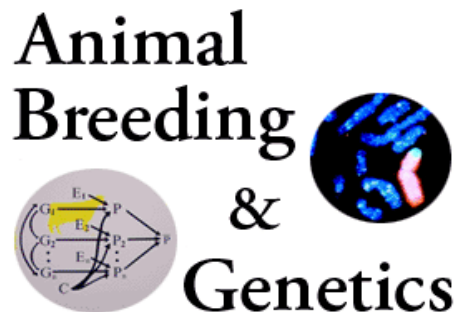


Genomic Selection in Pigs and Poultry

Jack Dekkers

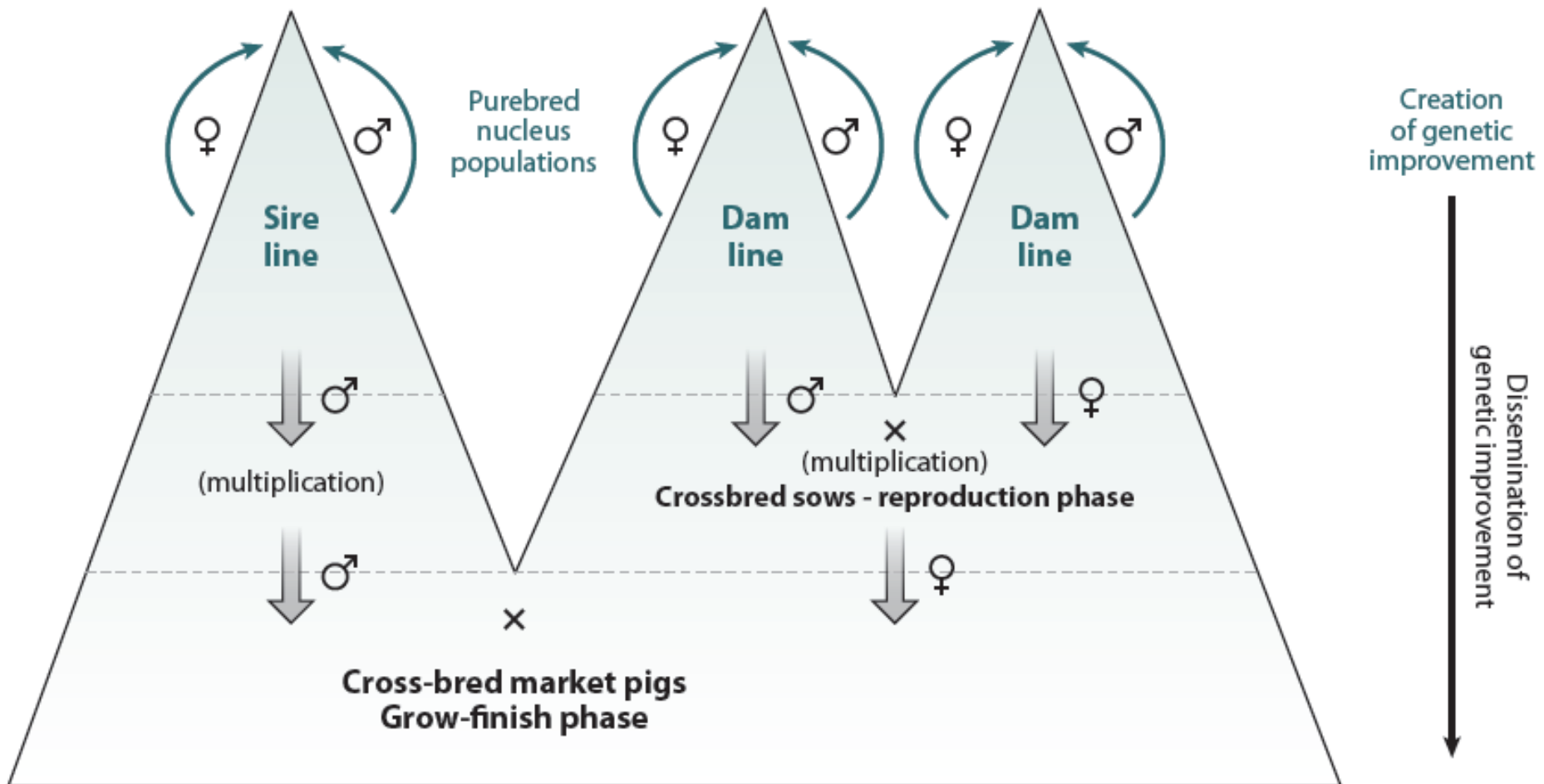
Animal Breeding & Genetics
Department of Animal Science
Iowa State University

IOWA STATE
UNIVERSITY

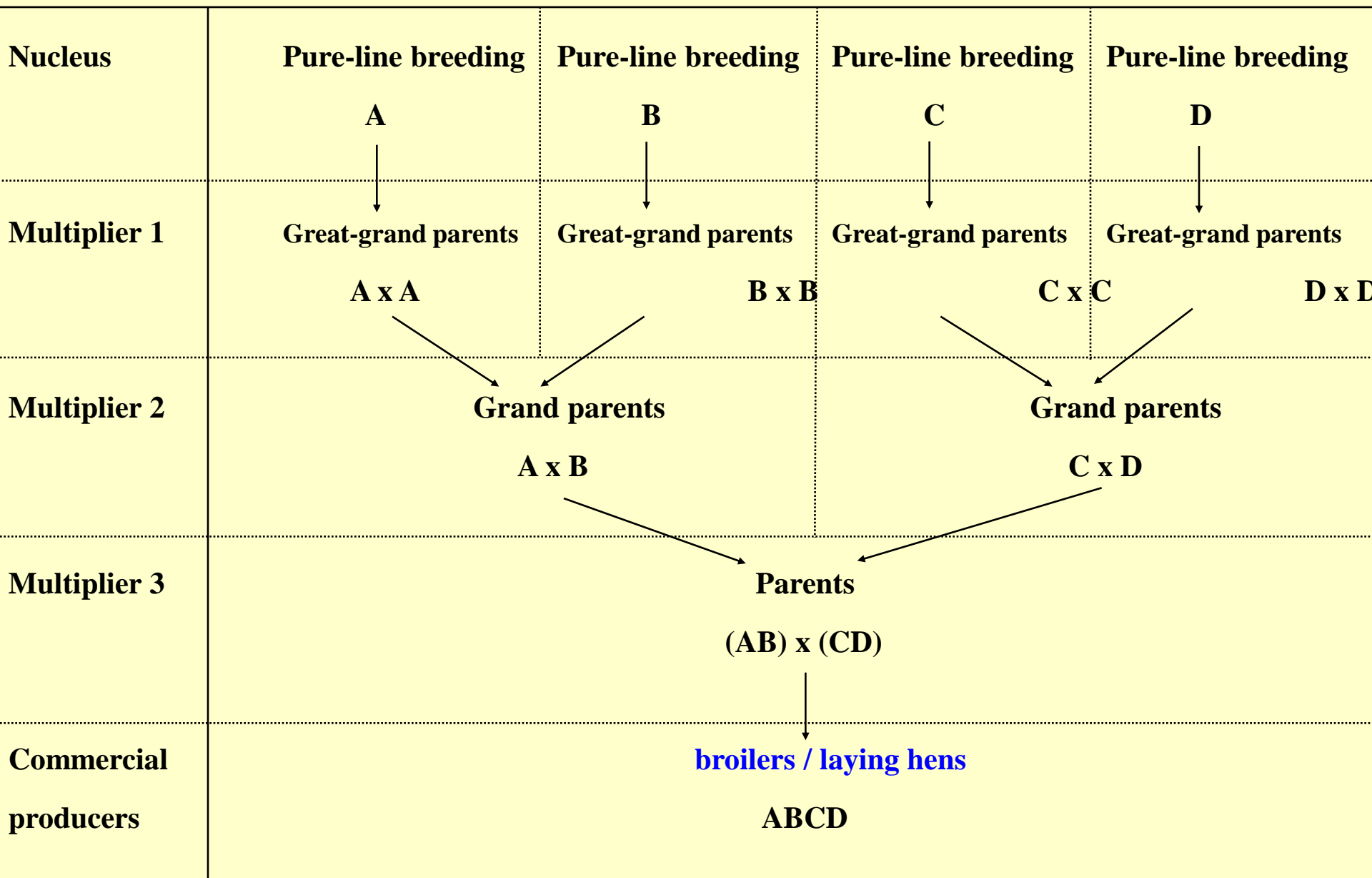


ANIMAL
SCIENCE

Typical Breeding Pyramid for Pigs



General structure of poultry breeding programs





Experimental Implementation of GS in Layers with Program Redesign

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HY-LINE INTERNATIONAL

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Objective

Develop and compare Genomic Selection programs that capitalize on opportunities to reduce generation intervals
Using layer chickens as an example

Breeding Program Goal

A Genomic Selection program for layer chickens

- that doubles response per year
- by reducing generation interval from 12 to 6 months
- but at the same rate of inbreeding per year
- and with a much smaller breeding program

Approach

1. Screen a large number of possible Genomic Selection programs by selection index methods.
2. Evaluate the program that meets the Goal by stochastic simulation.

Selection parameters for Traditional and Genomic Selection

Selection strategy	Traditional		Genomic	
Selection parameters	♂♂	♀♀	♂♂	♀♀
# candidates/gener.	1,000	3,000	N ?	N ?
# phenotyped	0	3,000	0	0
# selected	60	360	?	?
Generation interval	12 mo	12 mo	6 mo	6 mo
Accuracy of selection	0.44	0.62	0.6 / 0.7	0.6 / 0.7
Response / yr	0.48 σ_P		?	?
Inbreeding / yr	1.4 %		?	?

Obtained by SelAction
with $h^2=0.3$

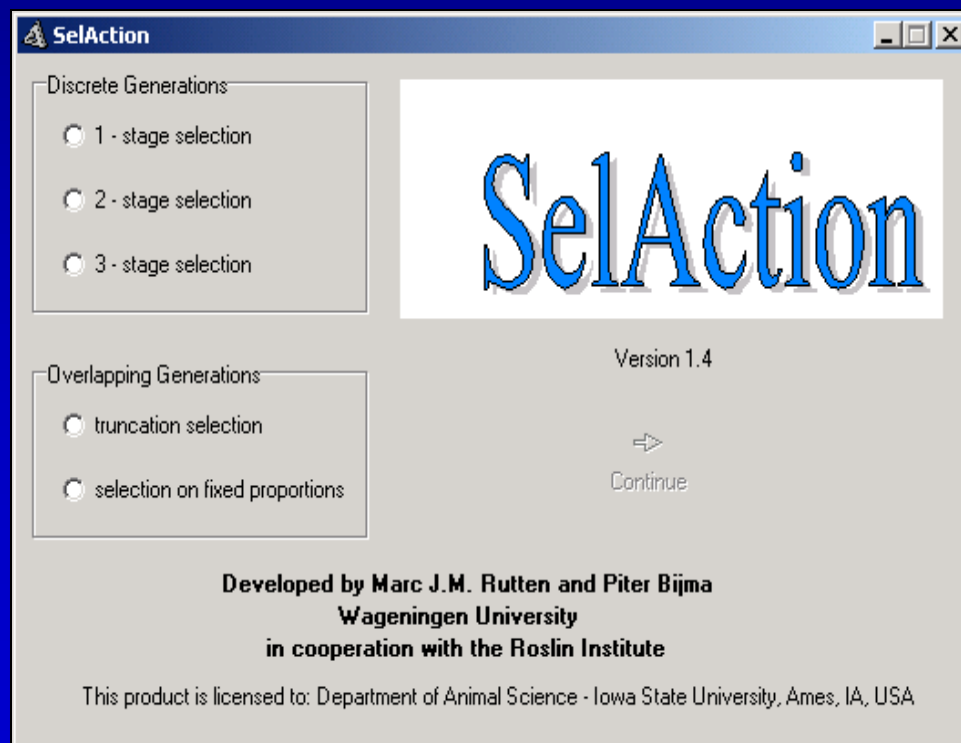
Assumed accuracy
of G-EBV

Prediction of Response and Inbreeding from Genomic Selection by Selection Index Methods

Include G-EBV as a correlated trait in SelAction with:

(Dekkers, JABG 2008)

- $h^2 = 1$
- $r_g =$ accuracy
of G-EBV
(assumed value)



Choice of selection parameters

Step 1:

Deterministic prediction of response and inbreeding (SelAction) for TS and GS

Trait $h^2=0.3$

Initial accuracy of GS EBV = 0.8

Aim to find GS program with similar ΔG but 50% lower ΔF per generation

Such that halving the generation interval would result in doubling ΔG at similar ΔF per year

	## selectec		Progeny per # fema			Accuracy		In SigP		TOTAL	28,880 SNPs	
	Sires	Dams	Male	Female	genoty	Males	Females	Response	Inbreeding	PROJECT	All in	
BLUP	60	360	3	8	0	0.437	0.618	0.48	1.38		cost per	Total
	60	360	3	8	8	0.709	0.709	0.59	0.29	25,820	sample	x \$1,000
1	25	100	4	4	4	0.704	0.704	0.53	0.71	6,860	\$215	\$1,475
2	25	100	4	3	3	0.706	0.706	0.50	0.70	6,260	\$234	\$1,465
3												
4	30	60	5	5	5	0.704	0.704	0.51	0.73	5,660	\$234	\$1,324
5	30	90	6	6	6	0.702	0.702	0.57	0.66	8,540	\$201	\$1,717
6	30	120	4	4	4	0.704	0.704	0.53	0.59	7,820	\$215	\$1,681
7												
8	40	40	5	5	5	0.707	0.707	0.46	0.73	4,460	\$301	\$1,342
9	40	40	8	8	8	0.704	0.704	0.53	0.78	5,900	\$234	\$1,381
10	40	80	5	5	5	0.704	0.704	0.51	0.55	6,860	\$215	\$1,475
11	40	80	4	4	4	0.706	0.706	0.48	0.53	5,900	\$234	\$1,381
12	40	120	3	3	3	0.707	0.707	0.46	0.46	6,380	\$234	\$1,493
13	40	120	4	4	4	0.705	0.705	0.51	0.48	7,820	\$215	\$1,681
14	40	120	5	5	5	0.703	0.703	0.54	0.49	9,260	\$190	\$1,759
15												
16	45	45	6	6	6	0.705	0.705	0.49	0.67	5,300	\$261	\$1,383
17	45	45	7	7	7	0.704	0.704	0.51	0.68	5,840	\$234	\$1,367
18	45	45	8	8	8	0.703	0.703	0.53	0.69	6,380	\$234	\$1,493
19	45	45	9	9	9	0.702	0.702	0.55	0.70	6,920	\$215	\$1,488
20	45	45	10	10	10	0.702	0.702	0.57	0.71	7,460	\$215	\$1,604
21												
22	45	90	3	3	3	0.709	0.709	0.43	0.45	5,300	\$261	\$1,383
23	45	90	4	4	4	0.706	0.706	0.48	0.48	6,380	\$234	\$1,493
24	45	90	5	5	5	0.704	0.704	0.51	0.49	7,460	\$215	\$1,604
25	45	90	6	6	6	0.703	0.703	0.54	0.50	8,540	\$201	\$1,717
26												
27	50	50	5	5	5	0.706	0.706	0.46	0.58	5,060	\$261	\$1,321
28	50	50	6	6	6	0.705	0.705	0.49	0.60	5,660	\$234	\$1,324
29	50	50	7	7	7	0.704	0.704	0.51	0.61	6,260	\$234	\$1,465
30	50	50	8	8	8	0.703	0.703	0.53	0.62	6,860	\$215	\$1,475
31	50	50	9	9	9	0.702	0.702	0.55	0.63	7,460	\$215	\$1,604
32	50	50	10	10	10	0.702	0.702	0.57	0.64	8,060	\$201	\$1,620
33												
34	50	100	3	3	3	0.709	0.709	0.43	0.41	5,660	\$234	\$1,324
35	50	100	4	4	4	0.706	0.706	0.48	0.43	6,860	\$215	\$1,475
36	50	100	5	5	5	0.704	0.704	0.51	0.44	8,060	\$201	\$1,620
37												
38	60	60	5	5	5	0.706	0.706	0.46	0.49	5,660	\$234	\$1,324

Choice of selection parameters

Initial accuracy of GS EBV = 0.7

BLUP	## selectec		Progeny per # fema			Accuracy		In SigP		TOTAL	28,880 SNPs	
	Sires	Dams	Male	Female	genoty	Males	Females	per gener.	per gener.	PROJECT	cost per	All in
	60	360	3	8	0	0.437	0.618	0.48	1.38	genotypes	sample	Total
1	25	100	4	4	4	0.589	0.589	0.46	0.70	6,860	\$215	\$1,475
2	25	100	4	3	3	0.591	0.591	0.44	0.69	6,260	\$234	\$1,465
3												
4	30	60	5	5	5	0.589	0.589	0.45	0.72	5,660	\$234	\$1,324
5	30	90	6	6	6	0.587	0.587	0.50	0.65	8,540	\$201	\$1,717
6	30	120	4	4	4	0.589	0.589	0.46	0.59	7,820	\$215	\$1,681
7												
8	40	40	5	5	5	0.592	0.592	0.40	0.71	4,460	\$301	\$1,342
9	40	40	8	8	8	0.588	0.588	0.47	0.76	5,900	\$234	\$1,381
10	40	80	5	5	5	0.589	0.589	0.45	0.54	6,860	\$215	\$1,475
11	40	80	4	4	4	0.591	0.591	0.42	0.52	5,900	\$234	\$1,381
12	40	120	3	3	3	0.593	0.593	0.40	0.45	6,380	\$234	\$1,493
13	40	120	4	4	4	0.590	0.590	0.44	0.47	7,820	\$215	\$1,681
14	40	120	5	5	5	0.588	0.588	0.47	0.48	9,260	\$190	\$1,759
15												
16	45	45	6	6	6	0.590	0.590	0.43	0.65	5,300	\$261	\$1,383
17	45	45	7	7	7	0.589	0.589	0.45	0.67	5,840	\$234	\$1,367
18	45	45	8	8	8	0.588	0.588	0.47	0.68	6,380	\$234	\$1,493
19	45	45	9	9	9	0.587	0.587	0.48	0.69	6,920	\$215	\$1,488
20	45	45	10	10	10	0.586	0.586	0.50	0.70	7,460	\$215	\$1,604
21												
22	45	90	3	3	3	0.594	0.594	0.37	0.45	5,300	\$261	\$1,383
23	45	90	4	4	4	0.591	0.591	0.42	0.47	6,380	\$234	\$1,493
24	45	90	5	5	5	0.589	0.589	0.45	0.48	7,460	\$215	\$1,604
25	45	90	6	6	6	0.588	0.588	0.47	0.49	8,540	\$201	\$1,717
26												
27	50	50	5	5	5	0.592	0.592	0.40	0.57	5,060	\$261	\$1,321
28	50	50	6	6	6	0.590	0.590	0.43	0.59	5,660	\$234	\$1,324
29	50	50	7	7	7	0.589	0.589	0.45	0.60	6,260	\$234	\$1,465
30	50	50	8	8	8	0.588	0.588	0.47	0.61	6,860	\$215	\$1,475
31	50	50	9	9	9	0.587	0.587	0.48	0.62	7,460	\$215	\$1,604
32	50	50	10	10	10	0.587	0.587	0.50	0.63	8,060	\$201	\$1,620
33												
34	50	100	3	3	3	0.594	0.594	0.37	0.40	5,660	\$234	\$1,324
35	50	100	4	4	4	0.591	0.591	0.42	0.42	6,860	\$215	\$1,475
36	50	100	5	5	5	0.589	0.589	0.45	0.43	8,060	\$201	\$1,620
37												
38	60	60	5	5	5	0.592	0.592	0.40	0.48	5,660	\$234	\$1,324
39	60	60	6	6	6	0.59	0.59	0.43	0.49	6,380	\$234	\$1,493

Selection parameters for Traditional and Genomic Selection

Selection strategy	Traditional		Genomic	
Selection parameters	♂♂	♀♀	♂♂	♀♀
# candidates/gener.	1,000	3,000	250	250
# phenotyped	0	3,000	0	0
# selected	60	360	50	50
Generation interval	12 mo	12 mo	6 mo	6 mo
Accuracy of selection	0.44	0.62	0.6 / 0.7	0.6 / 0.7
Response / yr	0.48 σ_P		0.80 / 0.92 σ_P	
Inbreeding / yr	1.4 %		1.14 / 1.16 %	

Obtained by SelAction
with $h^2=0.3$

Assumed accuracy
of G-EBV

Evaluation by Stochastic Simulation

Generation

0

$N_e = 500$

20 chr of 37.5 cM
120,000 SNPs (freq. = $\frac{1}{2}$, LE)

Random mating → LD by drift, mutation

900

$N_e = 100$

1000

1001

Allocate 200 loci with $MAF > 0.1$ as QTL and 6000 as SNPs
Training data: Expand to 1000 indiv. – phenotype + genotype
Estimate marker effects by Bayes-B ($\pi = 0.05$)
Mate random 50 males to random 50 females

1002

Select 50/250 males 50/250 females

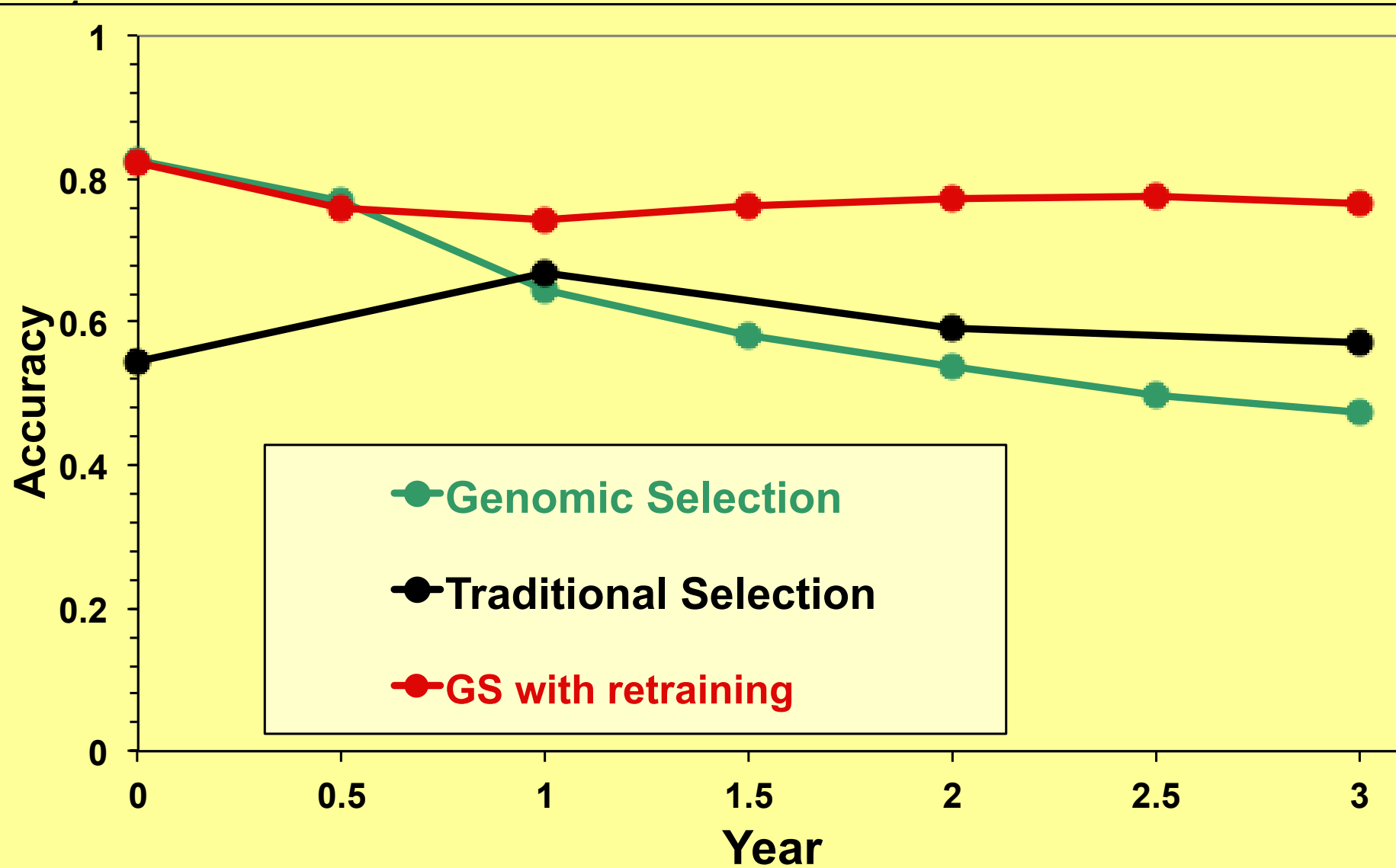
1012

Select Without / with retraining

Replicate 100 times

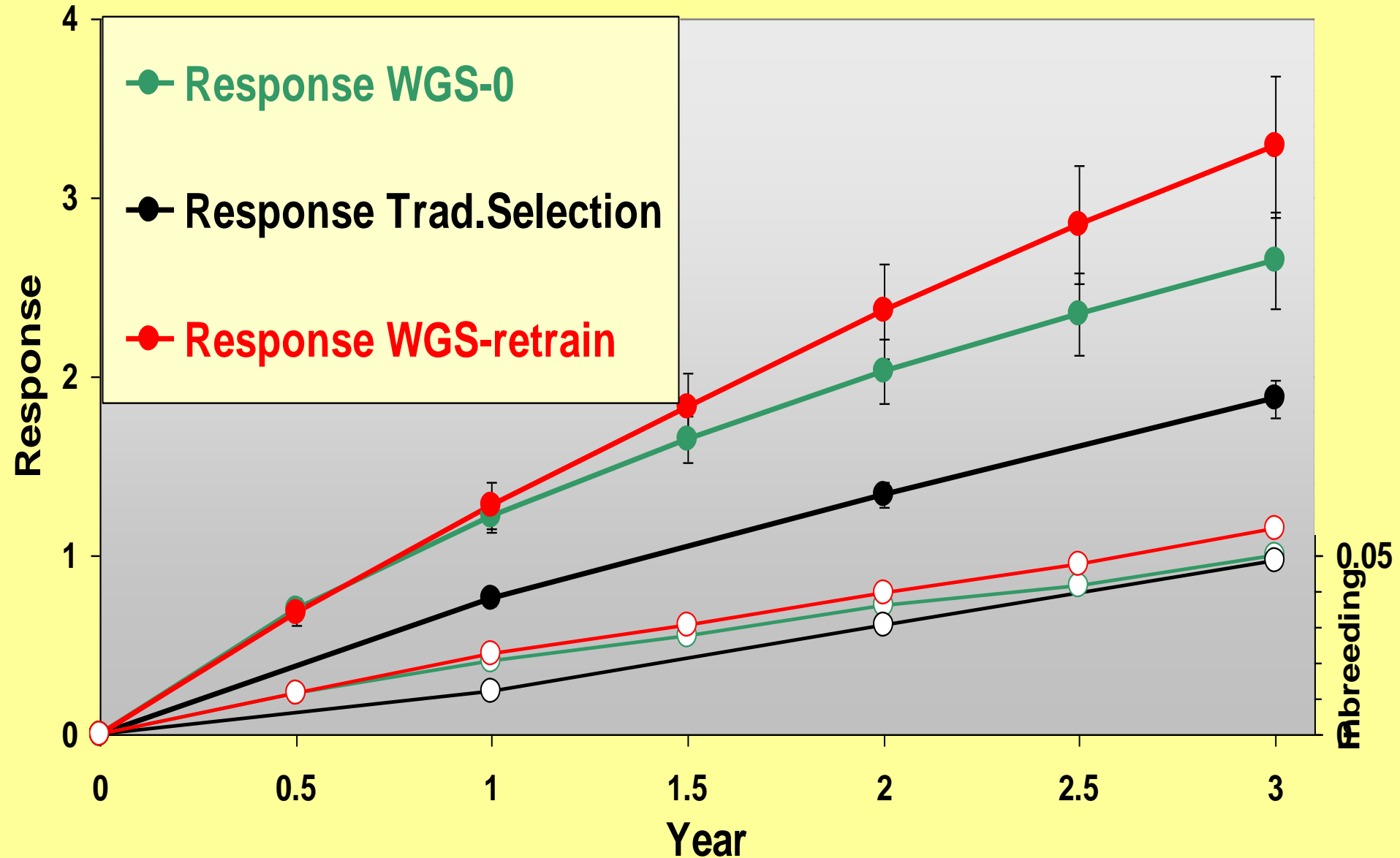
Accuracy of selection (50 replicates)

GS program with 50 sires and 50 dams

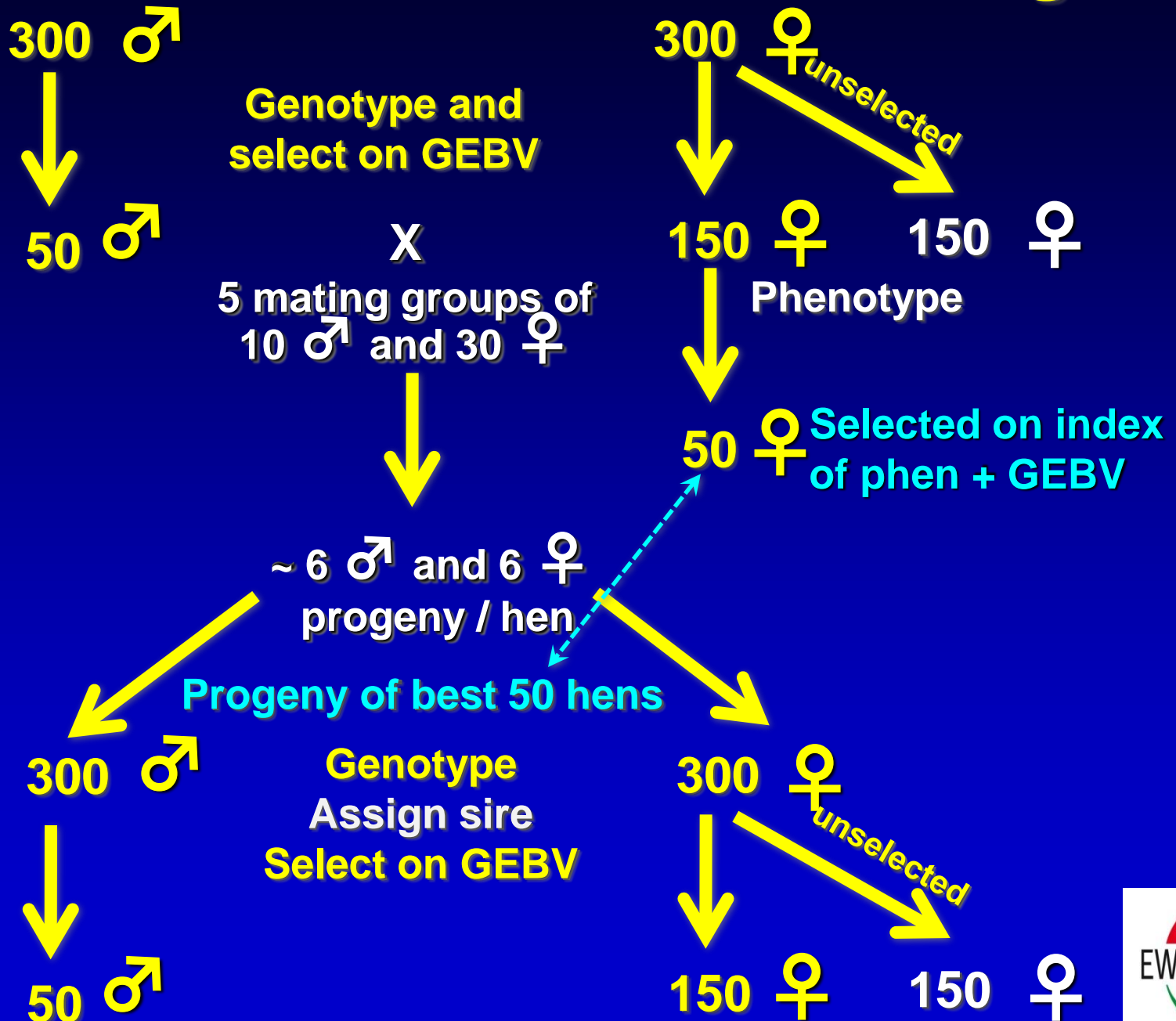


Response and Inbreeding (50 replicates)

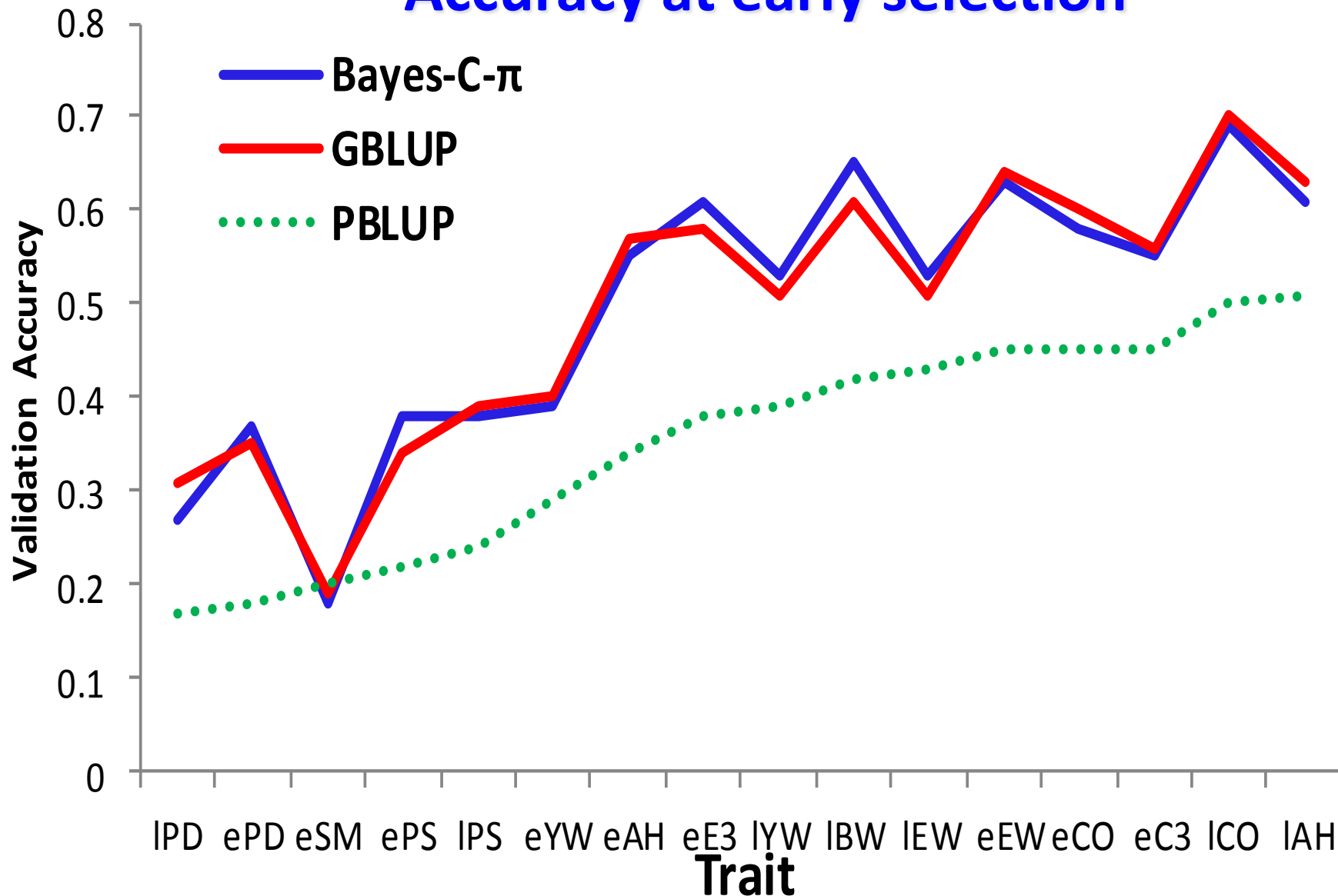
GS program with 50 sires and 50 dams



Modified Genomic Selection Program



Accuracy at early selection



Conclusions

- GS is revolutionizing dairy cattle breeding
- GS has promise also for other species

But requires:

- Large data sets, continuous re-training
- Improved statistical models for prediction
- Strategic use of low-density panels
and genotype imputation to reduce cost
- May require redesign of breeding programs
- Initial implementation likely within breeds
 - Across-breed prediction problematic at present

Acknowledgements

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Dorian Garrick

Xiaochen Sun

Neil O' Sullivan

Alfons Koerhuis

Sue Lamont

Ziqing Weng

Rudi Preisinger

Jim McKay

Christian Stricker



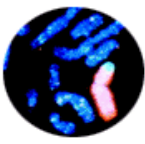
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