Balancing Selection and Inbreeding

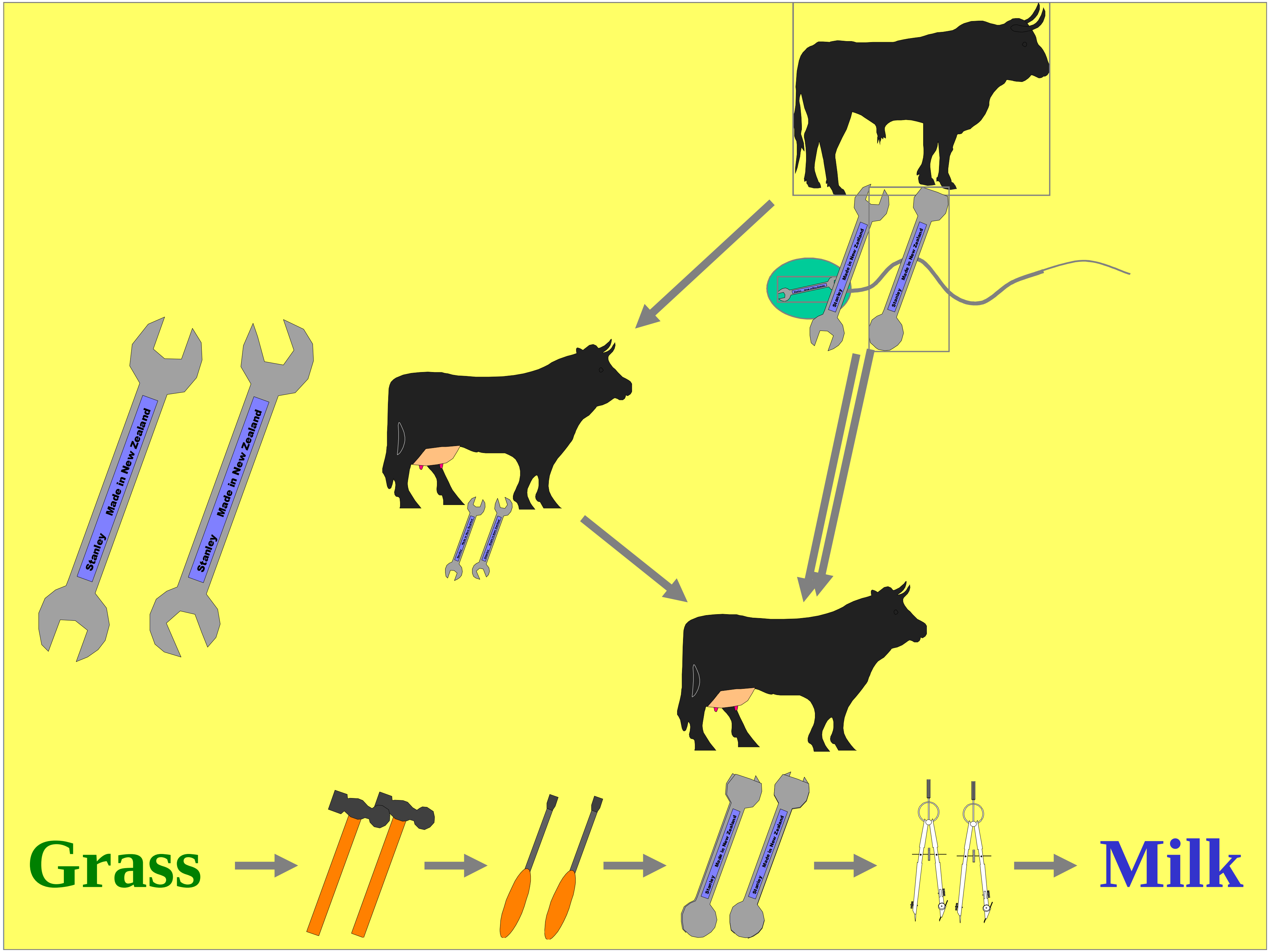
- Higher selection intensities make bigger gain
- Fewer animals are selected, so also more inbreeding
- This trend is more evident with higher rates of fecundity
- Effect of new reproductive technologies
- Genetic evaluation (BLUP) favors selection of related animals
- rationalization of selection make inbreeding restriction methods a necessity

Why restrict inbreeding

- Avoid loss of genetic variation/genetic diversity
- Inbreeding depression
- Increase of homozygotes with deleterious recessives
- Inbreeding is closely associated with risk (and genetic drift)

How to restrict inbreeding?

- Mating policies mostly affect
  - progeny inbreeding *(short term)*
  - but not *long term* rate of inbreeding ΔF
  - The long term inbreeding rate depends on *effective population size*
- Long term inbreeding is restricted by restricting the average co-ancestry among selected parents


Stanley
Made in New Zealand
Stanley
Made in New Zealand
Grass
Milk

So, previous slide illustrates …….

- Inbreeding coefficient

  Animals that have related parents have more chance to carry two alleles that are identical by descend

- Genetic defects

  Inbred individuals have more chance to express genetic defects

- Inbreeding depression:

  Heterozygosity has often positive effects on phenotypes (and therefore inbreeding/homozygisty a negative effect >>

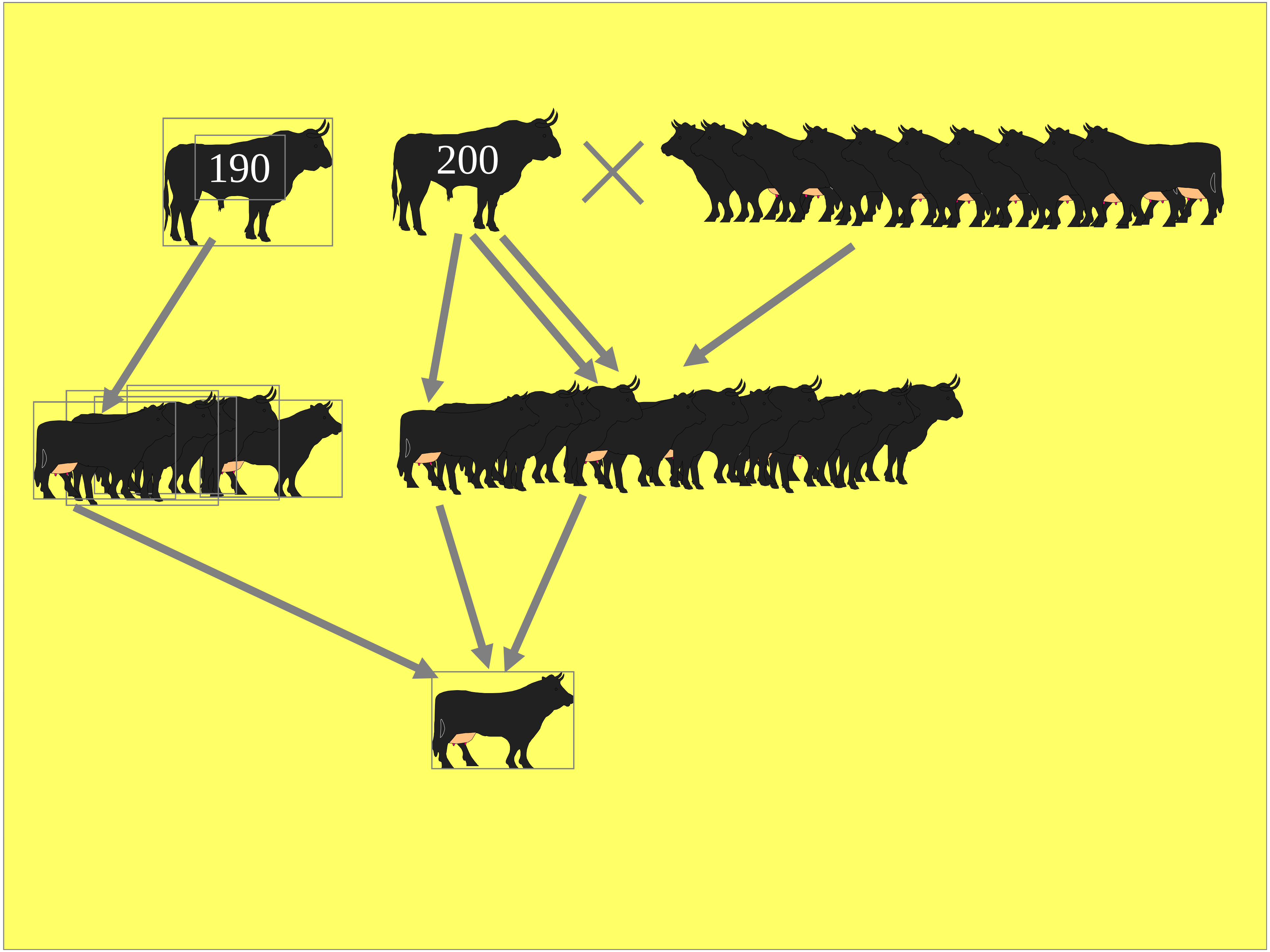
Calculating Effective Population Size: Ne

Accounting for unequal sex ratio

- Effective pop'n size (Ne) reduces towards sex with fewer breeding individuals

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

Males / generation	2	2	2	5	20	1
Females / generation	2	20	200	200	200	99999
N	4	22	202	205	220	100,000
Ne	4	7.3	7.9	19.5	72.7	4



190
200

Inbreeding rate

- Inbreeding occurs due to the mating of relatives
- In a closed population inbreeding is inevitable
- Inbreeding rate (ΔF) describes the increase in F over time

The rate of inbreeding

- F at time ‘t’ can be calculated as:

[redacted]

where t is number of generations

- Note that this only holds for no selection and random mating

- More importantly: **Inbreeding Rate** $\sim 1/2N_e$

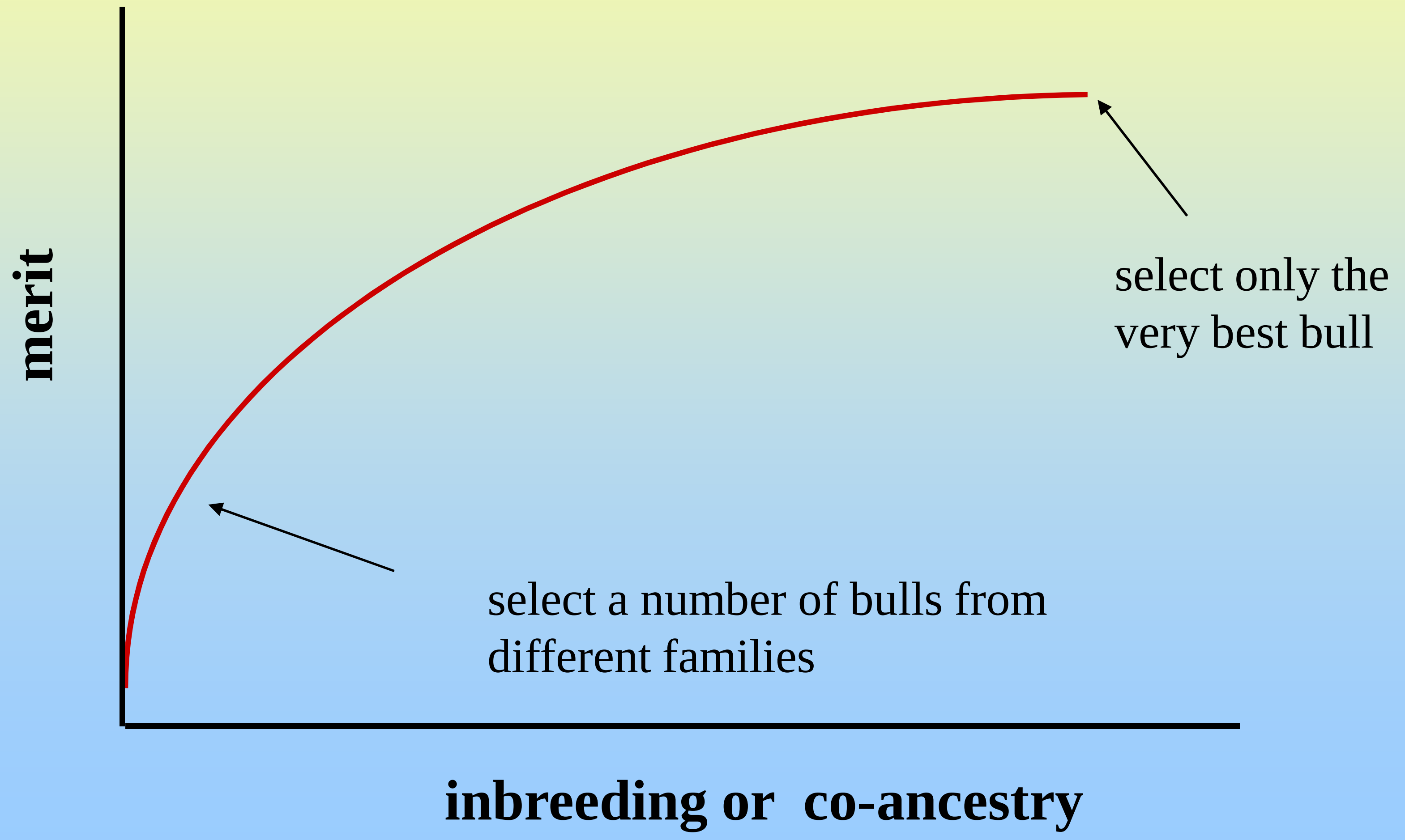
    - i.e. need $N_e > 50$ for Inbreeding Rate to be < 1%

      (which maybe about reasonable)

Balancing inbreeding and merit

- Restricting co-ancestry but this slows genetic (short term) progress
- How much inbreeding can we afford?
- Often inbreeding is restricted by limiting ΔF to a certain preset value
- This optimal value may depend on your situation (how open is your nucleus)

Balancing inbreeding and merit



Jointly optimizing merit and inbreeding

- merit: x'G
  - x = vector with each animal's contribution to progeny
  - G = the vector with merit (EBV's) for each animal

- Co-ancestry: x'Ax
  - x = vector with each animal's contribution to progeny
  - A = Numerator Relaionships Matrix

Remember: $\Delta F = x'Ax/2$ $F_i = 0.5\ a_{ij}$

Vector *x* of animal contributions

Source of animals	Animal#	x = Contribution	
Male candidates	1	0	$\sum = 0.5$
	2	.1	
	3	.05	
	4	0	
	5	.01	
	6	0	
	7	0	
	8	0	
	…	…	
Female candidates	101	0	$\sum = 0.5$
	102	.01	
	103	.01	
	104	.01	
	105	0	
	106	0	
	107	0	
	108	.08	
	…	…	

Optimizing genetic contributions

- Maximize objective function

$$x'G - \underline{\lambda} x'Ax$$

Question: what is best value for λ ?

Could preset rate of inbreeding (e.g. 1%) and determine λ accordingly (Meuwissen, 1997)

Alternative: look at graph (next slide)

Balancing inbreeding and merit

This graph will look different for each population