Optimizing Breeding Programs

Effect of Reproductive Technologies and Measurement

Armidale Animal Breeding Summer Course 2014

Decisions in breeding programs

Where to go? breeding objective (which traits)

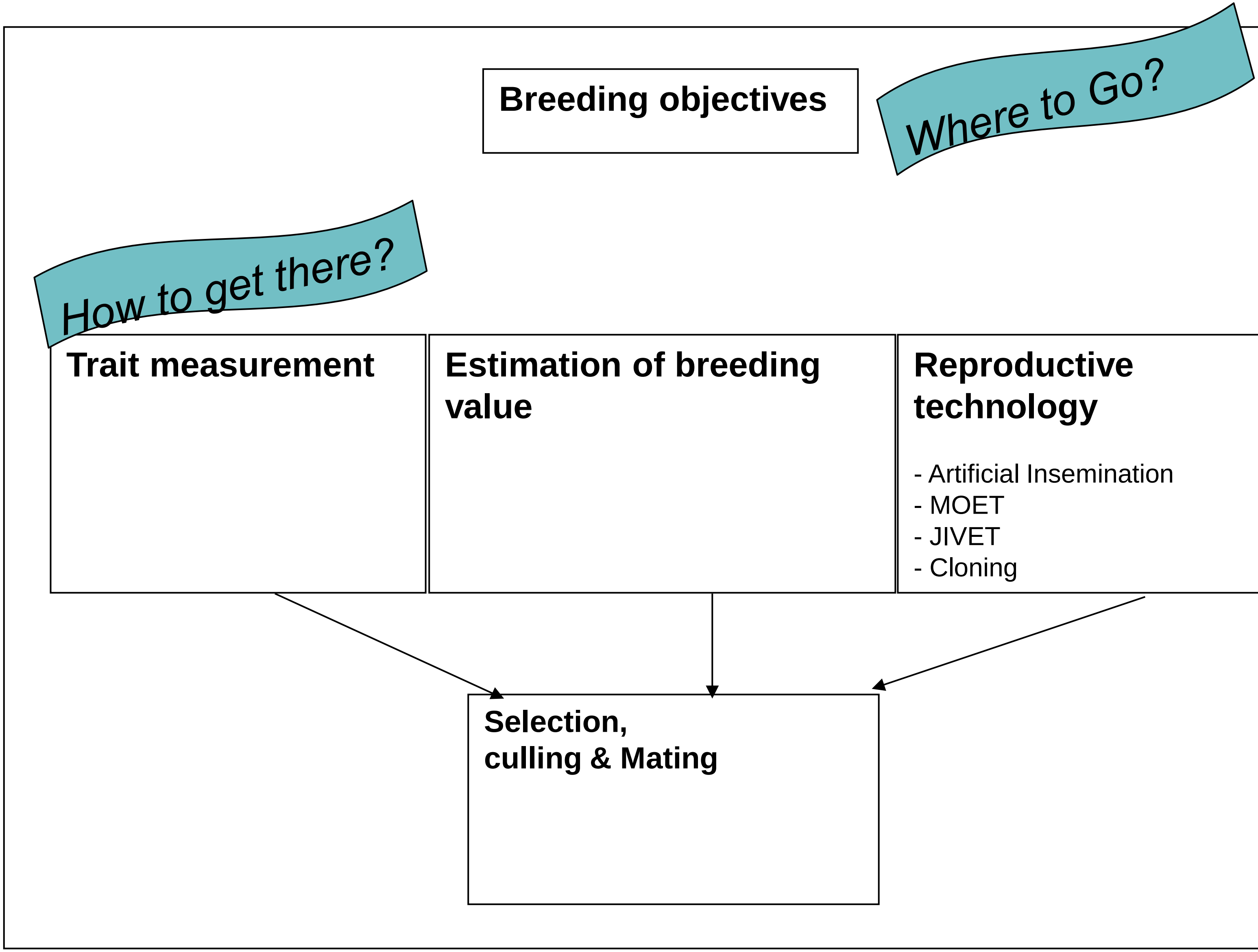
Who and what to measure? performance, DNA test

genetic evaluation

Who to select and mate? reproductive technol.

gains vs inbreeding

Animal Breeding in a nutshell



Making genetic progress is about

Selecting only the very best

Selecting accurately

$$R = \frac{i_m r_m + i_f r_f}{L_m + L_f} \sigma_A$$

Keeping generation intervals short

Reproductive rates affect all of the above!

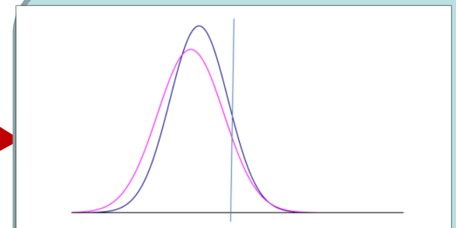
Aspects that need to be balanced:

$$\frac{i_m r_{IAm} + i_f r_{IAf}}{L_m + L_f}\sigma_A$$

- Selection accuracy versus generation interval
  - Short generation intervals are good for fast progress, but young breeding animals have lower EBV accuracy
- Selection accuracy versus selection intensity
  - Money available for testing (either performance or DNA) can be used to test a few animals accurately, or to test more animals with lower accuracy. For example, testing fewer young bulls but giving them more test progeny.
- Selection intensity versus generation interval
  - Selecting fewer animals for breeding each year and keeping those longer
- Selection intensity versus inbreeding
- The relative emphasis in selection for multiple traits
- Cost versus benefits

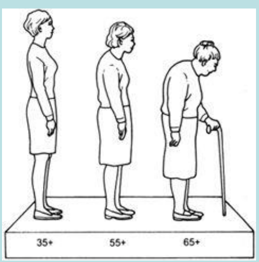
Aspects that need to be balanced

Selection accuracy



Selection intensity

$$\frac{i_m r_{IAm} + i_f r_{IAf}}{L_m + L_f}\sigma_A$$

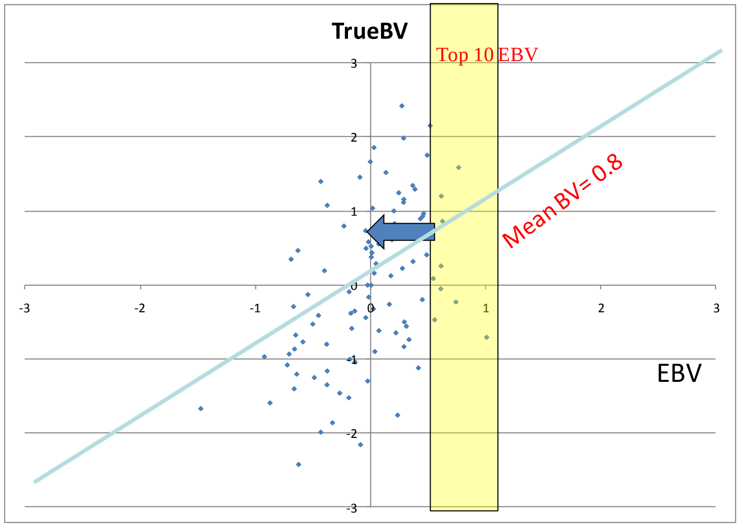


Generation Interval

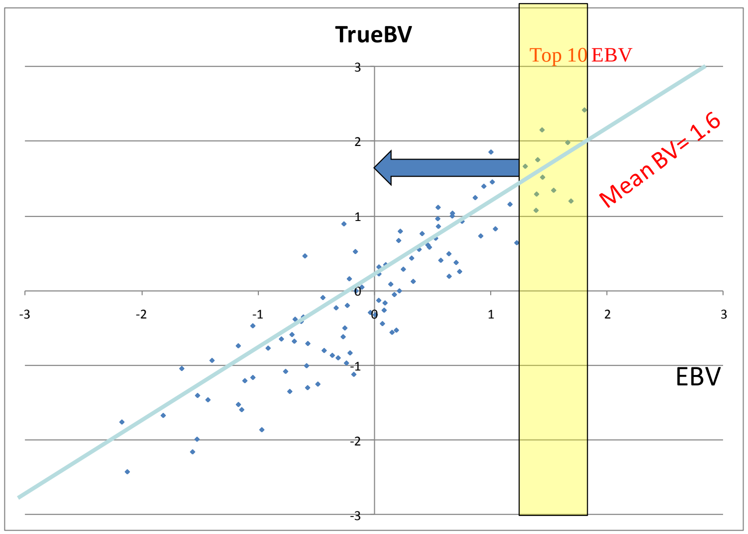
Inbreeding

Multiple traits

Cost Benefit



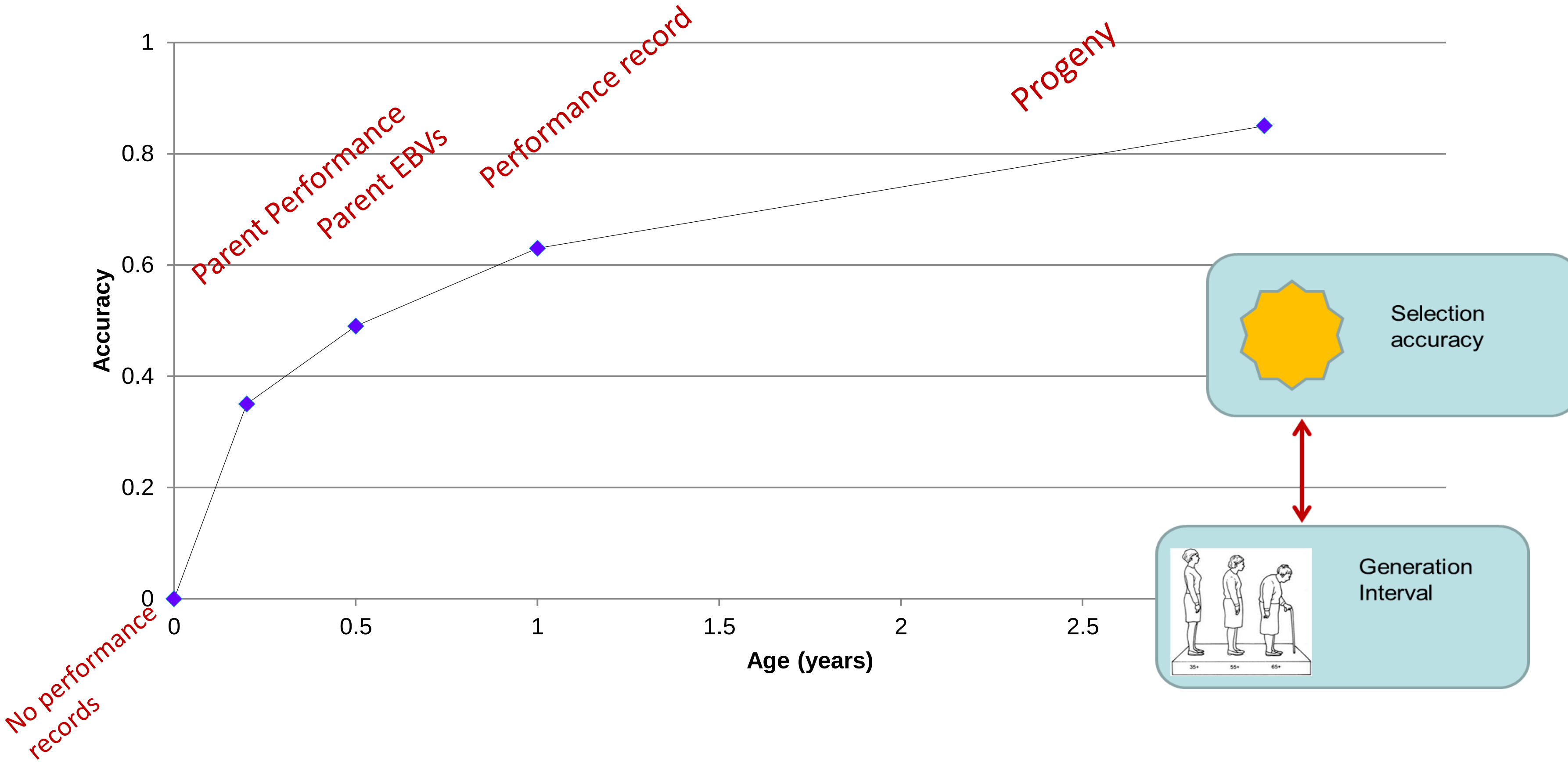
Accuracy = 45%



the more accuracy,
the more response

Accuracy of predicting a breeding value

- increases as an animal gets older

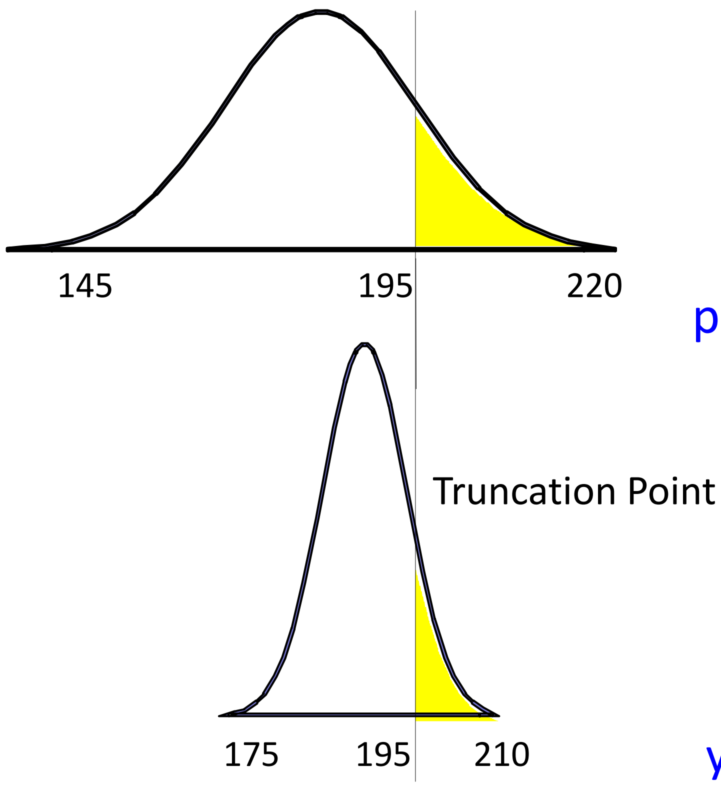


Assumed heritability = 25%

Need to balance accuracy and generation interval!

BLUP helps selecting between old and young bulls

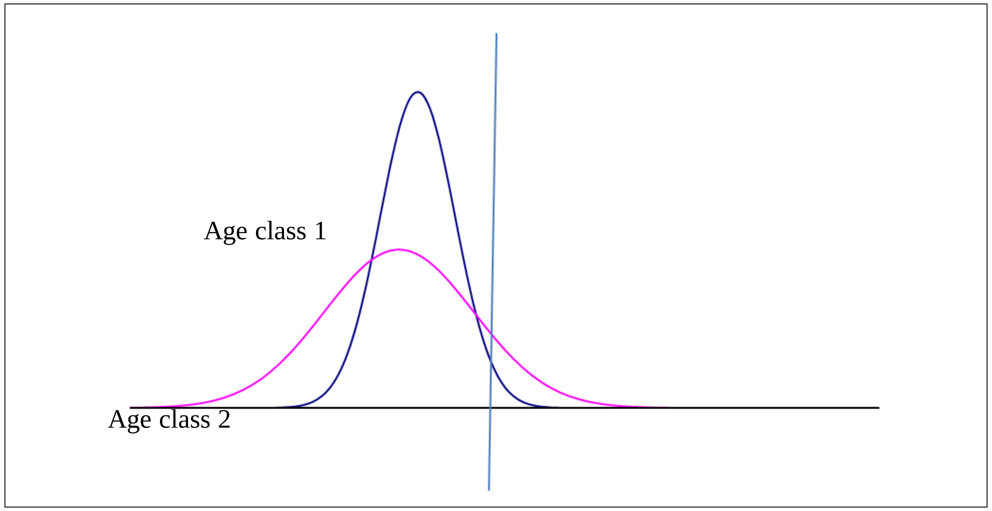
- EBVs can be compared directly over age classes
- Selection on BLUP EBVs optimizes generation interval



proven sires

young sires

Optimizing age structure

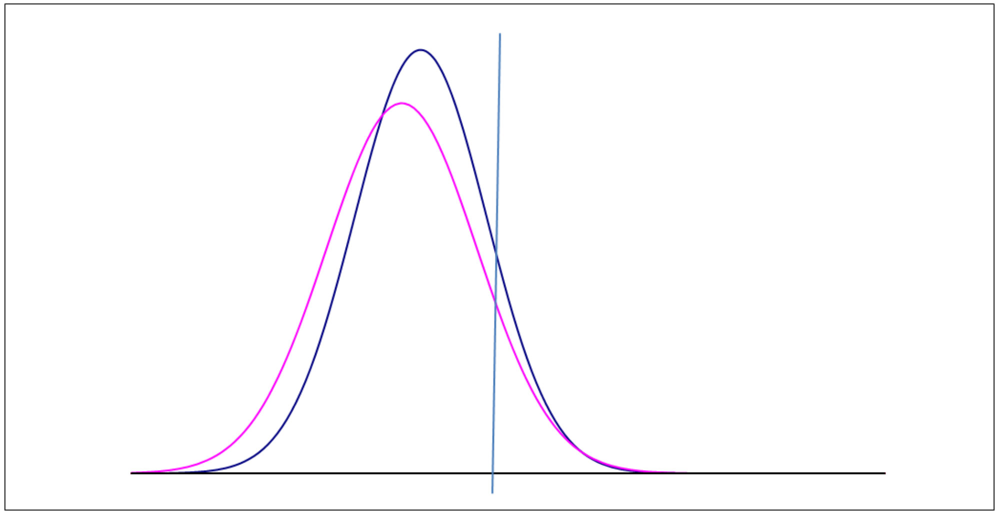


Accuracy changes with age class !

Without genomic selection

ageclass	N in group	mean	SD	Nr Selected
1	50	10.20	0.4	2.7
2	50	10.00	0.8	7.3

Accuracy



With genomic selection

ageclass	N in group	mean	SD	Nr Selected
1	50	10.20	0.7	5.4
2	50	10.00	0.8	4.6

une

Open nucleus systems

- Select the best animals from lower tiers to compete for being nucleus parents

- degree of ‘openness depends on
    - difference between nucleus and commercial
    - spread of their breeding values

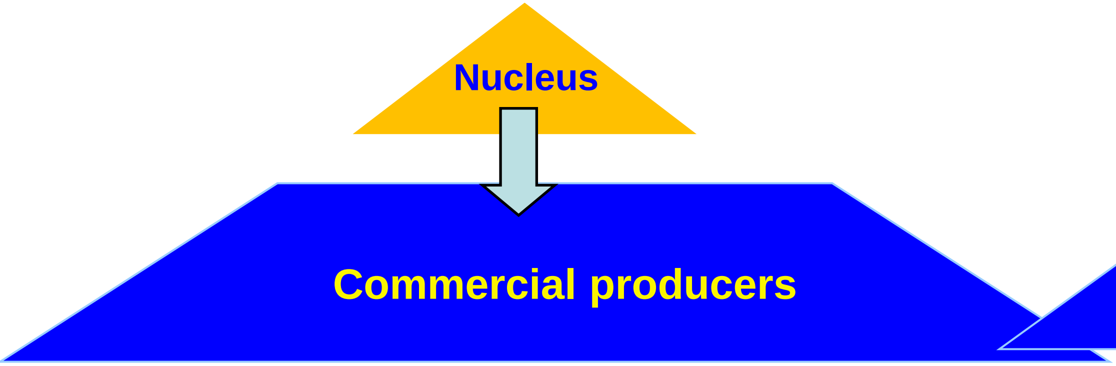
- Open to nuclei

Design Examples

Two-tier breeding program

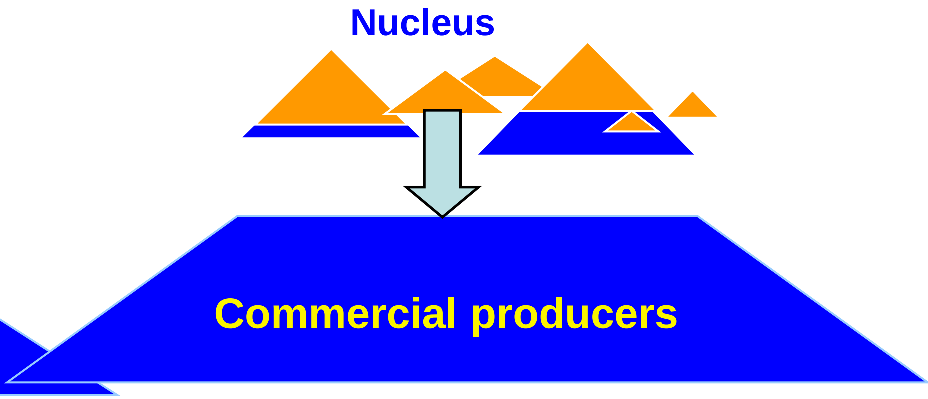
Central Nucleus

(pigs, poultry, some dairy)



or Dispersed

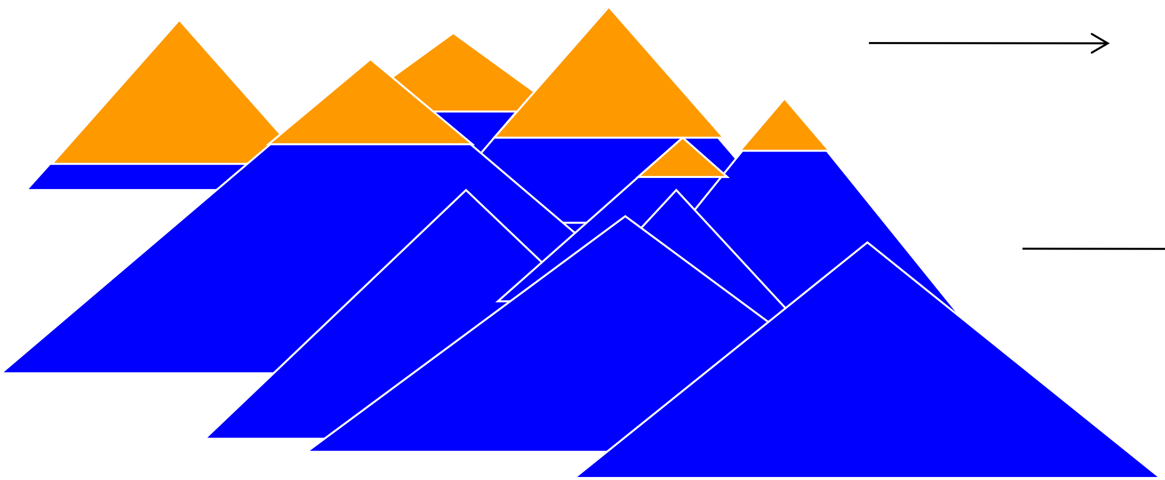
(sheep, cattle)



Dispersed Nucleus

Nucleus: could be defined as

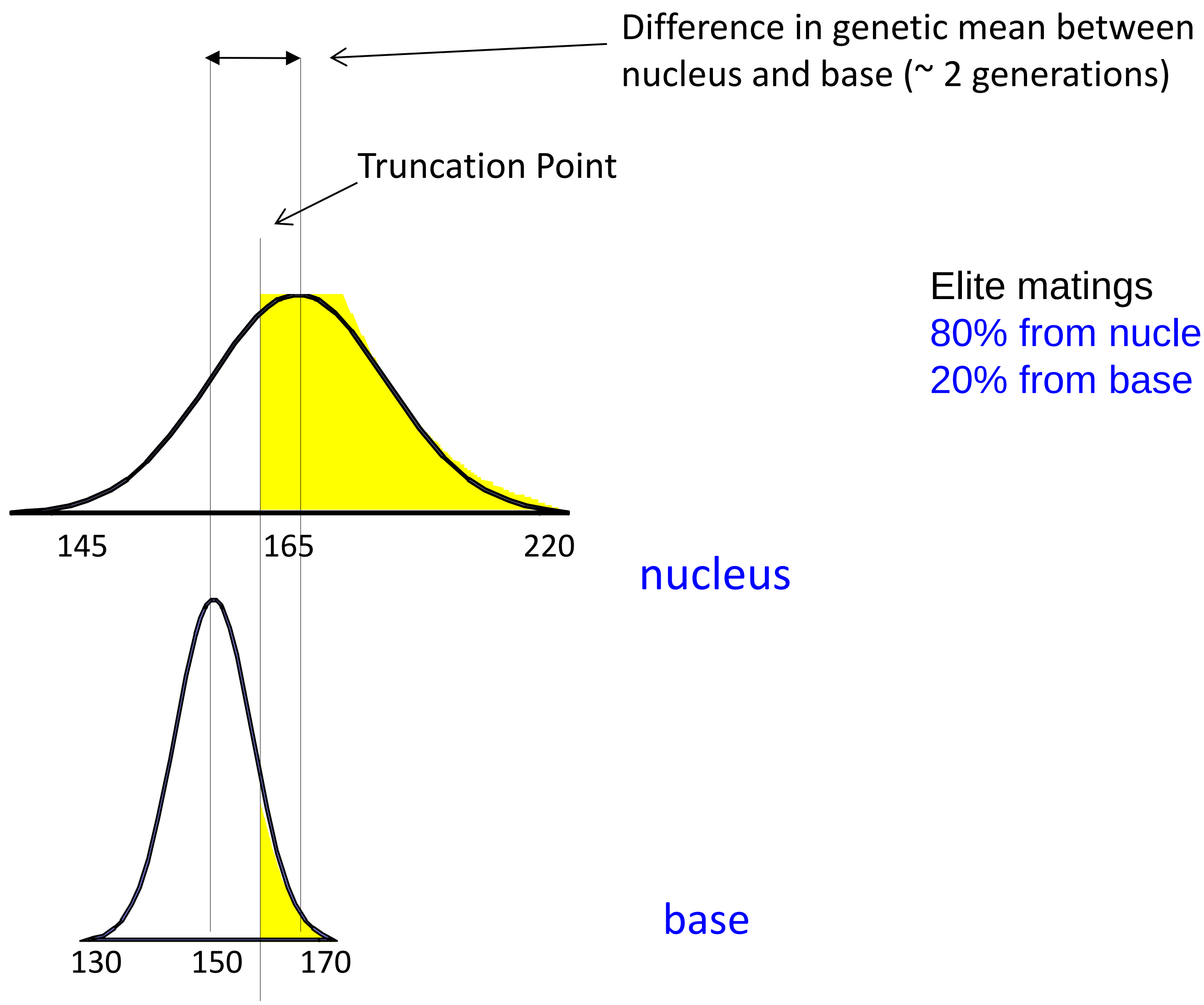
”the mothers and fathers of the future bulls”



Top studs
Delivering the genetics of the future bulls

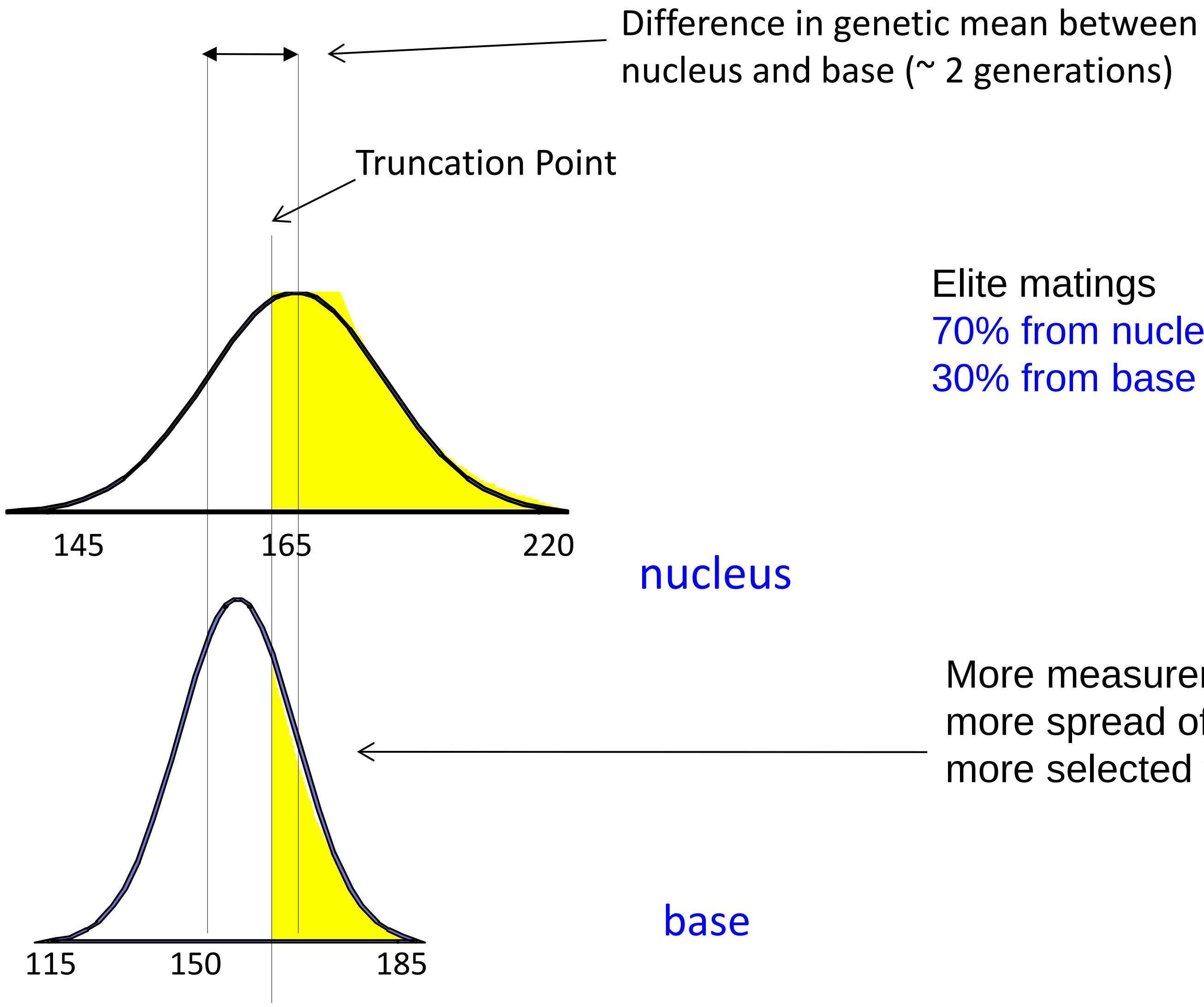
Other studs
Acquire their genetic from top studs
Themselves being merely multipliers

Open Nucleus



Elite matings
80% from nucleus
20% from base

Open Nucleus



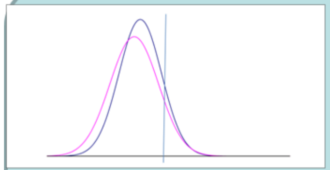
Elite matings
70% from nucleus
30% from base

More measurement in base,
more spread of EBV,
more selected from base

Best to select on EBV, irrespective of accuracy /genotyped or not / age

	birth year	genotyped	progeny	EBV	acc
Kevin	2009	Y	0	+124	71
Tony	2005	N	345	+119	97
Bob	2009	N	0	+117	63
John	2008	N	45	+113	85
Paul	2006	N	1087	+112	99
Geoff	2009	Y	0	+106	40
Malcolm	2007	N	67	+105	89

Example of BLUP selection



Selection intensity

inbreeding

Terminals - Top 150

Analysis Date Friday, 15 June 2001

LAMBPLAN

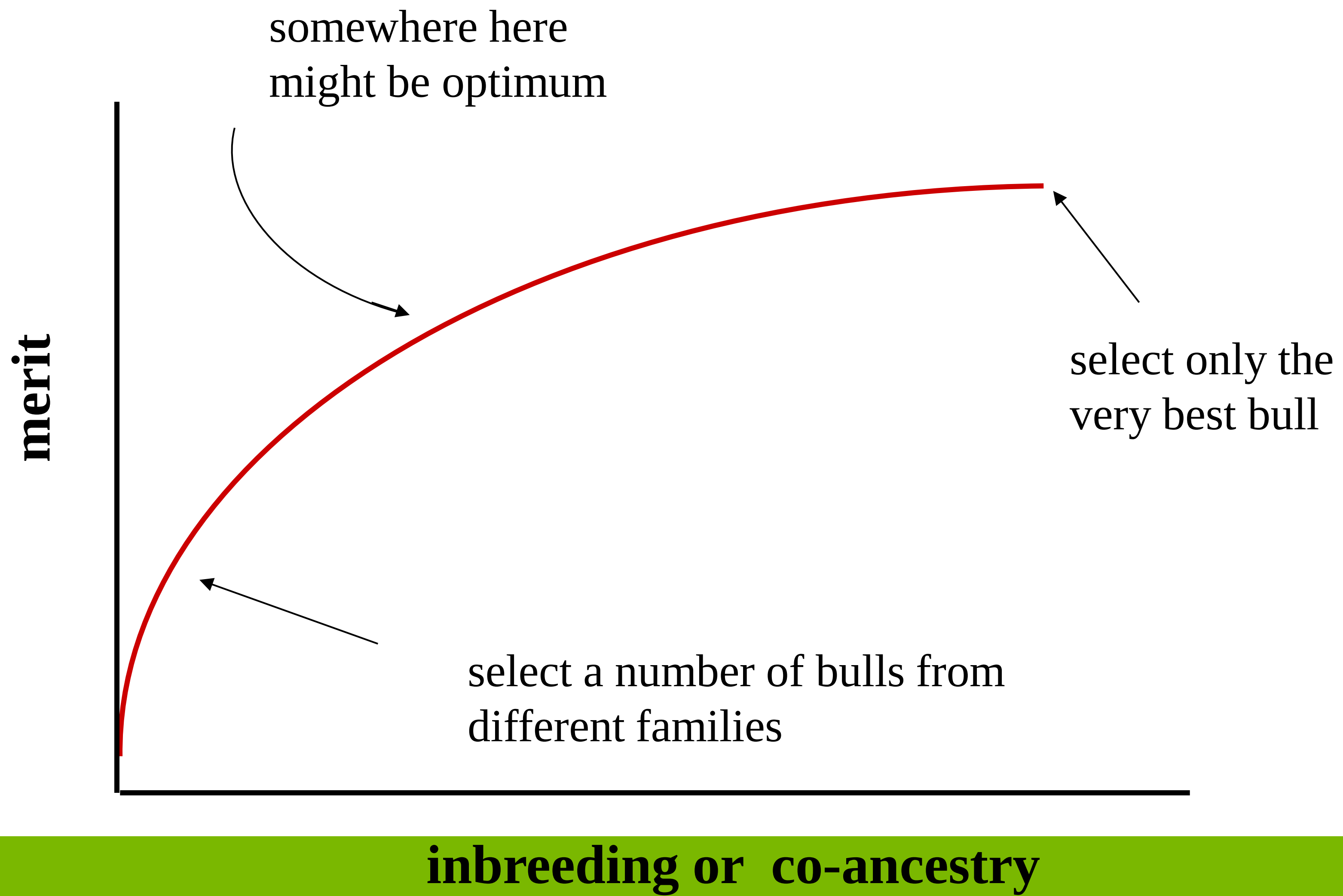
Sires

ID	Stud of breeding	Wwt	Pwwt	Ywt	Pfat	Pemd	Carcase +	Progeny	Inbreeding & Accuracies Coeff	Weight	Carcase	Sire	Sire of Dam
161972-1999-990196	HILLCROFT FARMS	5.46	14.95	14.94	-1.19	1.62	226.64	38	0.133	83	70	1619721998980093	16300019939301
162368-1998-980211	KURRALEA	6.60	12.39	12.69	-0.89	2.50	215.20	1148		97	96	1623681994940260	8600401992920
162204-1999-990453	BETHELREI	8.52	13.38	15.87	-1.18	1.11	211.75	224		93	89	8601221993930205	1619721995950
161972-1998-980093	HILLCROFT FARMS	5.15	14.40	16.00	-1.08	0.25	207.51	12		80	74	1630001993930134	1603361992920
161972-1998-980527	HILLCROFT FARMS	8.46	13.45	10.97	-1.66	-0.47	204.10	25		85	76	1619721996960091	1630001993930
860122-1993-930205	OHIO	6.95	11.94	13.72	-1.60	0.49	203.76	1522		98	97	8601221992920200	8601221987870
161143-1999-990204	DERRYNOCK	8.39	12.10	12.19	-0.49	2.19	203.60	38		82	[illegible]	1623681998980211	164000199393041
160060-1996-960004	ANNA VILLA	8.56	14.90	16.18	-0.48	0.24	200.47	151		93	87	1632801992920016	1623541990900584
161143-1999-990201	DERRYNOCK	5.43	11.83	11.14	-1.19	0.83	199.83	39		83	[illegible]	1623681998980211	1613151995950042
230034-1997-970904	BURWOOD	4.98	11.01	8.82	-2.27	-0.55	198.82	380	0.003	96	92	2300091994940171	2300341994940314
163677-2000-000140	FELIX	6.69	13.56	13.36	-0.59	0.61	197.98	56		70	63	1619721995950289	1600341994940020
160060-1997-970115	ANNA VILLA	6.30	14.47	11.69	-0.42	0.24	196.90	118		90	83	1600601996960004	1600601992920057
162204-1999-990394	BETHELREI	7.42	12.97	14.27	-1.03	0.14	196.85	24		82	74	8601221993930205	1622041996960579
161143-1999-990064	DERRYNOCK	5.10	11.20	10.10	-0.72	1.60	196.01	18		80	74	1623681998980211	1640001994940317
161972-1996-960020	HILLCROFT FARMS	5.32	12.96	10.66	-0.80	0.36	195.20	83		88	75	1630001993930134	
160185-1996-960001	JOLMA	6.19	10.29	10.42	-1.56	0.63	194.57	101		90	83	1630001993930134	1613151991910870
161235-1997-970830	POLLAMBI	7.10	10.69	10.35	-0.88	1.50	194.54	34		87	79	1700991993930002	1612351991910691
163677-1999-990307	FELIX	7.09	12.52	11.59	-1.29	-0.47	192.45	54		83	74	8601221993930205	1636771994940008
162368-1999-990290	KURRALEA	5.53	10.84	10.58	-0.62	1.59	192.11	68		69	62	1623681998980211	1630001993930160
860074-1995-950044	ADELONG	7.17	14.47	13.22	-0.80	-0.94	191.15	448		96	94	8600741993930189	
163000-1998-980575	RENE	7.59	12.01	13.06	-0.50	0.99	190.92	12		71	60	1623681994940260	8600371992920165
162368-1997-970443	KURRALEA	6.58	12.13	7.96	-1.00	0.08	190.69	178		88	83	1640001993930411	8600401992920175
160034-1999-991208	MOSSLEY	5.52	13.45	10.27	-0.53	0.04	190.41	17	0.003	78	70	1621001998980130	1600341994940171
161437-1999-990006	WARBURN	5.41	10.97	10.93	-1.21	0.37	190.26	14		73	65	1604621994940012	1640001993930411

These are sibs so might not select all of them as flock sire

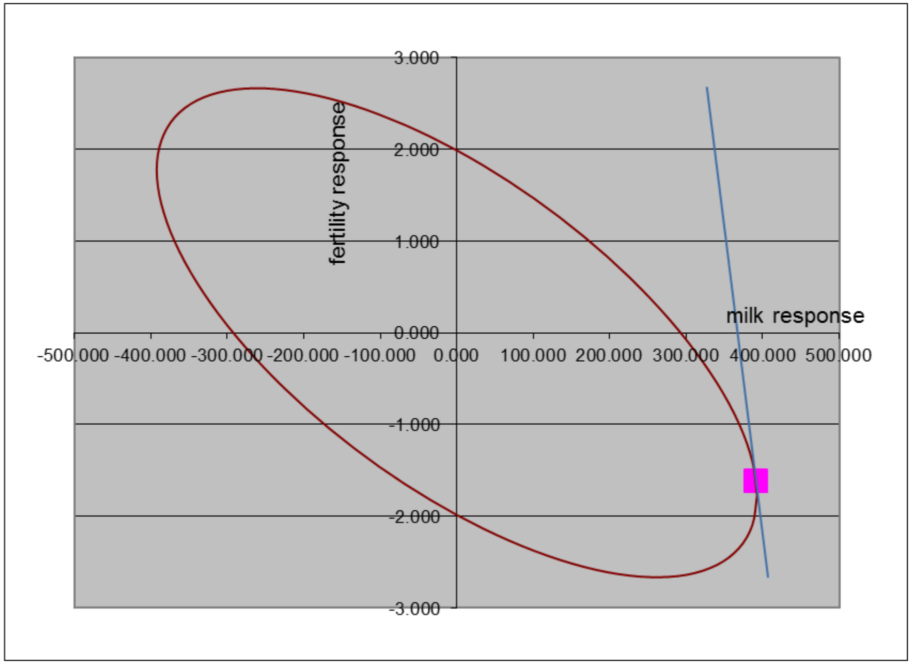
Balancing inbreeding and merit

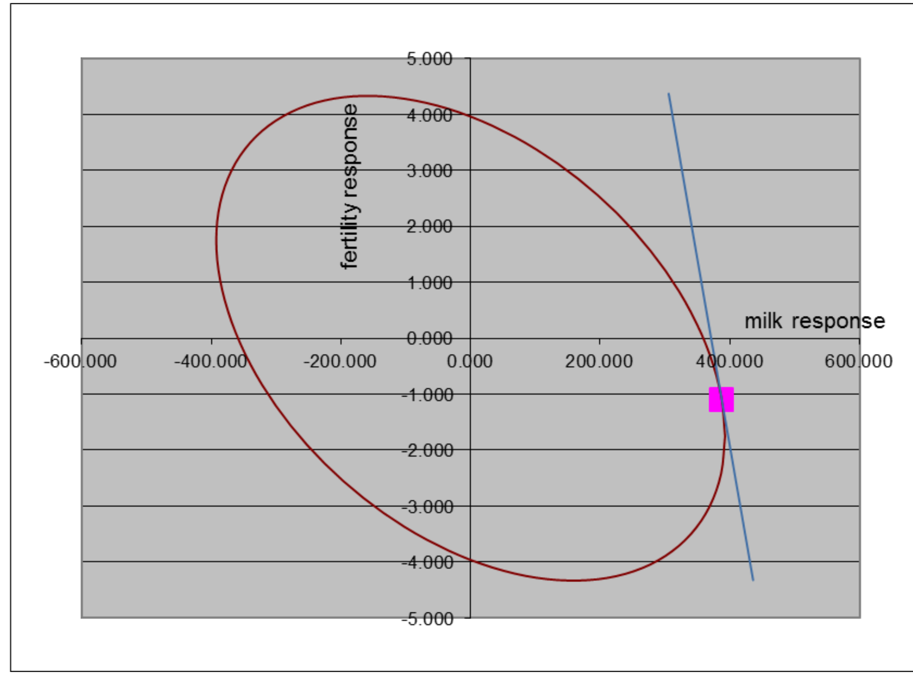
This graph will look different for each population



Selection for milk Yield and Fertility

Multiple traits





	economic	*weights*	*progeny*	*measured*	*response*	*(4 yrs)*
	milk	*fertility*	*milk*	*fertility*	*milk*	*fertility*
left	0.2	**3**	50	10	391	-1.61
right	0.2	**3**	50	50	387	-1.09

Effect of Reproductive Technologies

Making genetic progress is about

Selecting only the very best

Selecting accurately

$$R = \frac{i_m r_m + i_f r_f}{L_m + L_f} \sigma_A$$

Keeping generation intervals short

Reproductive rates affect all of the above!

Reproductive technologies

- Reproductive boosting
  - Artificial insemination, AI
  - Multiple Ovulation and Embryo Transfer, MOET
  - Oocyte Pickup
  - Juvenile In Vitro Embryo Transfer, JIVET
- Sexing of semen and embryos
- Cloning
- Whizzy Genetics - breeding in a test-tube

Reproductive (boosting) technologies

- Increases selection intensities
- Increases accuracy of EBVs
- Decreases generation intervals
- Increases inbreeding

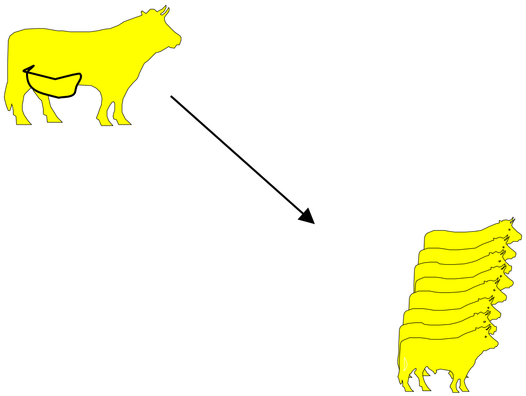
Artificial Insemination

- More intensive use of best sires
- Use of overseas bulls
- Establish links between herds
- Progeny testing

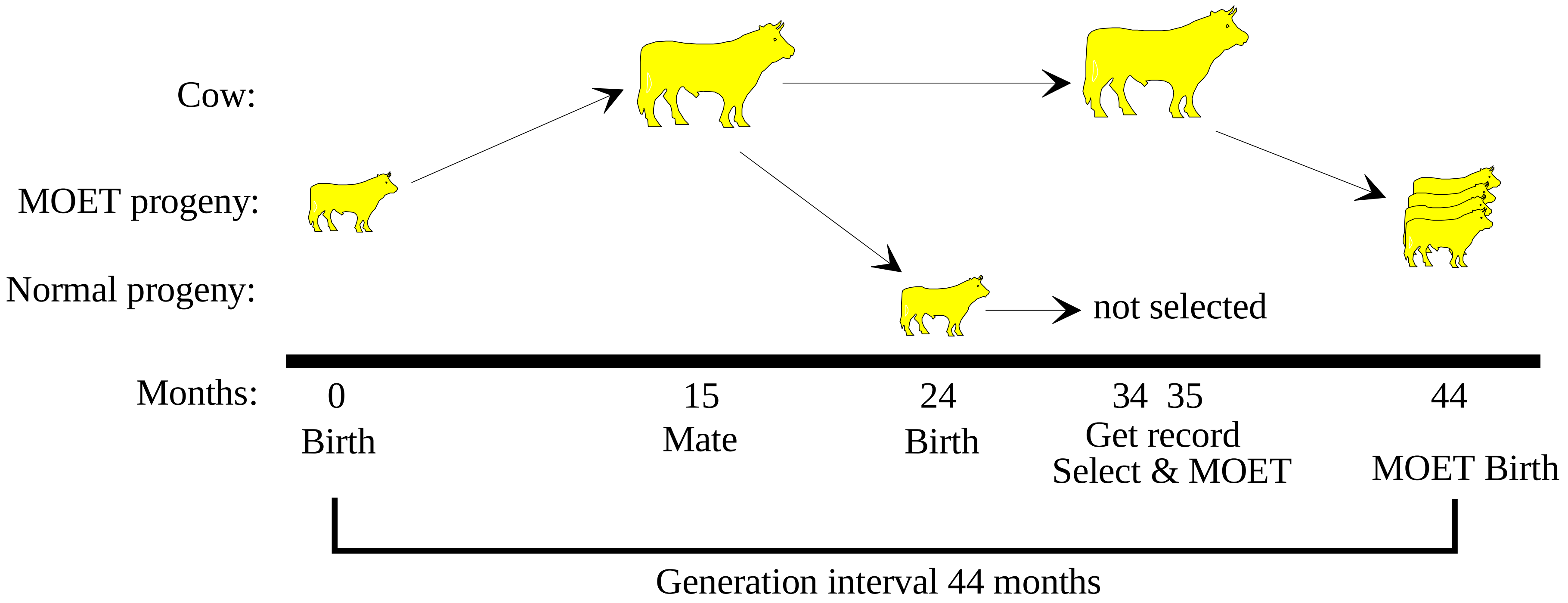
- More rapid dissemination of superior genes

Multiple Ovulation and Embryo Transfer - MOET

- More intensive use of best cows
  - *"turns a cow into a sow"*
- Use of overseas cows

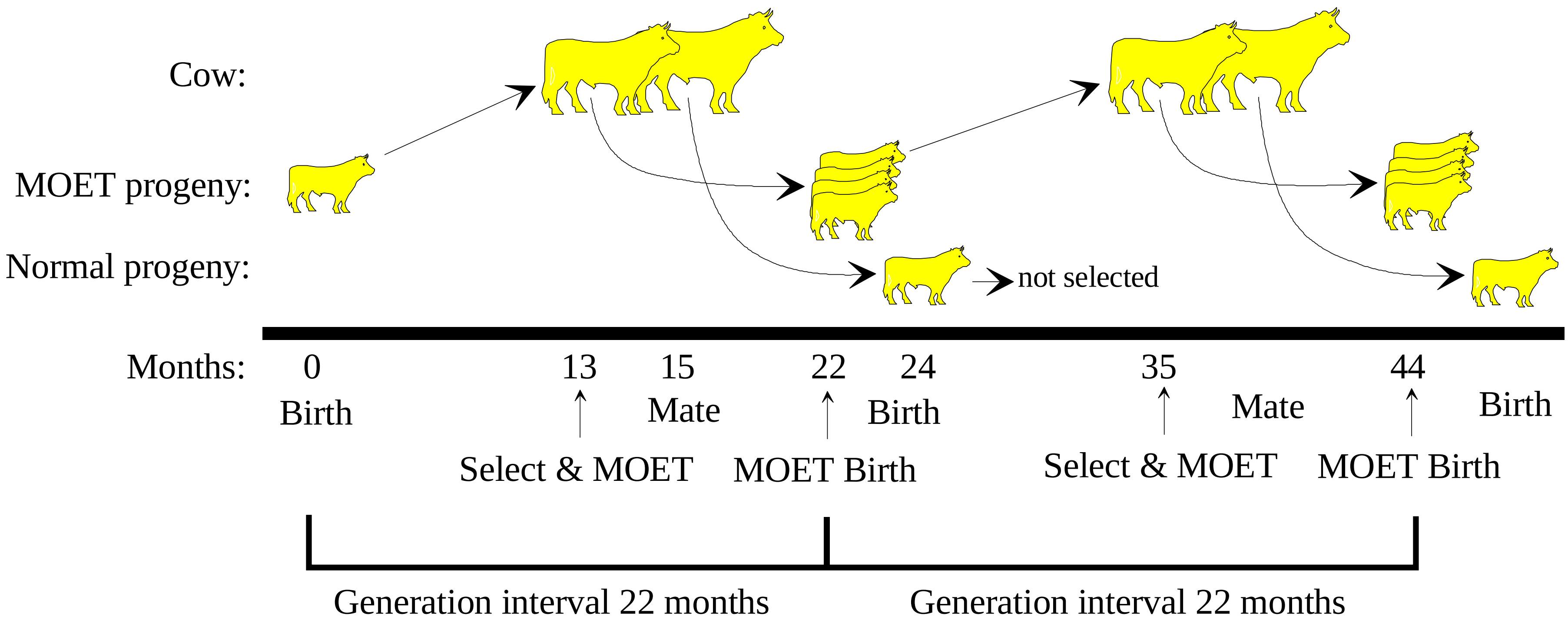


Adult dairy MOET scheme



More offspring of top cow *after* testing it

Juvenile dairy MOET scheme



More offspring of top cow *before* testing it

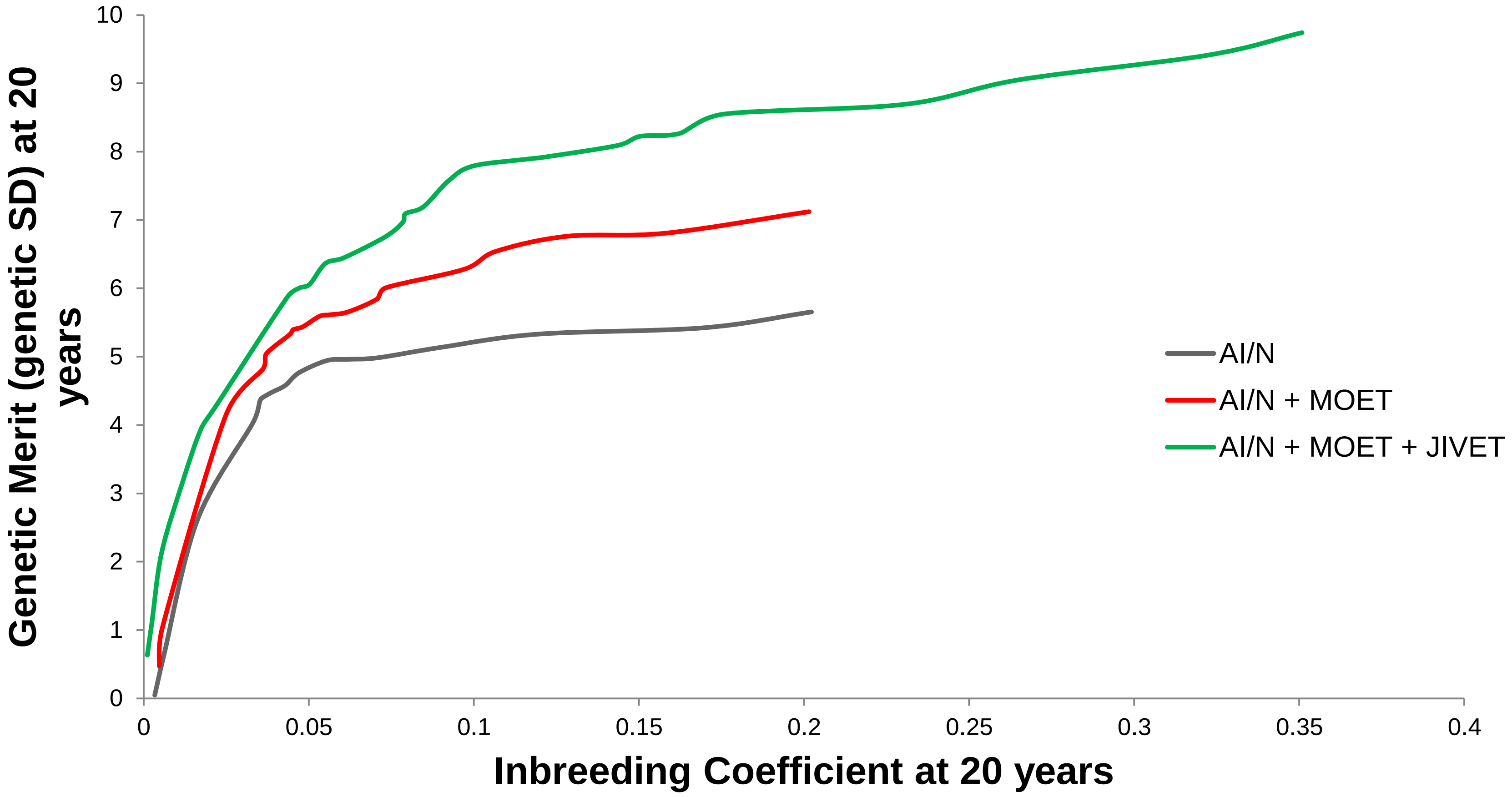
Select base on parent average

Genetic gain versus genetic diversity

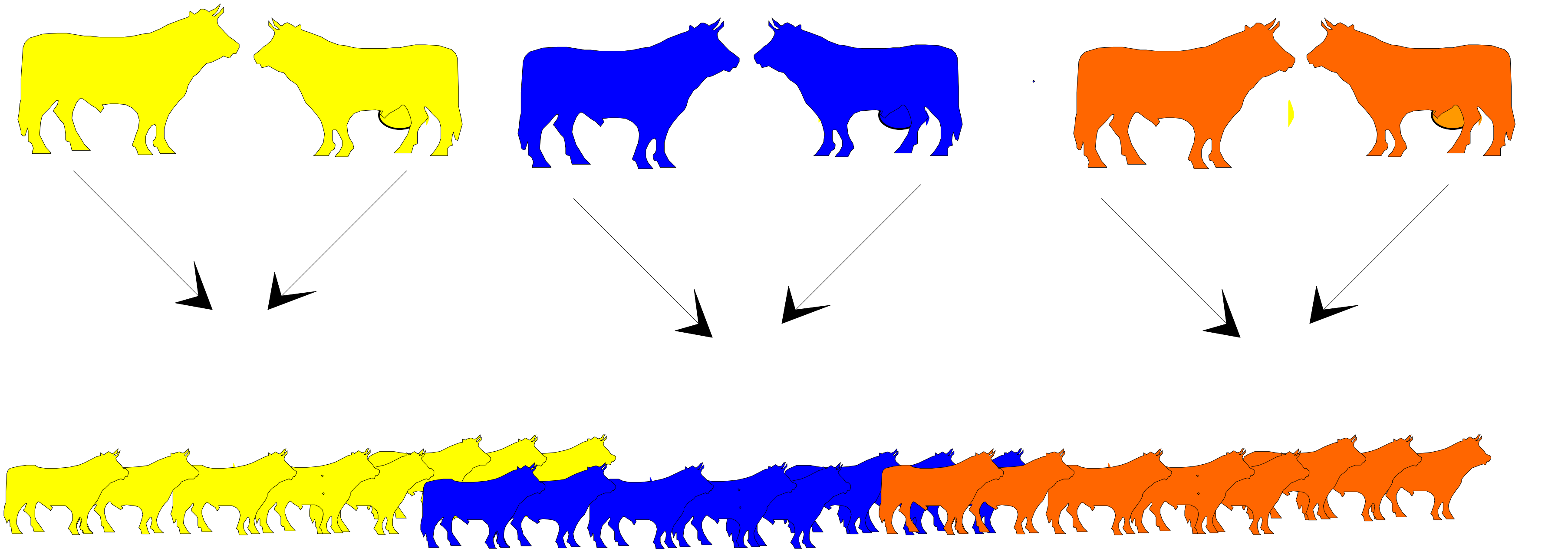
- Early selection can only be based on family information
- Sustainable breeding programs require optimal selection balancing genetic gain and genetic diversity
- Potential short term benefits from reproductive technologies are inhibited by the need to maintain diversity

Genetic Gain vs Inbreeding After 20 Years

Tom Granleese et al., AAABG 2013



Between versus within family selection



Own information (performance or *genotype*):

More variation within families

More within-family selection – ***less inbreeding***

Advantage of genomic selection

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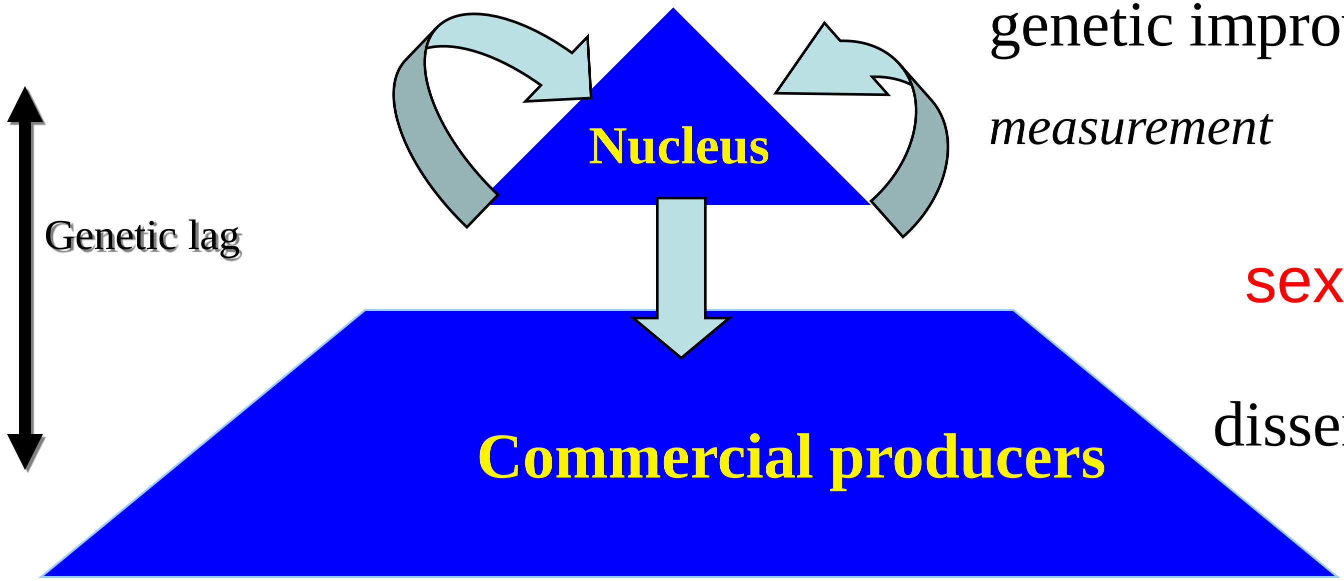
Reprod technol. In a breeding design context



AI, MOET, JIVET

genetic improvement

measurement

sexing, cloning

dissemination

Effect of Measurement

Some important points about MT selection

1 The ultimate response of a trait will depend on:

choice

its relative economic weighting

accuracy of its EBV

correlation with other EBVs

genetic parameters

We can control these

what has been measured

This includes genomic information!

Selection for milk Yield and Feed Intake

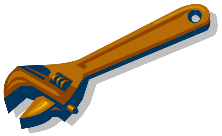
economic	*weights*	*progeny*	*measured*	*response*	*(4 yrs)*
milk	*feed*	*milk*	*feed*	*milk*	*feed*
0.2	0	50	-	1.23	0.56
0.2	0	50	50	1.23	0.59
0.2	**-0.2**	50	-	1.23	0.56
0.2	**-0.2**	50	50	0.97	0.16
0.2	**-0.3**	50	-	1.23	0.56
0.2	**-0.3**	50	50	0.52	-0.20
0.2	**-0.3**	50	10	0.79	0.14

To achieve response for a trait, we need to give it some weight

but we also need some data!

Decision Support

<u>Tools</u>



Where to go?	BreedObject, Indexes
Who and what to measure?	*Not much*
Who to select and mate?	EBVs, Indexes, TGRM

Tactical Decisions

vs

Strategic Decisions → Prediction and Simulation models

Optimizing Phenotyping

Cécile Massault, Brian Kinghorn and Julius van der Werf

Maximize the accuracy of selection candidates (offspring)
We have $$ for 15 phenotypes, who?

	Structure	# GP	# sires	# dams	# offspring	Family size
PED1	HS	66	3	30	30	10 10 10
PED2	FS	12	3	3	30	10 10 10
PED3	HS	66	3	30	30	2 10 18
PED4	FS	12	3	3	30	2 10 18

Pedigree structure	Heritability	TACT	RAND	OFFS	SIRE
PED1	0.1	63	33	51	63
	0.5	69	38	60	69
	0.8	72	40	62	69
PED2	0.1	73	63	71	69
	0.5	84	75	84	80
	0.8	84	76	84	80
PED3	0.1	66	32	61	64
	0.5	71	40	69	69
	0.8	73	42	70	71
PED4	0.1	77	67	75	73
	0.5	85	77	84	82
	0.8	85	77	82	81

Need to consider

Added value to a family
Merit of the family
Size of the family
Relatedness to other candidates

Predict future potential gain:

→ Merit versus diversity

Evaluating Breeding programs

- Deterministic vs Stochastic Simulation
- Optimization strategies