Optimizing Breeding Programs

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

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!

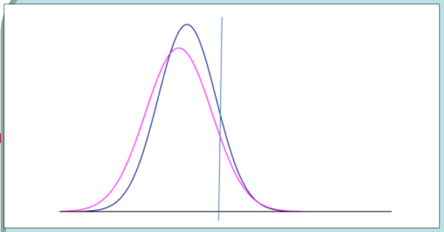
Aspects that need to be balanced:

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

- 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

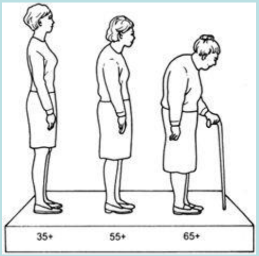
Aspects that need to be balanced

Selection accuracy



Selection intensity

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

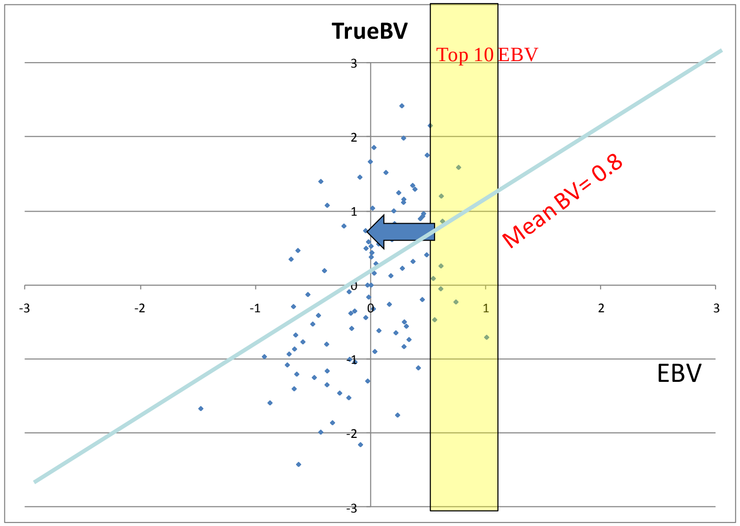


Generation Interval

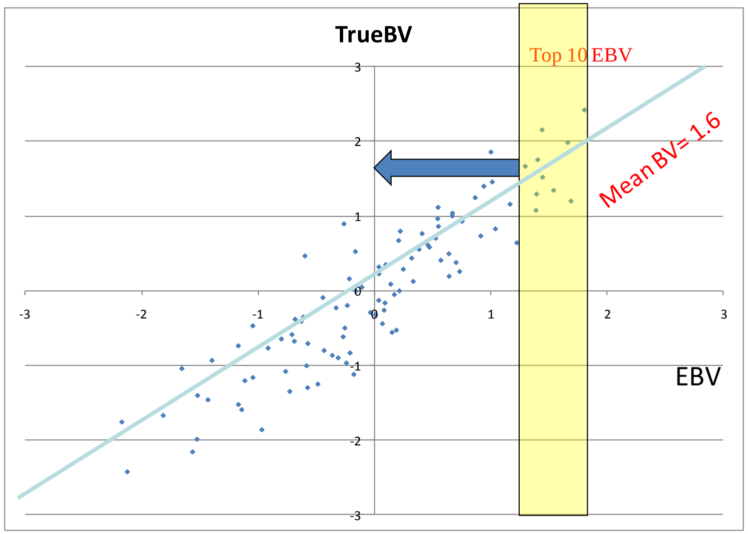
Inbreeding

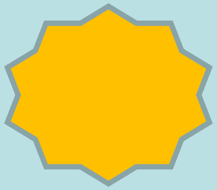
Multiple traits

Cost Benefit



Accuracy = 45%



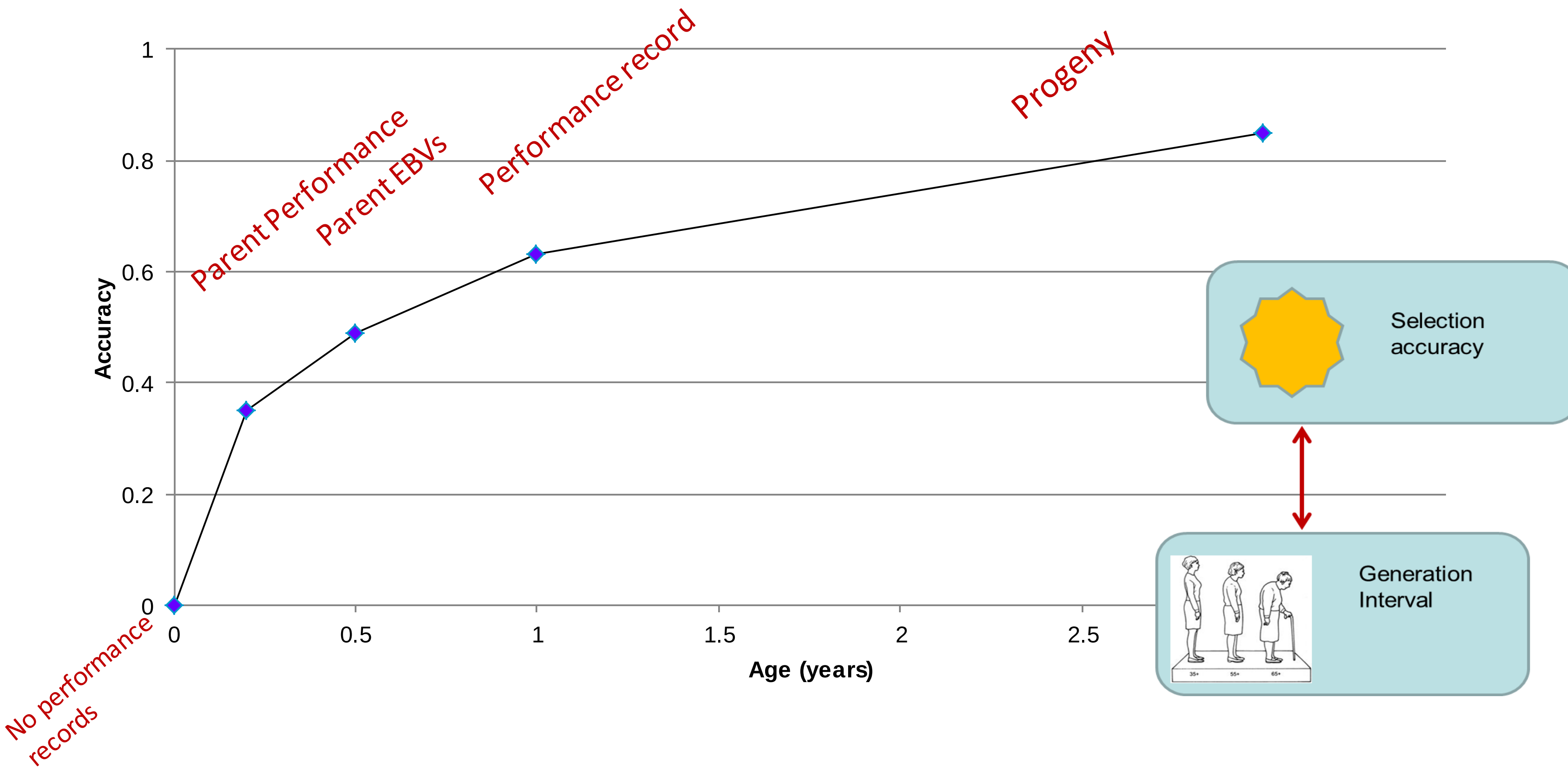


Selection accuracy

the more accuracy,
the more response

Accuracy of predicting a breeding value

- increases as an animal gets older

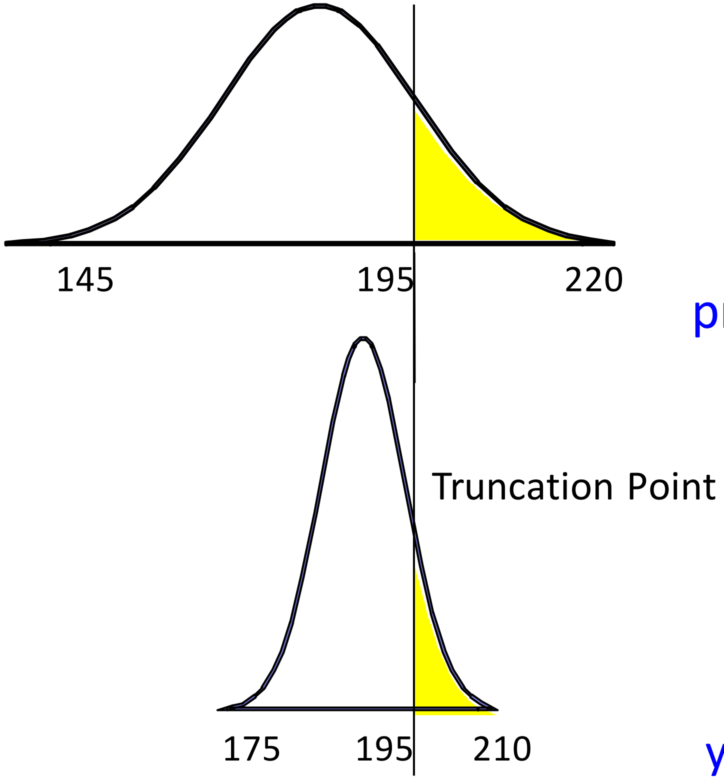


Assumed heritability = 25%

Need to balance accuracy and generation interval!

BLUP helps selecting between old and young bulls

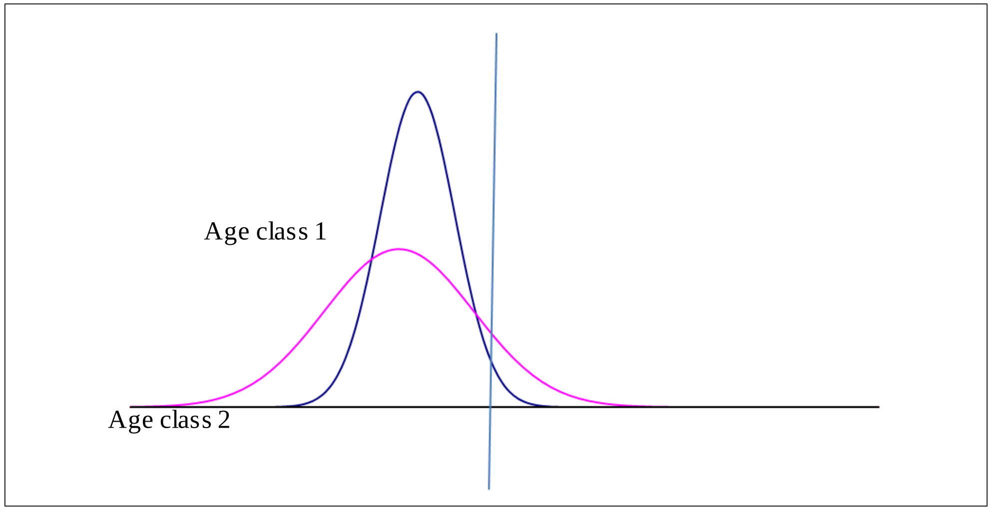
- EBVs can be compared directly over age classes
- Selection on BLUP EBVs optimizes generation interval

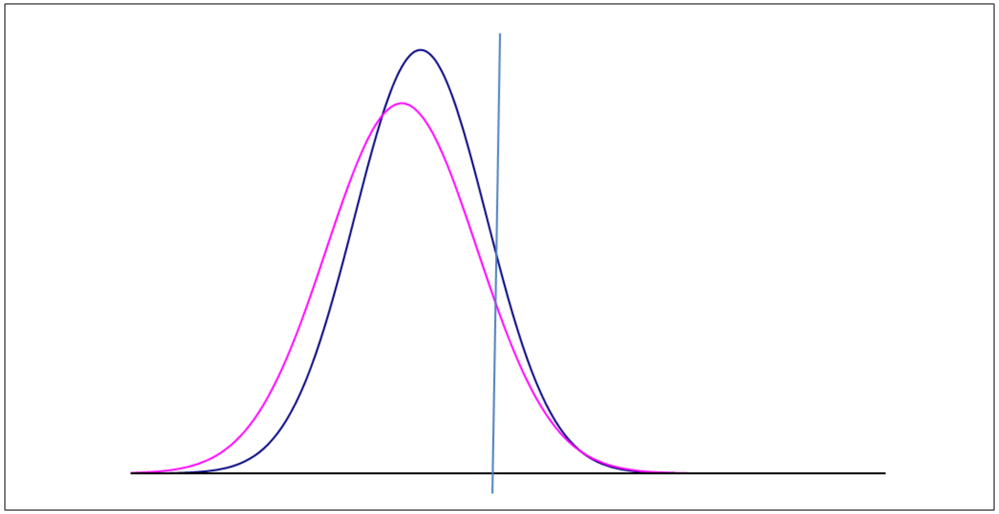


proven sires

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

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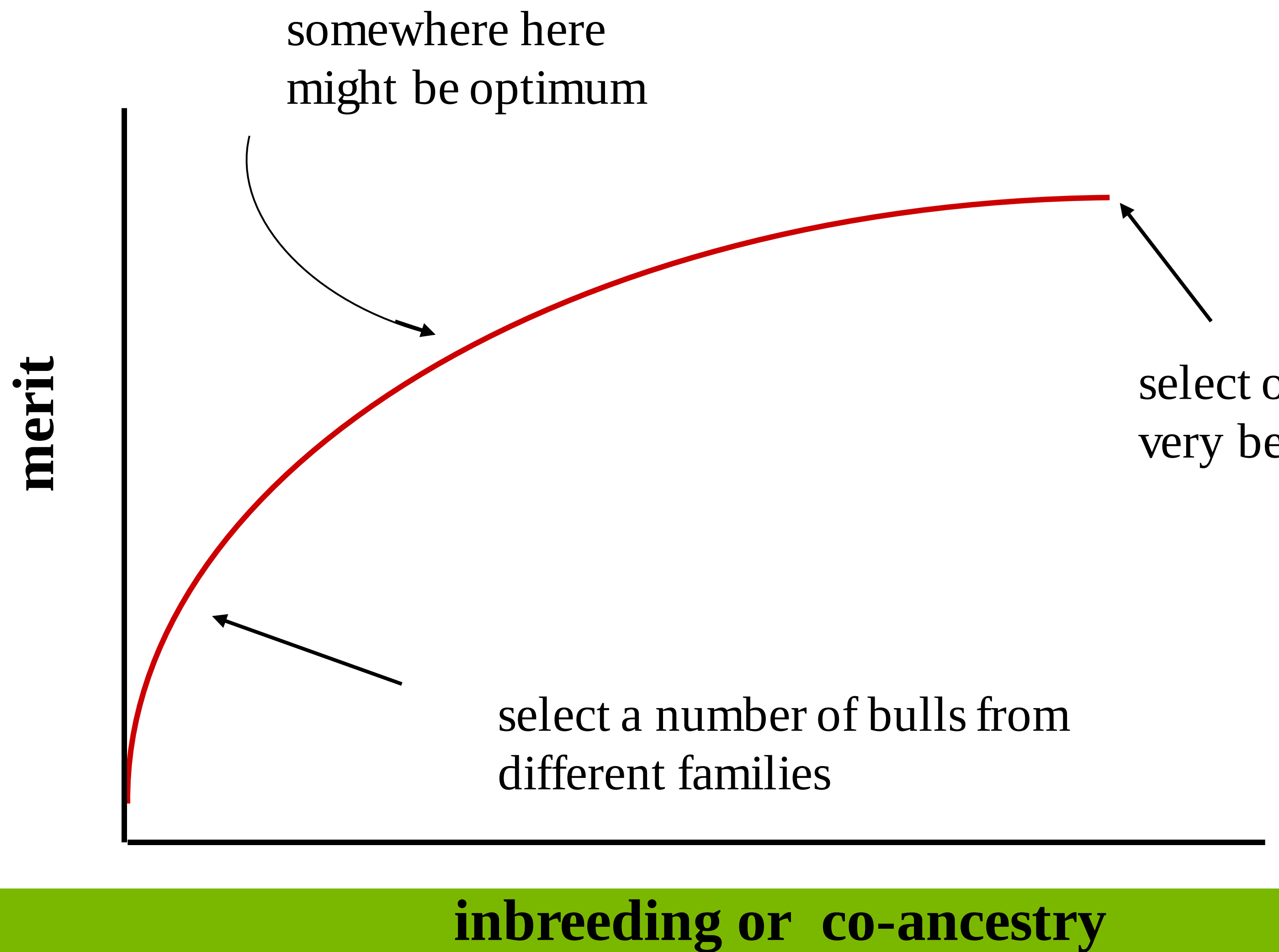
Best to select on EBV, irrespective of accuracy /genotyped or not / age

	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

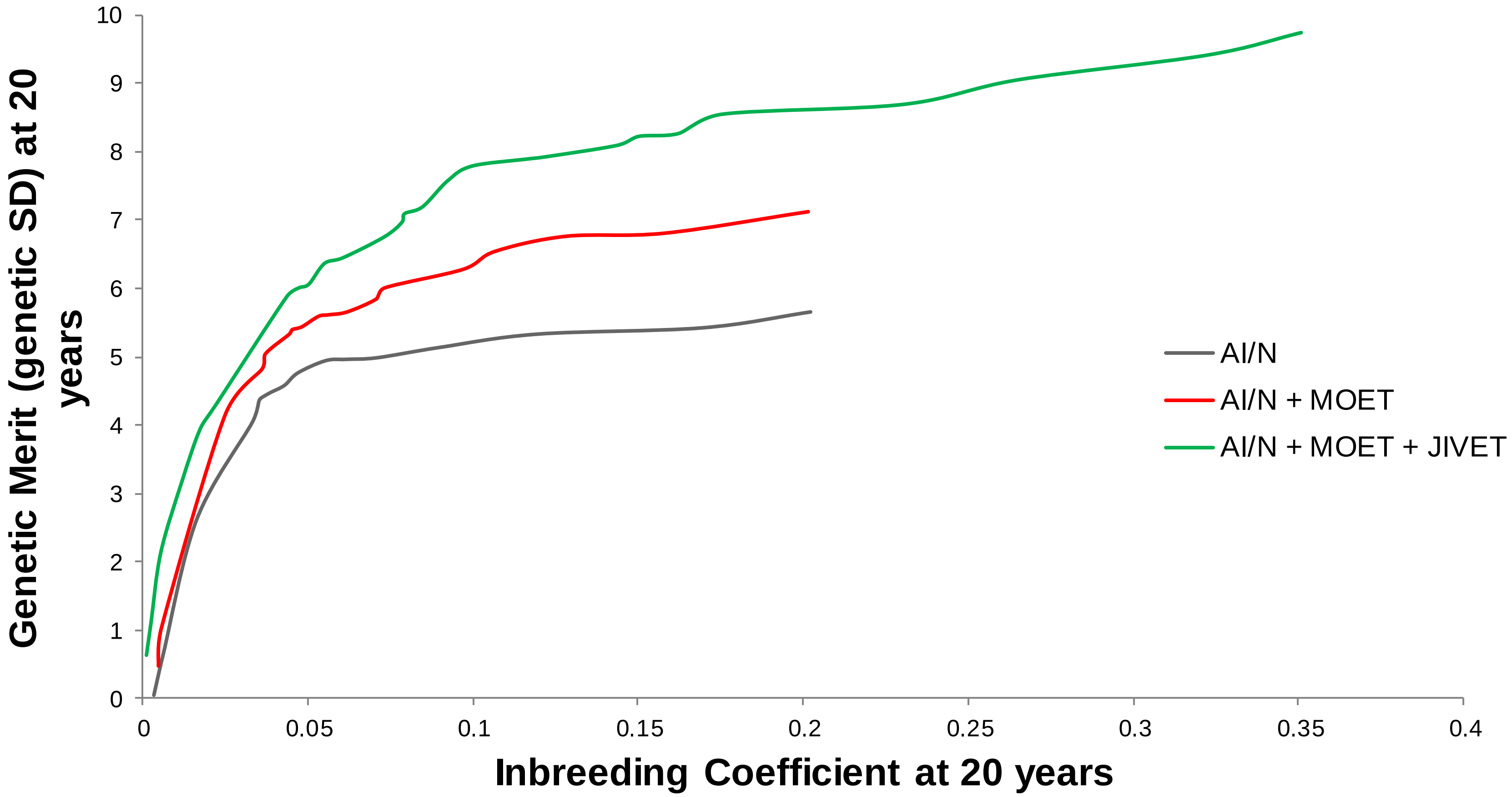
Balancing inbreeding and merit

This graph will look different for each population

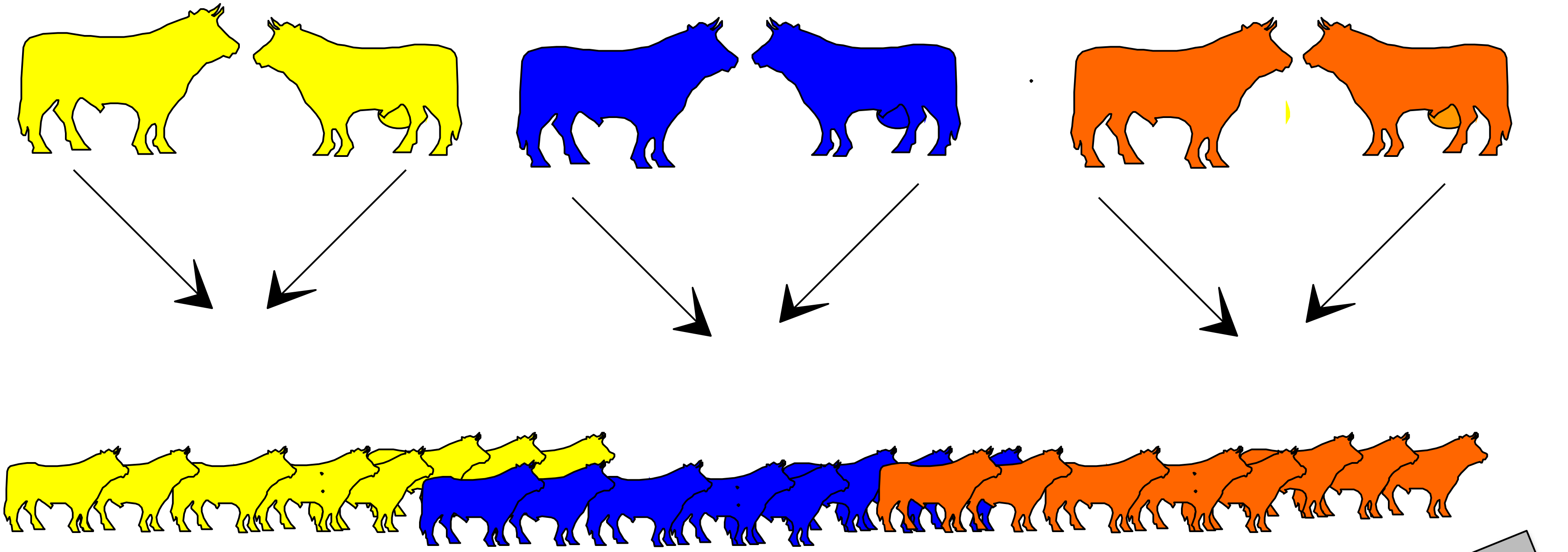


Genetic Gain vs Inbreeding After 20 Years

Tom Granleese et al., AAABG 2013



Between versus within family selection



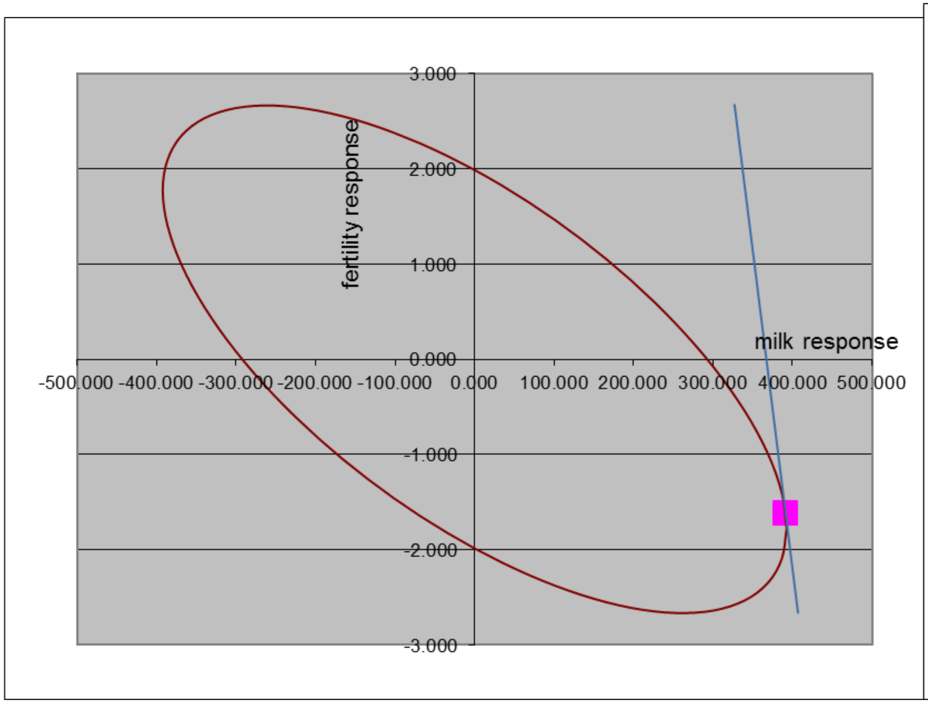
<u>Own information</u> (performance or *genotype*):

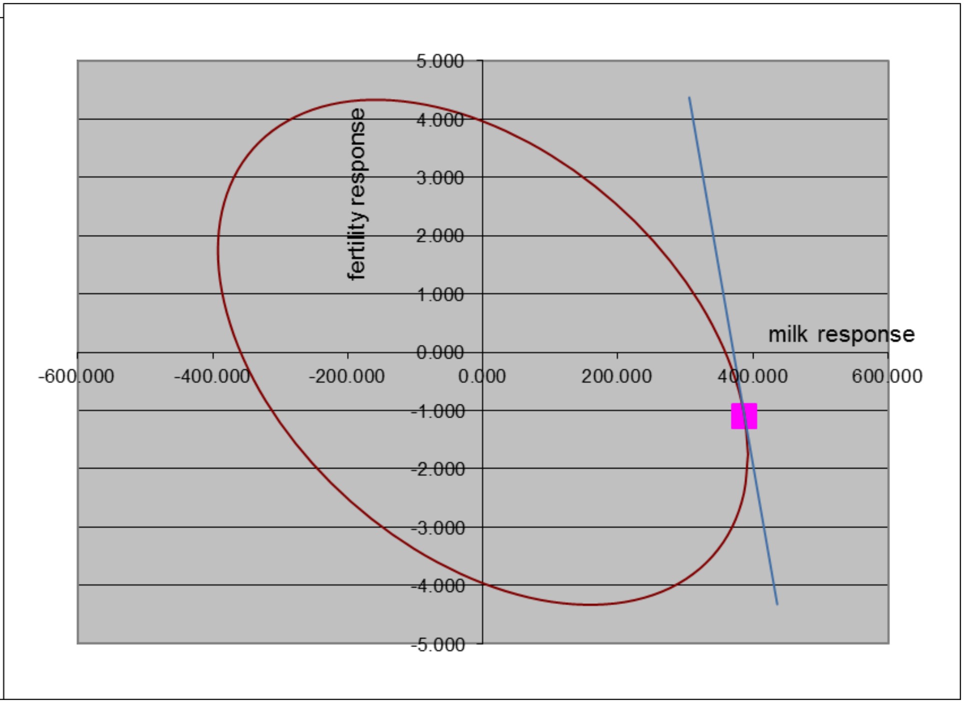
More variation within families

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

Balancing Traits, weights and information

Multiple traits





Usually push the traits that have more information/higher EBV accuracy

→ Balance may change with genomic information on 'hard to measure traits'

Importance of Trait measurement

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!

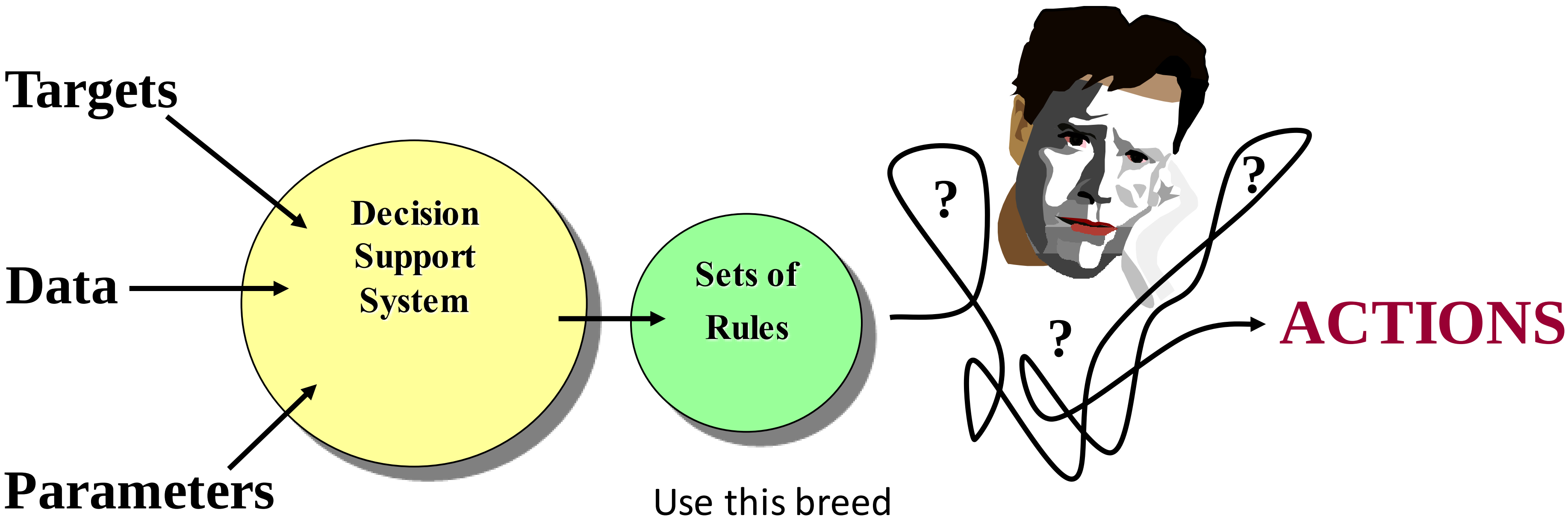
Evaluating Breeding programs

- Deterministic vs Stochastic Simulation
- Optimization strategies
- Rule based vs tactical design of breeding programs

Implementation of programs ...

- Rules-based approach:
  - "Start joining on 1st February"
  - "Use best 10 rams mated to best 400 ewes"
  - "Set up a rotational cross"
- Tactical approach
  - Maximise impact of selection and mating, based on ***prevailing*** animals, markets, costs, constraints and opportunities.

Rules-based approach to Design



Use this breed

Select on EBV

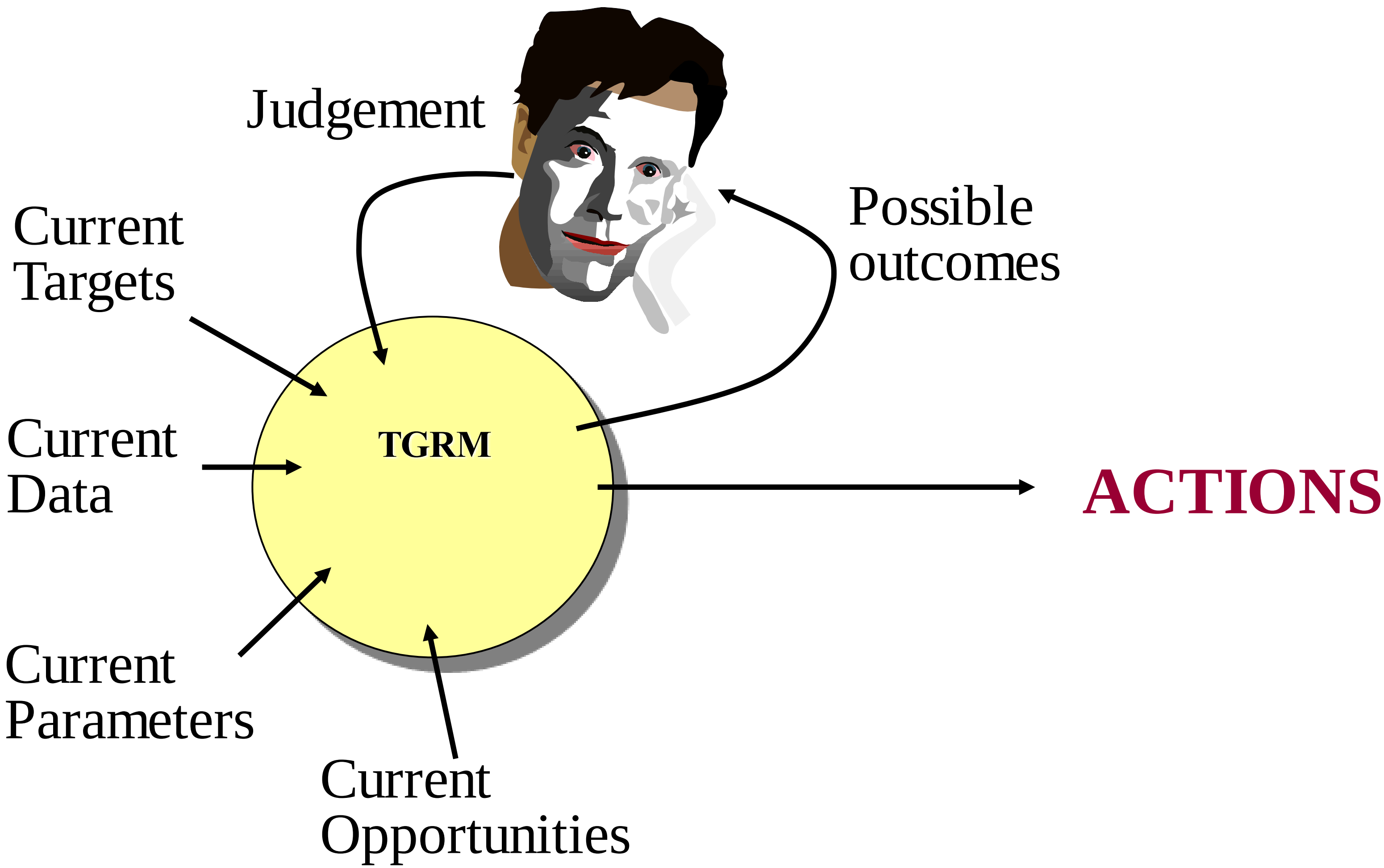
Age at culling

Connect herds

…etc.

Tactical approach to Design

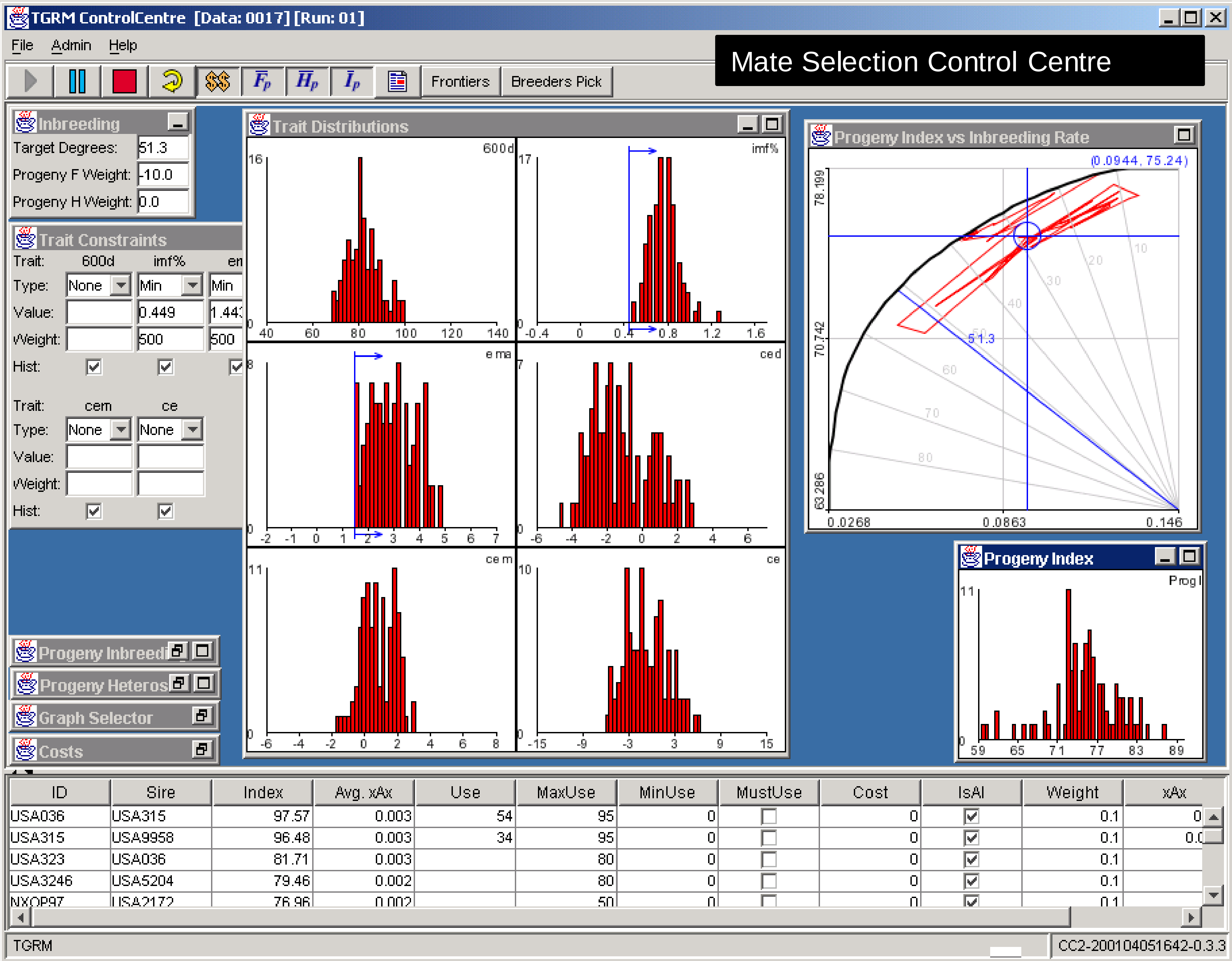
Action Decision Systems



Mate allocations ...

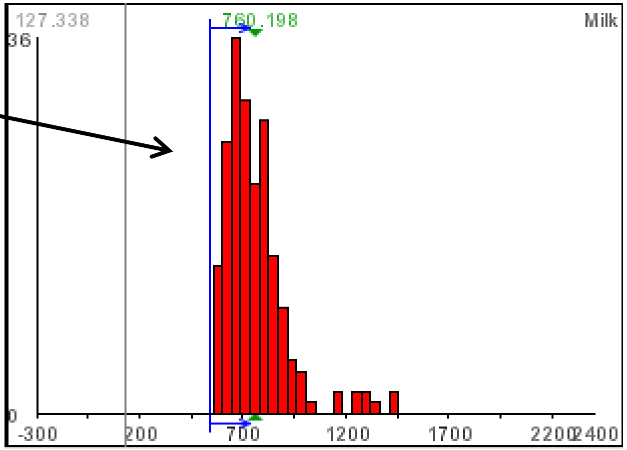
EPD / Cost	+1 / 0	+2 / 10	+10 / 10
+10 / 0	311	312	335
+25 / 3	341	322	322
+20 / 2	309	330	345

Mate Selection Control Centre



Achieving Trait Constraints

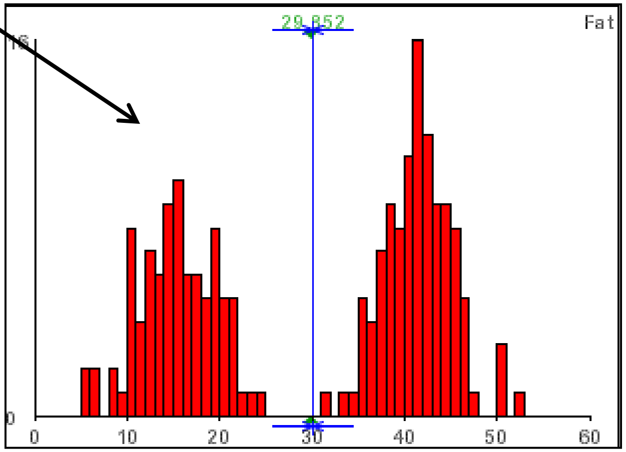
All progeny are predicted to be above the restriction of +545Kg



Predicted progeny Milk EBVs

Achieving Trait Constraints

Targeting two different objectives in one cycle of matings

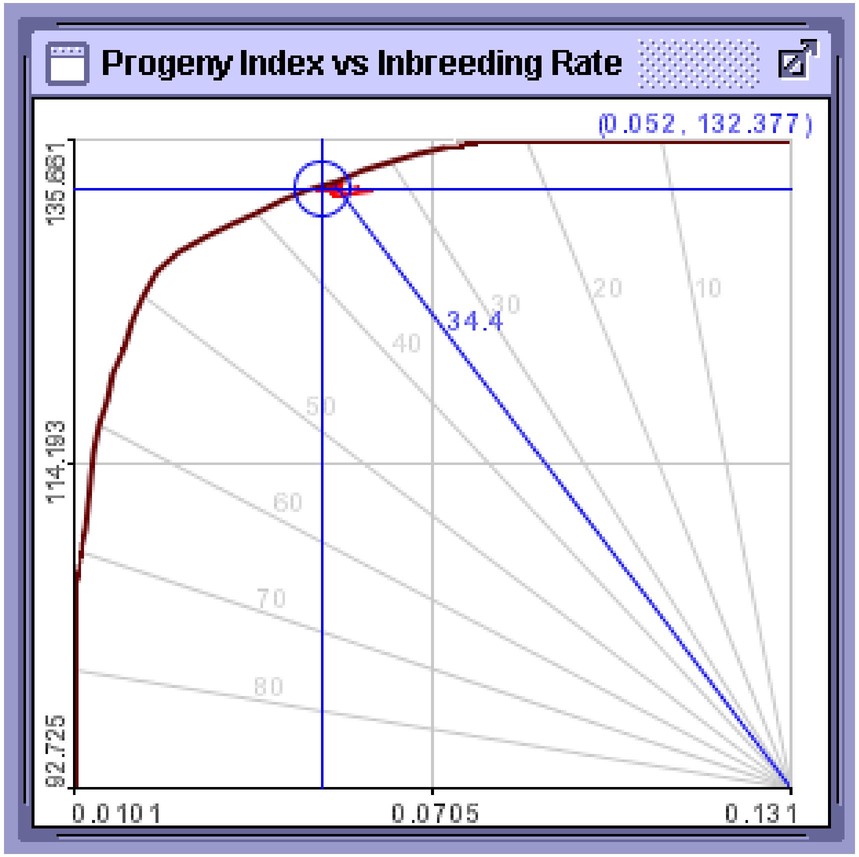


Predicted progeny Fat EBVs

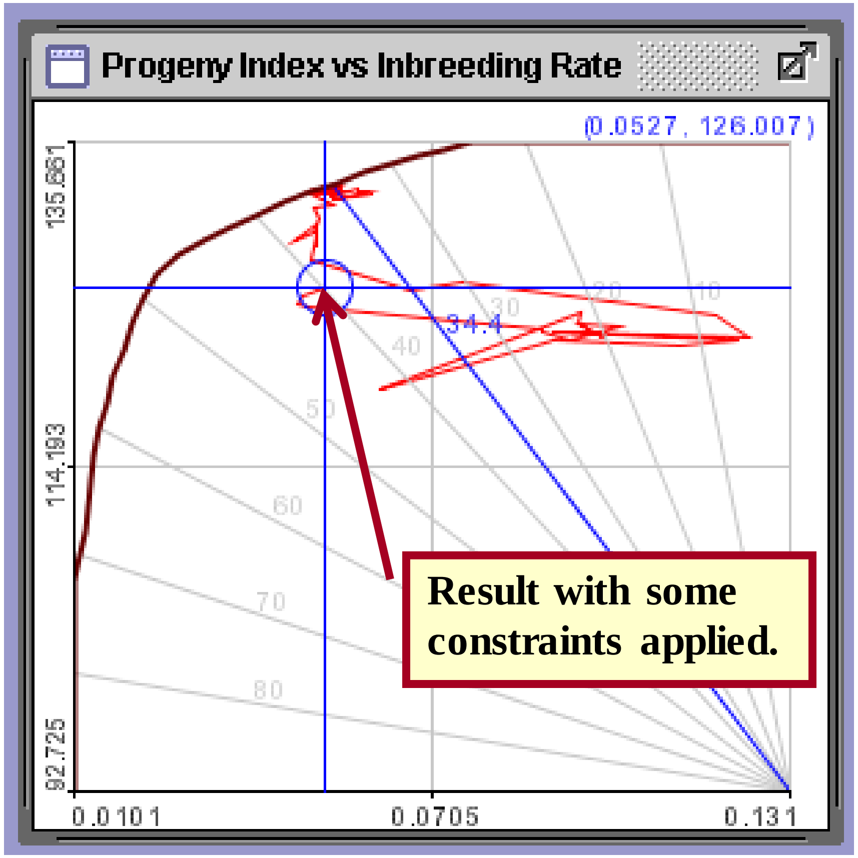
Imposing constraints

(eg. Sire use, QTL outcome, trait distributions)

Predicted progeny index



Mean parental coancestry



Mean parental coancestry

Output: Mating List

Mating List - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Shop Stop

Bookmarks Location: http://tgrm.une.edu.au/servlet/reports_show/987823367381_0018_01/matlst0.htm What's Related

Total Genetic Resource Management

Report List

Mating List (by Sire)

Report Summary | Sires Summary | Mating List | Mating List (CSV) | Mating List (TXT)

up|down Sire	up|down Dam	up|down index	up|down F	up|down SireCoan	up|down DamCoan	up|down SortIndex	up|down 600d-1	up|down 600d-2	up|down imf%	up|down ema-1	up|down ema-2	up|down ced	up|down cem	up|down ce
USA3246	T229	66.68	0.0156	0.003228	0.000138	64.9366	88.00	88.00	0.50	0.15	0.15	1.25	-0.70	0.02
USA3246	T213	70.18	0.0000	0.003228	0.000175	69.9997	81.50	81.50	0.65	1.55	1.55	2.35	0.48	3.48
USA3246	T157	64.68	0.0235	0.003228	0.000000	62.1640	85.00	85.00	0.45	0.20	0.20	2.81	-1.08	0.83
USA3246	T137	65.64	0.0000	0.003228	0.000000	65.4690	72.00	72.00	0.70	0.40	0.40	2.88	1.52	6.09
USA3246	T117	68.09	0.0078	0.003228	0.000087	67.1344	76.00	76.00	0.65	1.45	1.45	2.80	0.81	4.59
USA3246	T063	76.10	0.0039	0.003228	0.000000	75.5340	77.00	77.00	0.90	1.35	1.35	-0.09	0.03	0.14
USA3246	T057	73.06	0.0000	0.003228	0.000000	72.8840	70.00	70.00	0.90	-0.55	-0.55	2.74	0.34	3.60
USA3246	T029	64.08	0.0235	0.003228	0.000132	61.5570	77.50	77.50	0.60	0.40	0.40	3.38	-0.97	1.62
USA3246	T020	75.63	0.0078	0.003228	0.000000	74.6740	90.50	90.50	0.65	1.45	1.45	1.87	-0.43	1.17
USA3246	T013	67.38	0.0000	0.003228	0.000133	67.2019	77.50	77.50	0.70	1.20	1.20	1.69	0.48	2.82
USA3246	T008	72.18	0.0000	0.003228	0.000298	71.9982	73.50	73.50	0.75	1.05	1.05	3.04	2.21	7.62
USA3246	S305	63.88	0.0078	0.003228	0.000141	62.9215	81.50	81.50	0.55	1.35	1.35	-0.42	-0.71	-1.67
USA3246	R001	66.58	0.0000	0.003228	0.000000	66.4090	67.50	67.50	0.80	1.35	1.35	3.75	1.14	6.20
USA3246	Q075	62.24	0.0000	0.003228	0.009841	61.5426	84.00	84.00	0.55	0.35	0.35	2.09	0.25	2.76
USA3246	Q001	73.62	0.0000	0.003228	0.000000	73.4490	73.00	73.00	0.80	1.30	1.30	2.50	0.36	3.40
USA323	R211	67.93	0.0000	0.000296	0.000093	67.9094	87.50	87.50	0.55	2.85	2.85	-3.00	-2.26	-8.13
USA315	T99	74.46	0.0000	0.022720	0.000116	73.2452	89.50	89.50	0.70	2.00	2.00	0.22	-0.21	-1.76
USA315	T270	79.83	0.0000	0.022720	0.000000	78.6263	94.00	94.00	0.80	2.60	2.60	-0.14	0.27	-1.15
USA315	T259	72.26	0.0000	0.022720	0.000114	71.0503	85.50	85.50	0.70	0.55	0.55	-0.46	-0.01	-2.04
USA315	T243	76.79	0.0625	0.022720	0.000154	69.3281	88.00	88.00	0.75	2.95	2.95	-1.00	0.20	-2.15
USA315	T217	72.43	0.0000	0.022720	0.000000	71.2263	82.00	82.00	0.70	0.55	0.55	0.49	0.13	-0.80

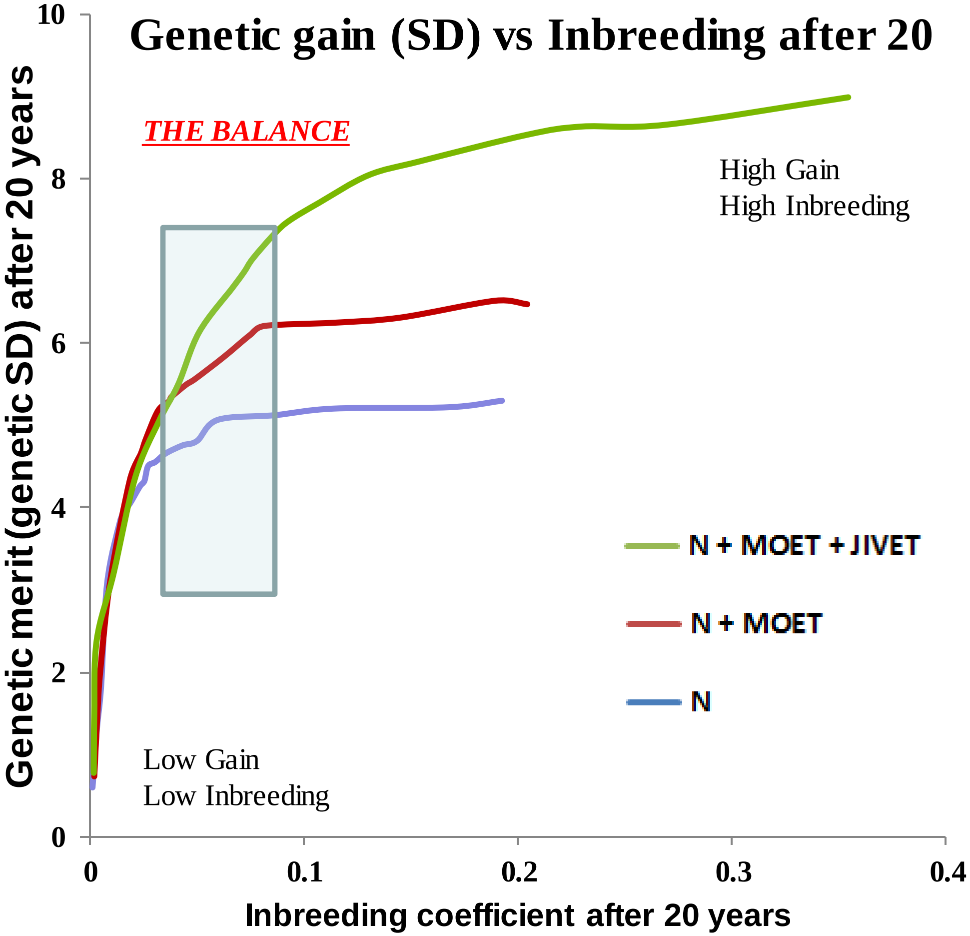
Document: Done

Genetic Gain vs Inbreeding
while using female reproductive technologies

Tom Granleese, 2015

<u>Reproductive technologies</u>

Natural	MOET	JIVET
		
Mature Ewe ↓	Mature Ewe ↓	Juvenile Ewe ↓
		
1 Lamb	Many Lambs	Loads of Lambs



Proportion of females assigned technologies

at 1% ΔdF per gen

	AI/N	MOET	JIVET	Total Females*	Males Used*	Females per male
Early Trait						
With GS	0.29	0.28	**0.43**	85	19	4.5
NO GS	0.34	0.36	**0.30**	88	20	4.4
Late Trait						
With GS	0.31	0.26	**0.43**	88	14	6.3
NO GS	0.34	0.35	**0.31**	89	15	6.0
Dairy						
With GS	0.38	0.28	**0.34**	218	39	5.6
NO GS	0.47	0.35	**0.18**	237	41	5.8

GS SHIFTS PROPORTION to JIVET

Compensate female lack of diversity with more sire diversity

Granleese et al., AAABG 2013

SHEEP CRC

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Optimizing use of repro technologies

Proportion Captured by breeder	AI	MOET	JIVET	Dams Used	G/yr ($)	L
0.06	0.95	0.00	0.05	261	$2.26	1.87
0.32	0.77	0.04	0.19	221	$2.82	1.46
0.64	0.36	0.10	0.54	136	$3.96	1.21

↓

If breeder captures more benefit she/he can afford to invest more and make more gain