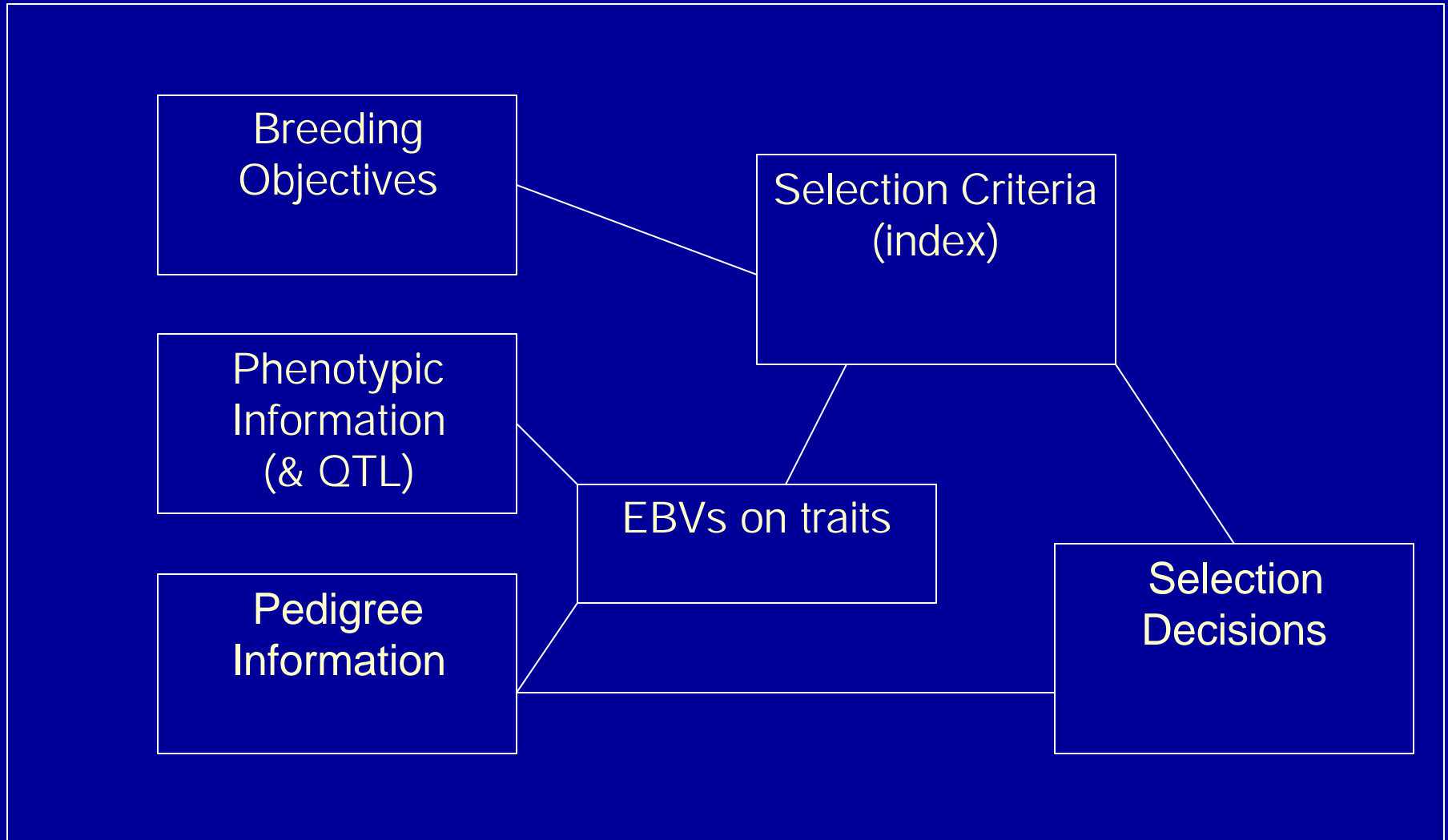


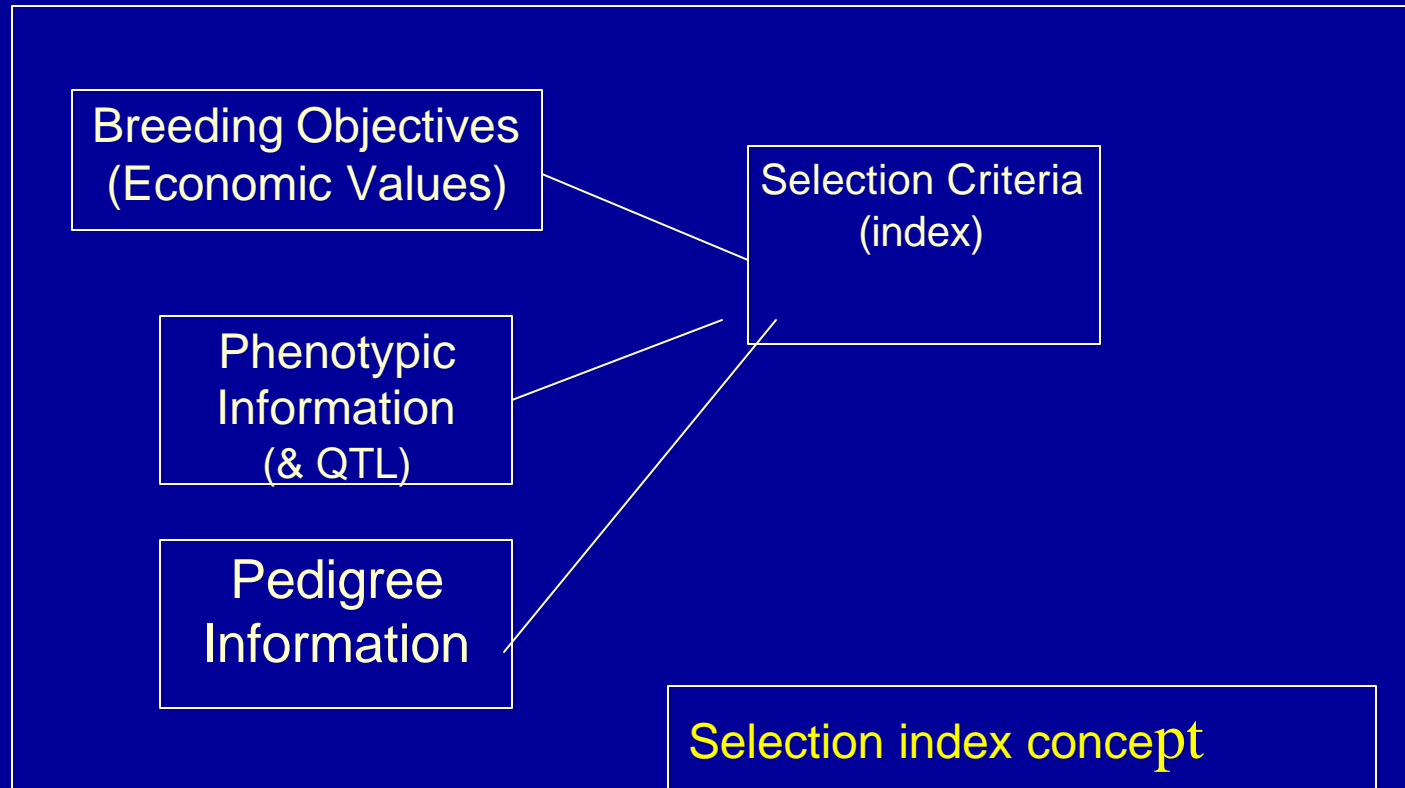
# Multiple Trait Selection

- Defining Selection Criteria
- Prediction Selection Response
- Manipulating Selection Response

# *Relationship between information, pedigree, index and multiple trait selection*

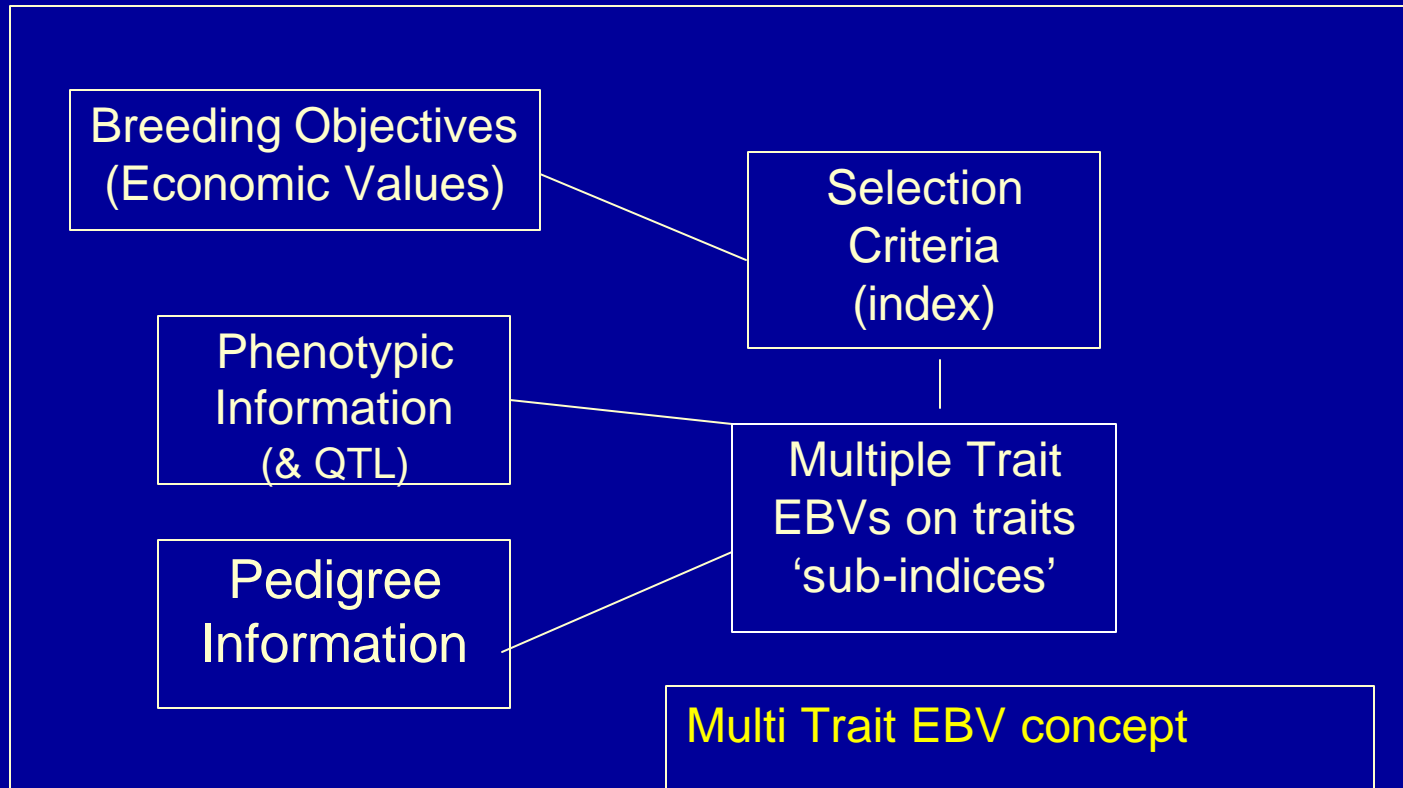


# *Relationship between information, pedigree, index and multiple trait selection*



$$\text{Index} = 0.195.W_{\text{own}} + 0.056.W_{\text{sire}} + 0.164.W_{\text{HS}} - 0.916.FI_{\text{sire}}$$

# *Relationship between information, pedigree, index and multiple trait selection*

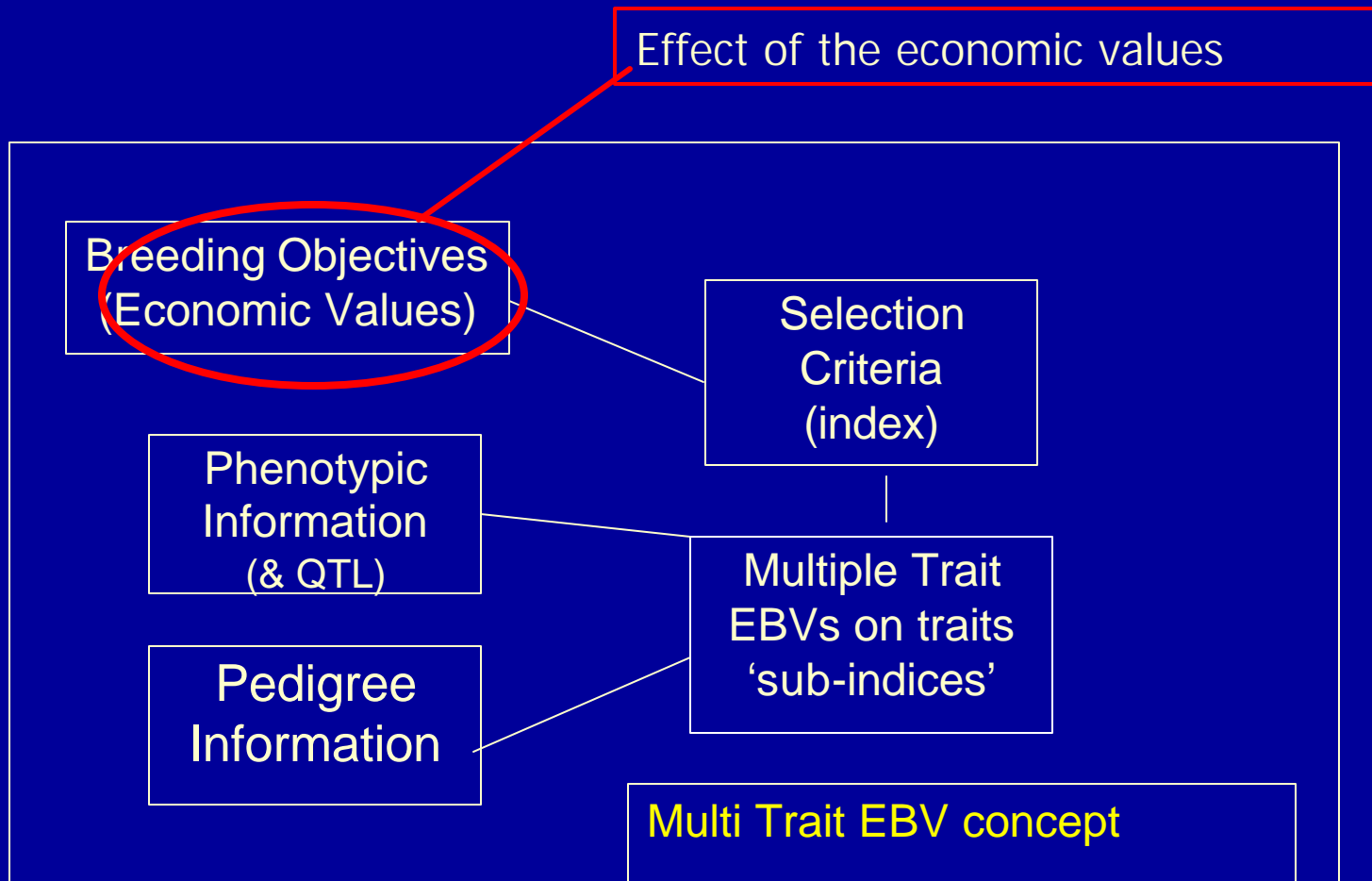


$$\text{Index} = 1.W_{\text{EBV}} - 10.FI_{\text{EBV}}$$

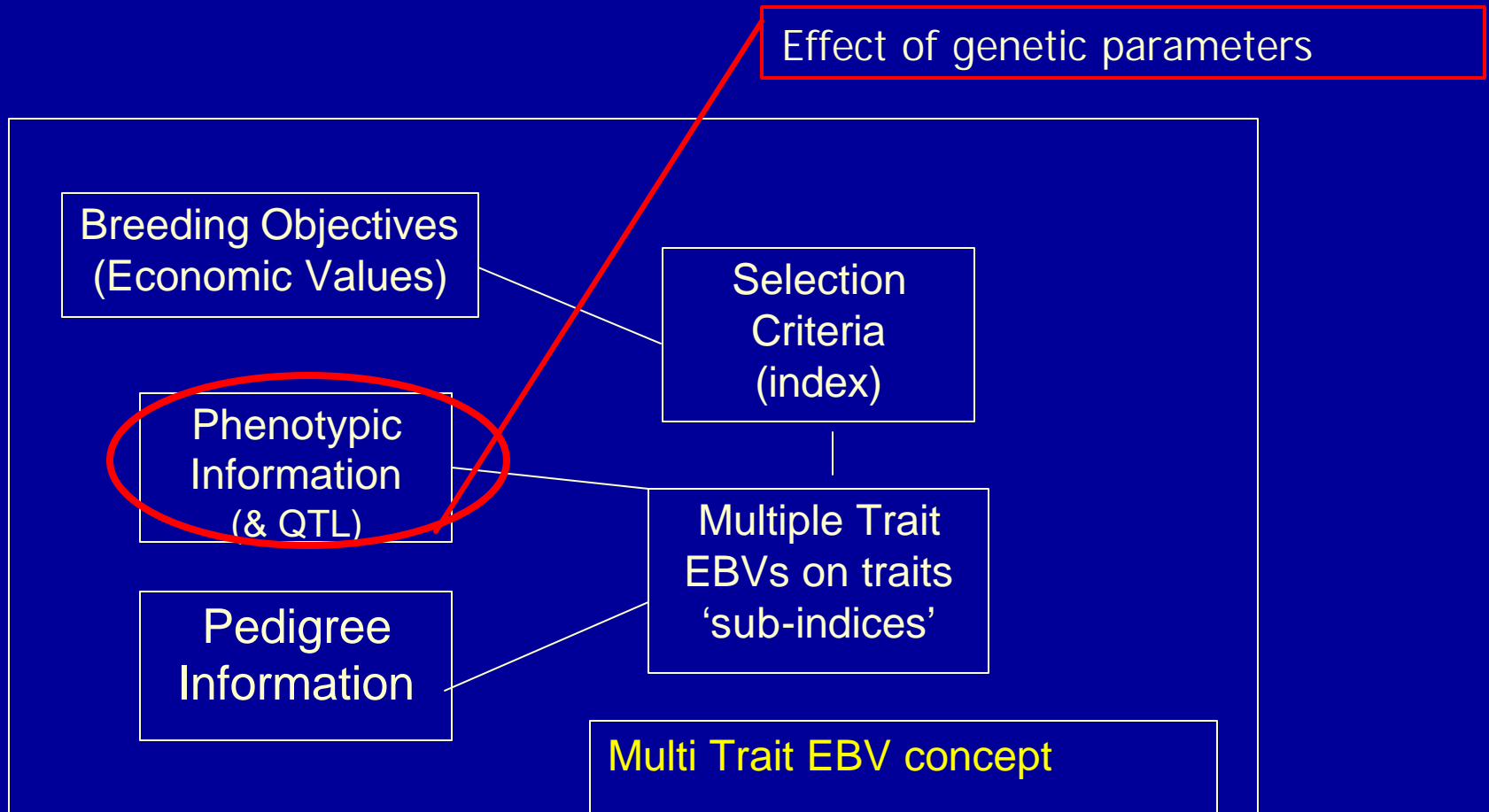
# Outline MT Selection

- Properties of EBVs
- Single Trait Selection Index
- Multiple Trait Selection Index
  - Predicting Response
  - Manipulating Response
  - MT Index and MTBLUP selection
  - Increased Accuracy from MT Selection
  - Effect of Incorrect Parameters
  - Other Issues

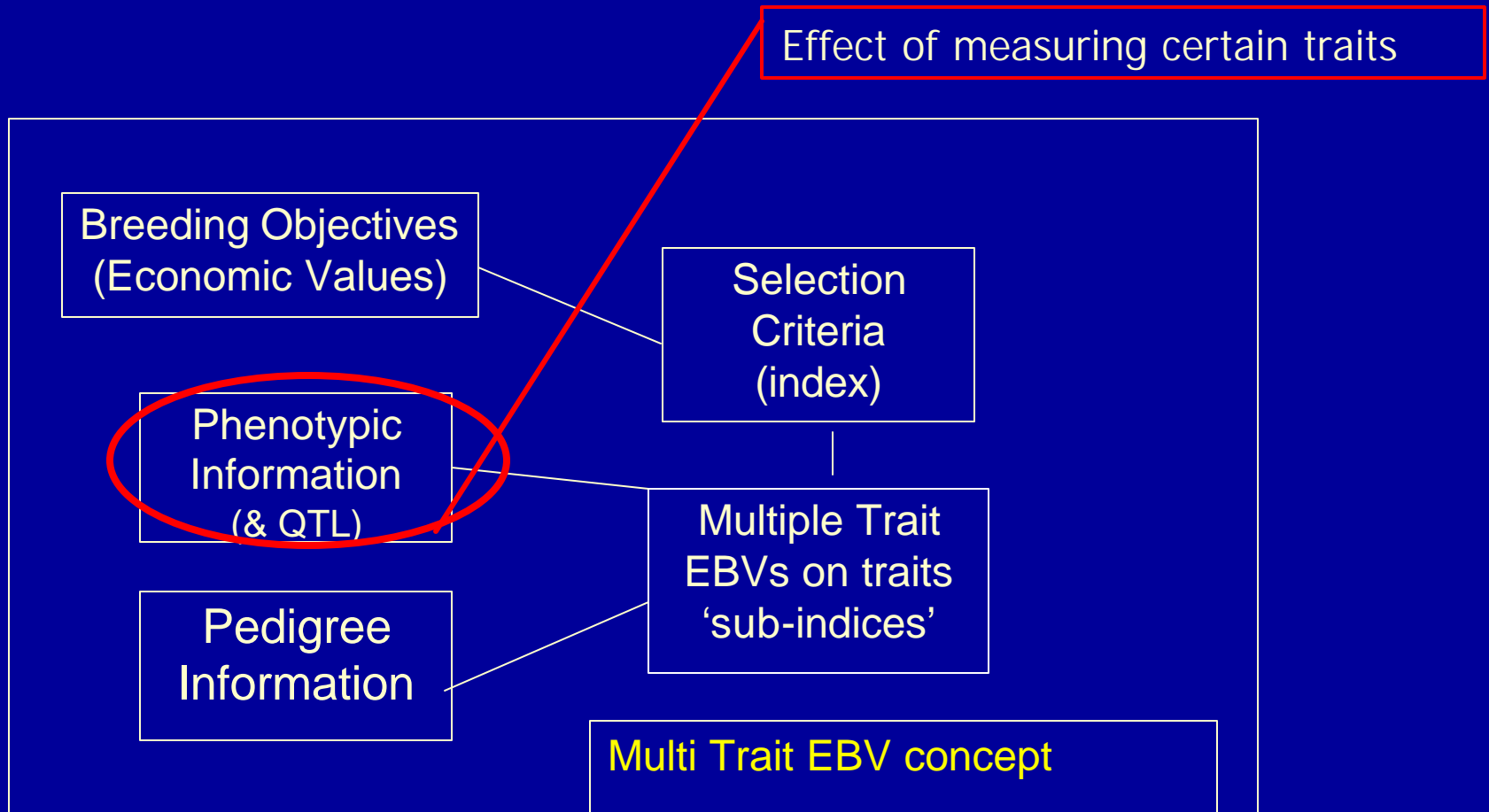
# *Selection Index framework allows to study.....*



# *Selection Index framework allows to study.....*

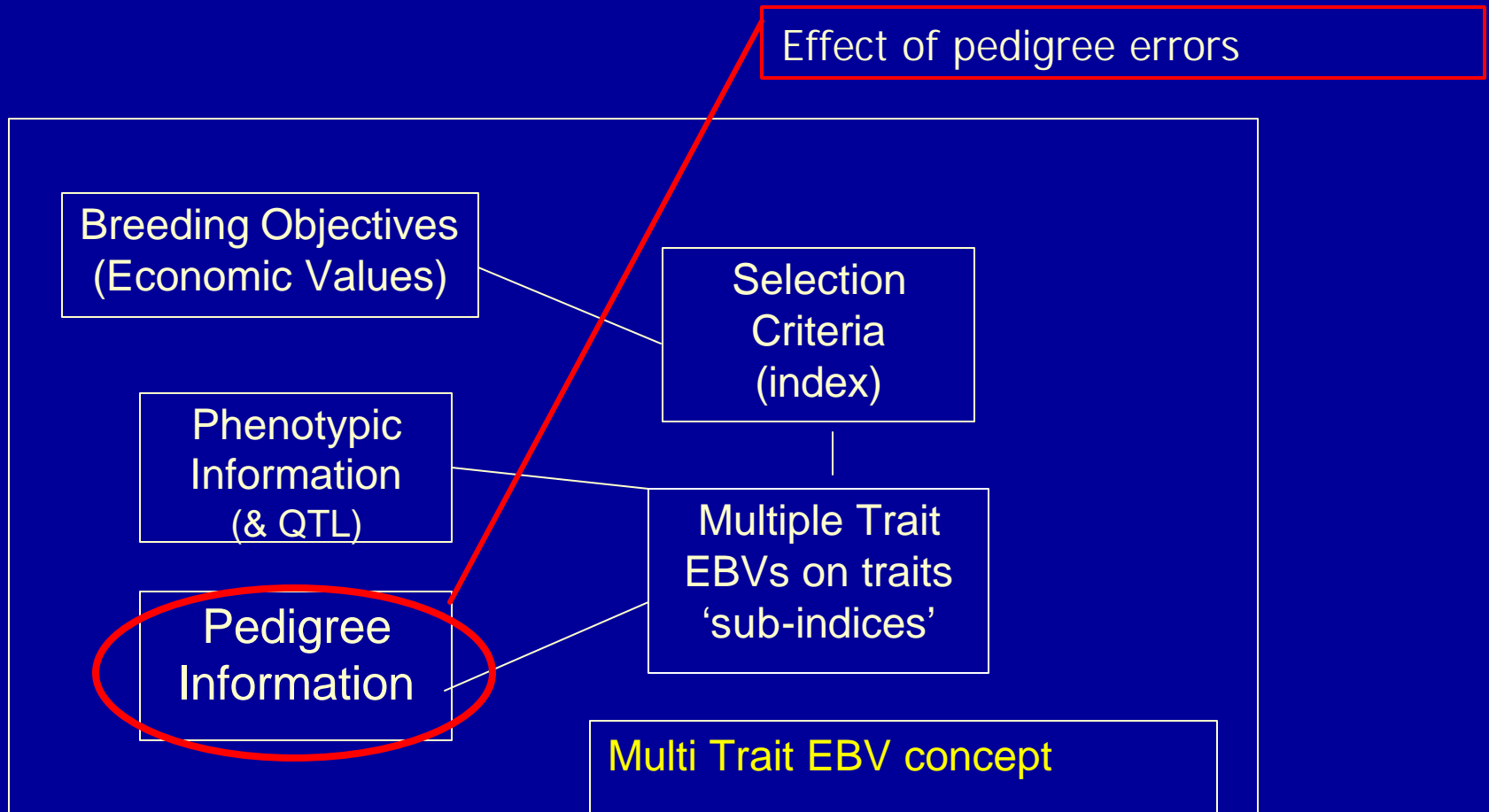


# *Selection Index framework allows to study.....*





# *Selection Index framework allows to study.....*



# Estimated Breeding Values

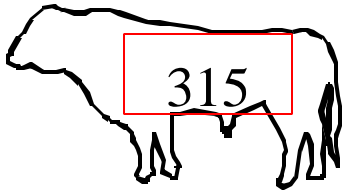
- Properties                      accuracy, variance,.....
- Selection Response            select on EBV

Observed

Phen. Dev.

Genetic Value

Env. Effects



P G E

+15 +3 +12

307 +7 +7 0

303 +3 -2 +5

294 -6 +8 -14

287 -13 -6 -7

SD 11 6 10

$h^2 = ?$

Observed

Phen. Dev.

Genetic Value

Env. Effects

P

G

E

+27

+3

+24

+7

+7

0

+8

-2

+10

-20

+8

-28

-20

-6

-14

$h^2 = ?$

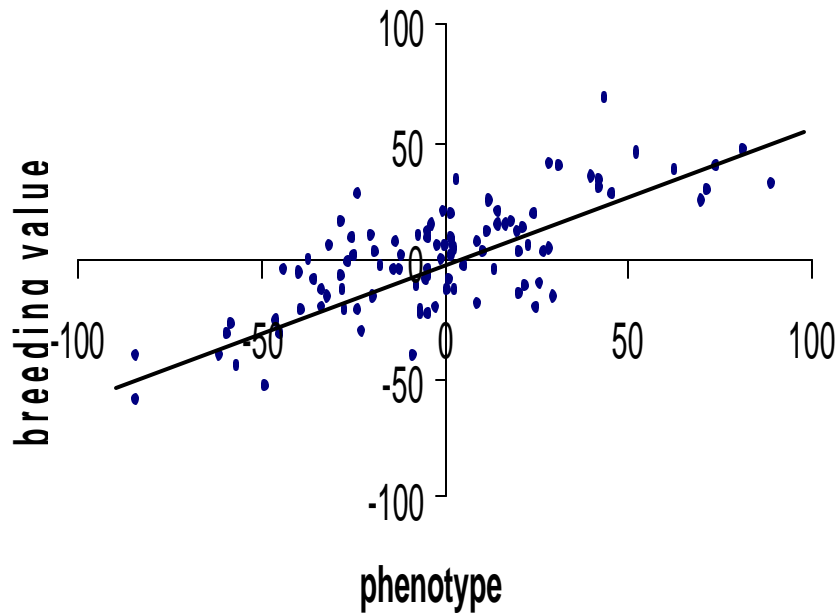
21

6

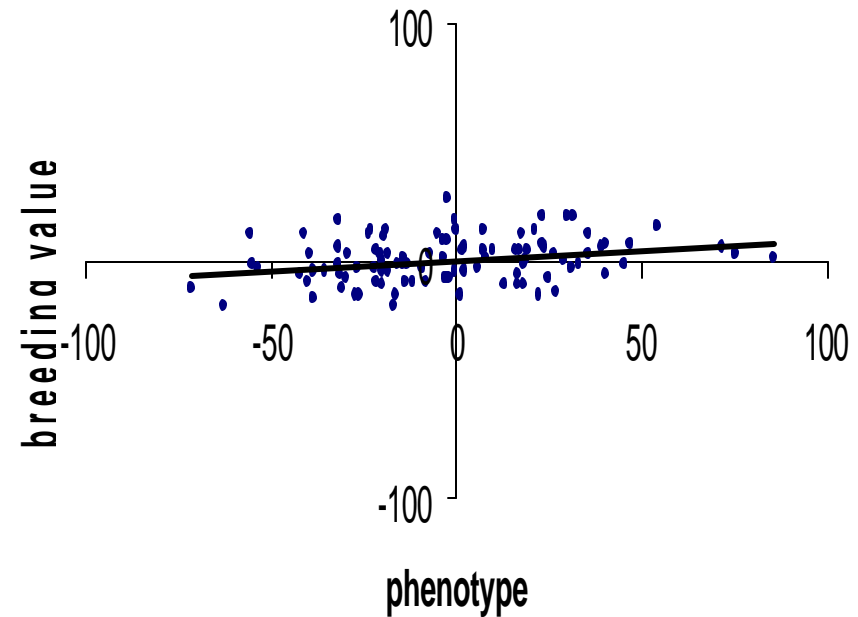
20

The larger heritability, the more of phenotypic differences are due to (additive) genetic value

heritability 50%



heritability 10%



# Estimation of Breeding Value

- Is based on regression

$$b = \text{covariance (A,X)} / \text{variance(X)}$$

$$\text{EBV} = b.X$$

# Accuracy of EBV

Symbol:  $r_{IA} =$

correlation between

estimated ("I") and true breeding value ("A")

or:  $r_{IH} =$

correlation between

estimated ("I") and true breeding objective ("H")

# Accuracy of EBV

---

Information used	$h^2 = 0.10$	$h^2 = 0.30$
Sire EBV ( $rIA=0.5$ )	0.25	0.25
Sire EBV ( $rIA=0.9$ )	0.45	0.45
Sire EBV ( $rIA=0.5$ ) + Dam EBV ( $rIA=0.5$ )	0.35	0.35
Sire EBV ( $rIA=0.9$ ) + Dam EBV ( $rIA=0.5$ )	0.51	0.51
Own Performance only	0.32	0.55
OP+ Sire EBV ( $rIA=0.9$ )+ Dam EBV ( $rIA=0.5$ )	0.57	0.66

---



# Accuracy of EBV

---

Information used	$h^2 = 0.10$	$h^2 = 0.30$
Own Performance only	0.32	0.55
OP+ Sire EBV ( $r_{IA}=0.9$ )+ Dam EBV ( $r_{IA}=0.5$ )	0.57	0.66
Mean of 5 full sibs	0.32	0.48
Mean of 10 half sibs	0.23	0.33
OP + 5 FS + 10 HS	0.43	0.65
Mean of 1000 half sibs	0.49	0.50
Mean of 1000 full sibs	0.70	0.71
Mean of 20 progeny	0.58	0.79
Mean of 100 progeny	0.85	0.94
Mean of 1000 progeny	0.98	0.99

---

# Examples of accuracies

	$h^2=0.1$	$h^2=0.3$	
own information	0.32	0.55	<i>equal to sqrt <math>h^2</math></i>
mean of 10 half sib	0.23	0.33	
mean of 1000 half-sibs	0.49	0.50	<i>max is sqrt 0.25 = 0.5</i>
mean of 1000 full-sibs	0.70	0.71	<i>max is sqrt 0.5 = 0.71</i>
mean of 100 progeny	0.85	0.94	<i>max approaches 1.0</i>

$$\text{Var}(A) = V_S + V_D + V_{MS} = .25V_A + .25VA + .5VA$$

# Accuracy of EBV

<u>Information used</u>	<u>Index</u>	<u>Accuracy</u> (approx)
own performance	$EBV = h^2.P$	$h$
progeny test	$EBV_{\text{sire}} = \frac{2n}{n+a}.PM$	$\sqrt{n/(n+a)}$
		$n = n_{\text{prog}}$ $a = (4-h^2)/h^2$

Generic

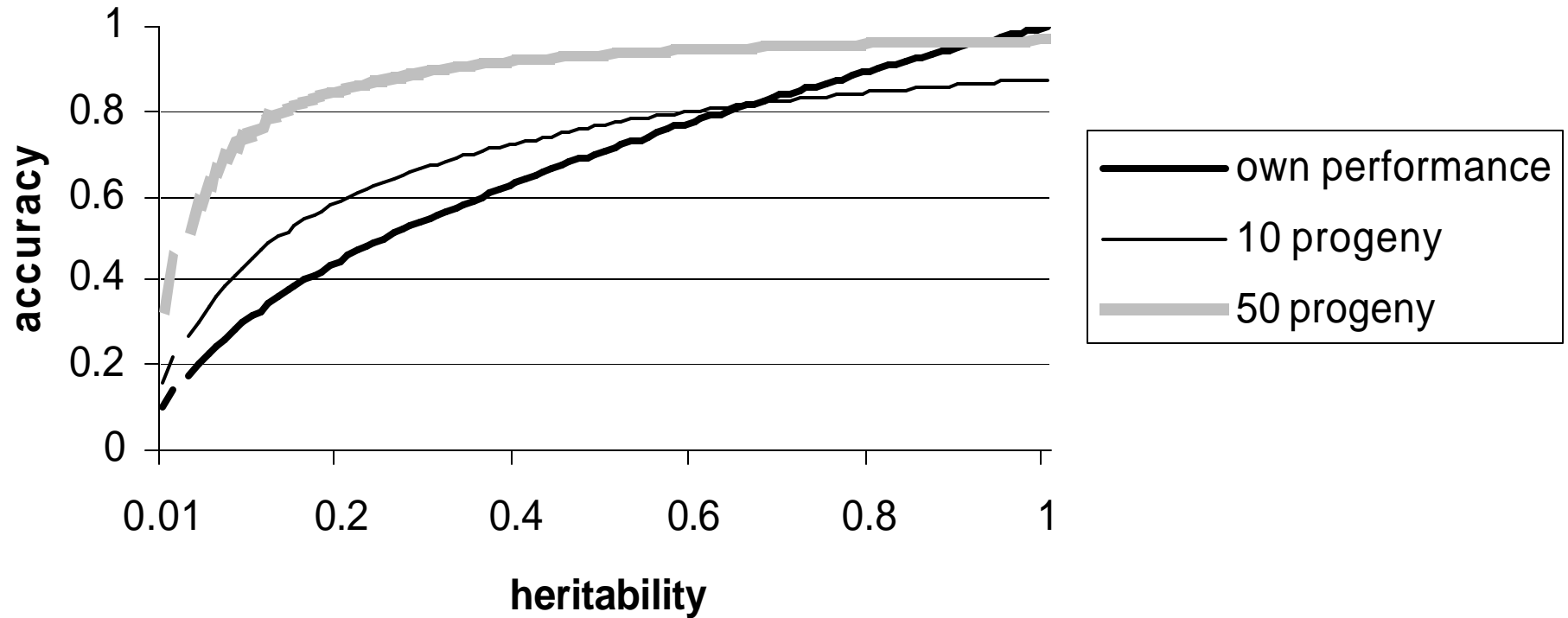
$$EBV = b_1P_1 + b_2P_2 + \dots$$

Use Selection Index Theory

## Example: Accuracy of progeny test

		Nr of progeny		
		5	50	100
$h^2$	0.1	0.34	0.75	0.85
	0.5	0.91	0.99	0.995

# Accuracy of own performance vs progeny test



# Accuracy of EBV

<u>Information used</u>	<u>Index</u>	<u>Accuracy (approx)</u>
-------------------------	--------------	--------------------------

Generic

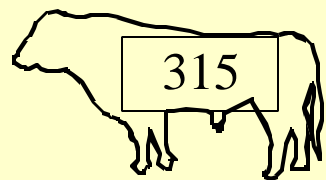
$$EBV = b_1P_1 + b_2P_2 + \dots$$

Use Selection  
Index Theory

# Variance of EBV - *how much they differ*

- $\text{Var}(\text{EBV}) = r_{IA}^2 V_A$
- $\text{SD}(\text{EBV}) = r_{IA} \sigma_A =$  Standard deviation of EBVs

Observed      Phen. Dev.   Genetic Value   Env. Effects   EBV ( $h^2=0.3$ )

	P	G	E	
	+15	+3	+12	4.5
307	+7	+7	0	2.1
303	+3	-2	+5	0.9
294	-6	+8	-14	-1.8
287	-13	-6	-7	-3.9
SD	11	6	10	3.3



Phen. Dev. Genetic Value Env. Effects EBV ( $h^2=0.09$ )

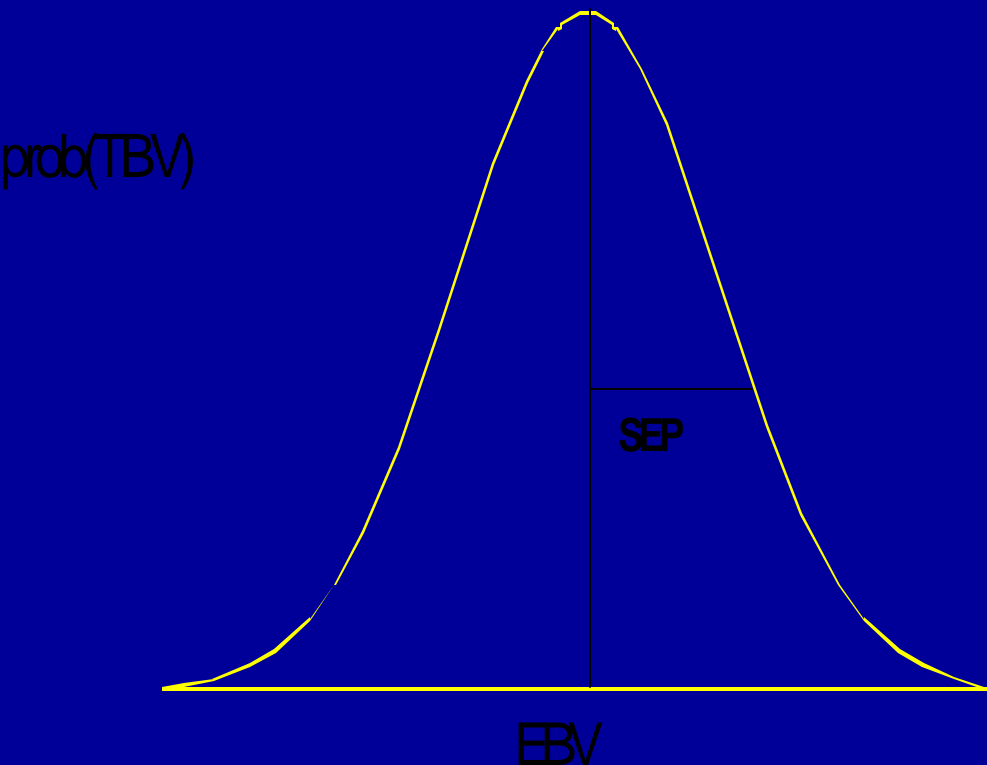
---

P	G	E		
+27	+3	+24	2.4	
+7	+7	0	0.6	
+8	-2	+10	0.7	
-20	+8	-28	-1.8	
-20	-6	-14	-1.8	
SD	21	6	20	1.8

# Prediction Error Variance

*- how much they still may change*

- $PEV = \text{var}(EBV-TBV) = (1-r^2_{IA})V_A$



Let  $s_a = 19$ ,  $EBV = +12$ ,

**Accuracy<sup>2</sup> =  $r^2 = h^2 = 0.4$**

Then  $SEP = \sqrt{(1-0.4) \cdot 19} = 14.7$

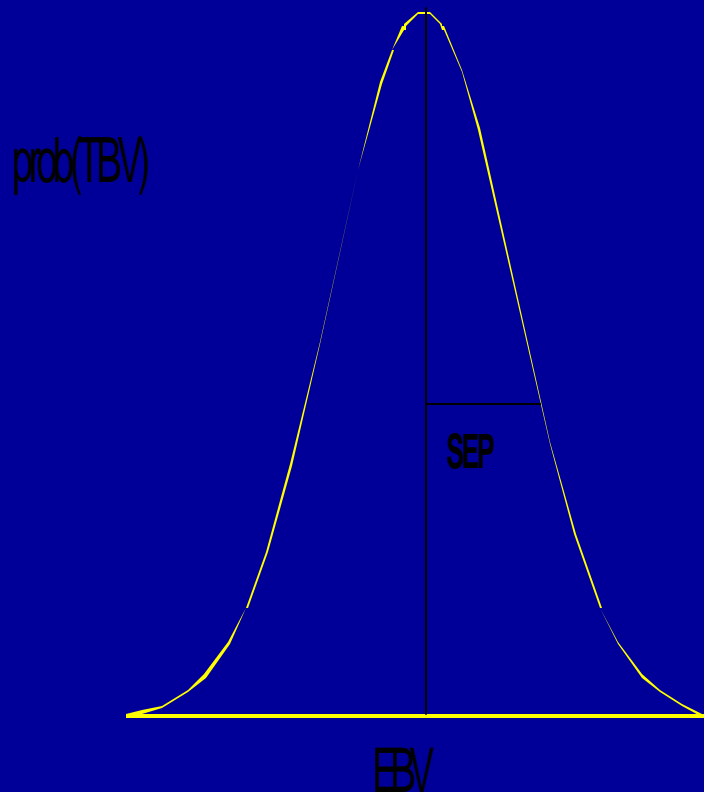
Conf. Interval:  $EBV \pm 2 \cdot SEP$

$\langle -17.4 - 41.4 \rangle$

# Prediction Error Variance

- *how much they still may change*

- $PEV = \text{var}(EBV-TBV) = (1-r^2_{IA})V_A$



Let  $s_a = 19$ ,  $EBV = +12$ ,

**Progeny Test: Accuracy<sup>2</sup> =  $r^2 = 0.81$**

Then  $SEP = \sqrt{(1-0.81)} \cdot 19 = 8.3$

Conf. Interval:  $EBV \pm 2 \cdot SEP$

$\langle -4.6 \quad - \quad 28.6 \rangle$

# Prediction Error Variance

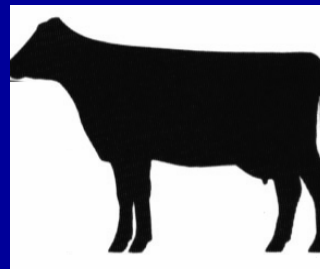
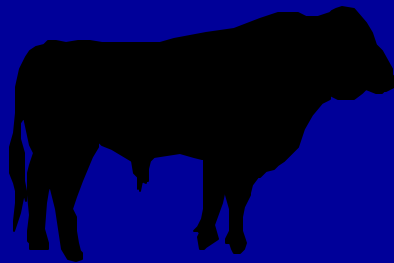
- *how much they still may change*

Consider Yearling weight EBV ( $h^2 = 0.4$ ;  $\sigma_a = 19$ )

EBV = +12

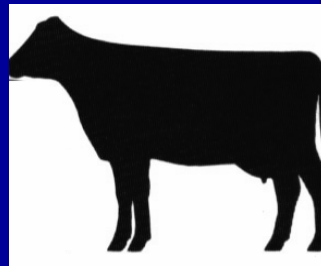
Information for EBV 95%CI_ EBV	Accuracy ( $r_{IH}$ )	SEP	
None	0	19	
Own performance	0.63	14.7	-17.4 - 41.2
Progeny Test n=40	0.90	8.3	-4.6 - 28.6
Progeny Test n=200	0.98	3.8	4.4 - 19.6

# Selection on EBV



50% of dad's  
genes  
1/2 EBV Sire

50% of mum's genes  
1/2 EBV Dam



$$\text{Expected Value of progeny} = 1/2 EBV_{sire} + 1/2 EBV_{dam}$$

# Some things to note

- EBV's on parents are additive
- Predicted performance of offspring does not depend on accuracy of the parents' EBVs

- Suppose 

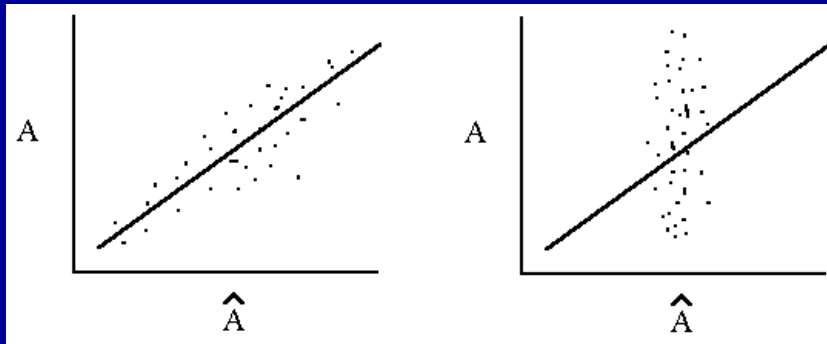
EBV_A	+56	$r = 0.50$
EBV_B	+56	$r = 0.95$

**select A or B?**

Answer: should not matter (if one is risk neutral)

# Predicted Response

Regression of A on EBV = 1



**Response =  $i * SD(EBV)$**

$$R = i * r * S_a$$

Message:

One unit EBV relates to one unit BV, whether accurate or not

$$dG = \frac{R_{males} + R_{fem}}{L_{males} + L_{fem}}$$

# Response to selection based on EBV

## A Realistic Simulation

Parent Average-EBV	Realized Performance	True BV	EBV_op
-11.5	291	1.4	-3.5
-9.0	279	21.3	-8.4
-8.8	245	-22.9	-22.2
-4.8	315	17.0	6.0
-3.1	295	-6.6	-2.0
4.0	278	-23.5	-8.6
4.2	291	0.4	-3.7
4.4	323	12.2	9.0
5.9	278	1.9	-8.7
9.7	333	34.4	13.0

EBV's may look inaccurate for individual, but they do provide selection response!

**Select top 50% on**

•PA\_EBV

+5

•Own Perf\_EBV

+11

•True\_BV

+17

**average BV**



# Response to selection based on EBV

- $\text{Response} = \text{selection intensity} * \text{accuracy} * \text{spread of TBV}$

$$= i r_{IA} \sigma_A$$

Example

$$\sigma_A = 19 \quad i = 0.80$$

selection on	accuracy ( $r_{IA}$ )	Expected Resp (R)	Realized Resp.
EBV_PA	0.45	+6.8	+5
EBV_op	0.63	+9.5	+11
BV	1	+15	+17

See next slide

The more accuracy, the more response!

General to predict response per year

$$R_{yr} = \frac{i_{sires} r_{IA_{sires}} + i_{dams} r_{IA_{dams}}}{L_{sires} + L_{dams}} \mathbf{S}_A$$

Should optimize  $i$  and  $L$

Should maximize  $r_{IA}$   Information from correlated traits

 Information from relatives