetic gain opposed to maintenance of variability**

$$R = i \rho \sigma / L$$

Larger gains (responses) by ...

- ✓ **more intense selection**
  - ⇒ **lower *Ne***
- ✓ **use of relative's information for accuracy**
  - ⇒ **increase of *f* and *F***
- ✓ **reduce the generation interval**
  - ⇒ **speed up genetic drift**

Task 1. Adopt a general breeding strategy to maintain the conserved breed

Action 1: Determine which trait or traits are to be improved in the conserved breed

- ✓ already said

Action 2: Agree upon the acceptable rate of inbreeding in the conserved population

- ✓ if highly endangered the same as for pure conservation programmes
- ✓ can be increased as the population rise

Task 2. Design a breeding programme generating genetic improvement while maintaining genetic variability

Action 1: Determine the ideal number of parents when applying mass selection

- ✓ relay on the simple formulae relating number of individuals with Ne

Action 2: Apply within family selection

- ✓ avoid the selection of close relatives
- ✓ ignores differences between families

Action 3: Apply family selection

- ✓ **higher response but higher inbreeding**
- ✓ **look for intermediate solutions**

Action 4: Implement weighted selection

- ✓ **allow for differential contributions**
- ✓ **contributions proportional to merit**
- ✓ **same response with less inbreeding**

Action 5: Apply optimum contribution strategy for selection

- ✓ contributions proportional to merit and coancestry

- ✓ establish a limit to the permitted rate of inbreeding

$$\Delta G - \Delta F$$

- ✓ computational demanding

6.3 Crossbreeding local breeds for enhanced production

- **allow introgression may benefit the profitability of the breed**
  - ✓ **pure breed crosses**
  - ✓ **rotational crosses**
  - ✓ **synthetic breeds**

Task 1. Develop a system for crossbreeding to conserve a local AnGR

Action 1: Outline the desired outcomes of the crossbreeding system

Action 2: Evaluate the status of the targeted indigenous breed

Action 3: Evaluate the other breeds that are potentially available for inclusion in the crossbreeding plan

Action 4: List the potential crossbreeding systems that might function in the relevant conditions

Action 5: Describe the function of the indigenous breed and complementary breeds in the crossbreeding system

Action 6: Choose the optimal crossbreeding system

Task 2. Organise the logistics, implement and monitor the crossbreeding plan