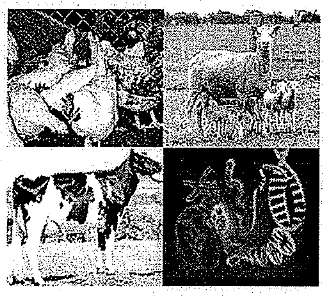
Response to selection I



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IAEA, Korea, April, 2006

Revision

For individual parents we can predict progeny merit by

- Estimating breeding values of each parent

$$EBV = h^2 P$$

- Averaging these to predict progeny merit

$$\hat{G}_o = \frac{EBV_{Sire} + EBV_{Dam}}{2}$$

Response to selection I

Similarly for a selection policy

For a given selection policy (breeding operation) progeny merit is predicted by

- Predicting the phenotypic superiority of selected parents
- Predicting superiority of progeny generation

Why is this useful?

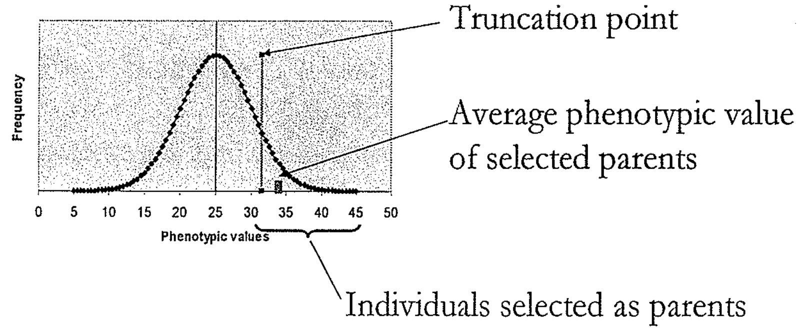
Predicting progeny merit for a selection policy (i.e. response to selection) is useful as it allows us to compare different selection policies

- For example, is there greater genetic gain if
  - Breeding females are kept for three years only, requiring more replacements each year but quicker turnover

  OR
  - Breeding females are kept for five years, requiring less replacements each year but slower turnover

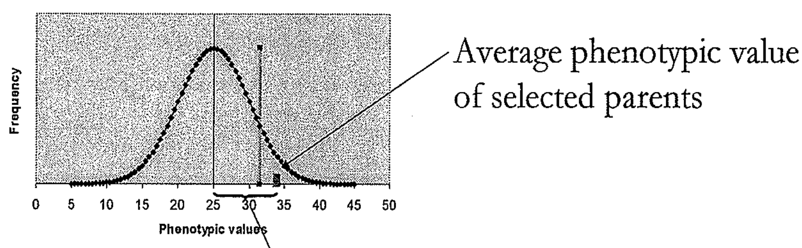
Direct determination of phenotypic superiority of selected parents

Assume that individuals are selected as parents only if their phenotypic value is greater than a truncation point



Continued

The selection differential (S) is the phenotypic superiority of selected parents (i.e. mean of selected parents – population mean)



In this example S is ~9 units

Continued

S is averaged if different proportions of males and females are selected

$$S = \frac{S_{Male} + S_{Female}}{2}$$

For example

- Mean of selected males is 32kg, mean of all male candidates is 27kg. S_{male} = 5 kg
- Mean of selected females is 25kg, mean of all female candidates is 22kg, S_{female} = 3 kg
- Average S is 4 kg

A more useful way to determine S

Rather than determine S directly (as in the previous slides) it is more useful to determine S from a knowledge of the selection policy

Determining S from knowledge of the selection policy

First determine selection intensity (*i*)

- Selection intensity (*i*) is the number of phenotypic standard deviation units that selected parents are superior to the mean
- *i* is obtained from selection intensity tables according to the proportion (P) of animals selected as parents

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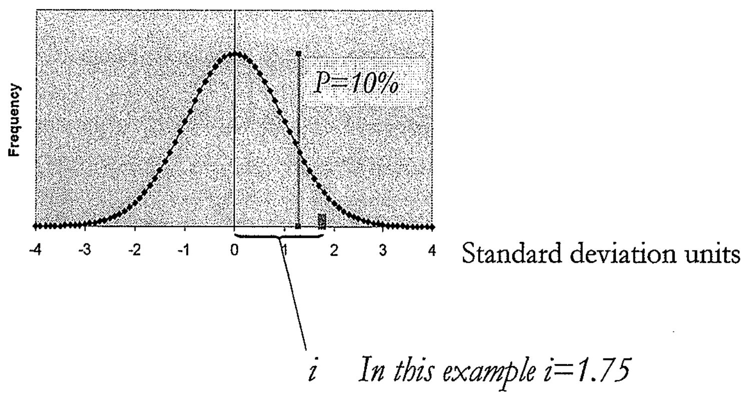
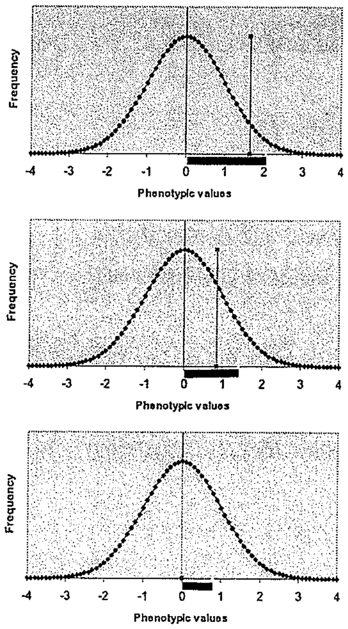


In this example i=1.75
(from selection intensity tables for P=10%)

Selection intensities



5 out of 100 animals selected

p = 5%, $i = 2.06$

20 out of 100 animals selected

p = 20%, $i = 1.40$

50 out of 100 animals selected

p = 50%, $i = 0.80$

Continued

Note the relationship between proportion selected (P) and selection intensity (*i*)

- ❖ Select few individuals → low P and high *i*
- ❖ Select many individuals → high P and low *i*

Continued

i is averaged for males and females

$$i = \frac{i_{Male} + i_{Female}}{2}$$

For example

- 2 out of 100 males selected:
  - P_{male} = 2% and i_{male}=2.421
- 80 out of 100 females selected:
  - P_{male}=80% and i_{female}=0.350
- Average *i* is 1.38

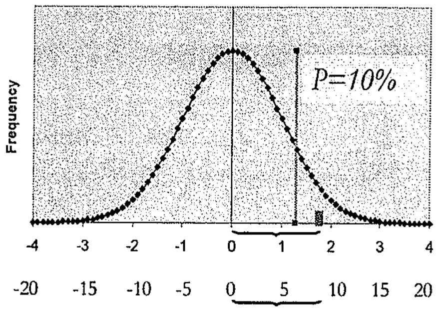
Continued

Then determine S by multiplying *i* by the phenotypic standard deviation

$$S = i\sigma_p$$

The selection differential is equal to the selection intensity multiplied by the phenotypic standard deviation.

Continued



Standard deviation units

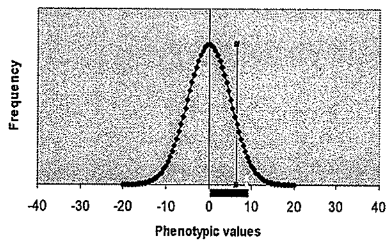
Phenotypic units for σp=5

In this example i=1.75 and S=8.75

as $S = i\,\sigma_p = 1.75 \times 5$

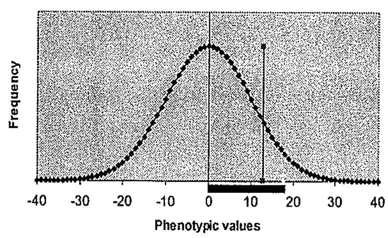
Response to selection I

Phenotypic standard deviation



$\sigma_P = 5$, p=10%, i=1.76

$S = i\,\sigma_P = 1.76 \times 5 = 8.8$



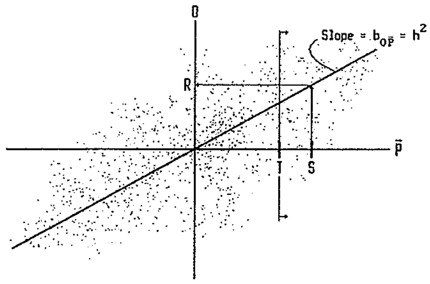
$\sigma_P = 10$, p=10%, i=1.76

$S = i\,\sigma_P = 1.76 \times 10 = 17.6$

Response to selection I

Predicting superiority of the progeny generation

Only the heritable portion of the phenotypic superiority of selected parents will be passed onto the offspring



Thus offspring mean superiority (over a no selection policy) equals the selection differential multiplied by the heritability

Continued

Thus

$$R_{gen} = Sh^2$$

$$R_{gen} = i\sigma_p h^2$$

$$R_{gen} = \frac{i_{male} + i_{female}}{2}\sigma_p h^2$$

where R_{gen} is response per generation.

From R_{gen} to R_{year}

It is also useful to determine response per year (R_{year})

This requires calculation of the generation interval (L)

Generation interval (L)

Generation interval (L) is the average age of parents when progeny are born

L is calculated seperately for males and females and then averaged

For example

- Equal numbers of 2 and 3 year old bulls selected as parents L_{male}= 2.5 years
- Equal numbers of 2, 3 and 4 year old cows selected as parents L_{female}= 3.0 years
- $L_{average}$= 2.75 years

Continued

Another example of calculating L

Age structure of animals selected for breeding					
Age (years)	2	3	4	5	Total
Male	7	5			12
Female	200	150	100	50	500

$$L_{male} = \frac{(7x2)+(5x3)}{7+5} = 2.4 years$$

$$L_{female} = \frac{(200x2)+(150x3)+(100x4)+(50x5)}{200+150+100+50} = 3.0 years$$

$$L_{average} = \frac{2.4+3.0}{2} = 2.7 years$$

Response to selection I

Continued

Given

$$R_{gen} = \frac{i_{male} + i_{female}}{2} \sigma_p h^2$$

and

$$L = \frac{L_{male} + L_{female}}{2}$$

$$R_{year} = \frac{i_{male} + i_{female}}{L_{male} + L_{female}} \sigma_p h^2$$

Alternatively

$$\frac{R}{year} = \frac{R}{gen} x \frac{gen}{year}$$

where

$$\frac{gen}{year} = \frac{1}{L}$$

Response to selection I

Balancing i and L: consider age structures

Age	2	3	4	5	6
Males	5	5			
Females	100	100	100	100	100

Higher i : replacing 5 / 250 males and 100 / 250 females
Higher L : Lm=2.5 years, Lf=4.0 years, L=3.25 years

Age	2	3	4	5	6
Males	10				
Females	125	125	125	125	

Lower i : replacing 10 / 250 males and 125/ 250 females
Lower L : Lm=2.0 years, Lf=3.5 years, L=2.75 years

$$R_{year} = \frac{i_m + i_f}{L_m + L_f} \sigma_P h^2$$

Thus high i → high L & low i → low L

- this does not fit well with maximising i / L

The *best compromise* between i and L is required

Example of response calculation

- Sheep breeder has 180 ewe flock, selecting for FW
- Rams first selected at 2 years old, and mated for 2 years
- Ewes first selected at 2 years old, and mated for 4 years
- Each ram mated to 30 ewes, 90% lambing, 50:50 sex ratio
- No significant mortality in adults
- Trait heritability = 0.25, and σ_P=0.6kg
- What is R per year ?

Answer

Age structure of animals selected for breeding					
Age(yrs)	2	3	4	5	Total
Male	3	3			6
Female	45	45	45	45	180

- 180 ewes, 90% lambing → 162 lambs total (81 of each sex)
- Need to select 3 out of 81 males each year
  - P=3/81=3.7%, which corresponds to an *i* of 2.18
- Similarly need to select 45 out of 81 females each year
  - P=45/81=55%, which corresponds to an *i* of 0.72
- L_{male}=2.5years, L_{female}=3.5years

$$R_{year} = \frac{i_{male} + i_{female}}{L_{male} + L_{female}} \sigma_p h^2$$

$$R_{year} = \frac{2.18 + 0.72}{2.5 + 3.5} x0.6x0.25 = 0.07kg$$

FW is expected to increase by 0.07kg per year

Revision problems

Which of the two options will results in the higher response to selection?

- 80% of females selected and 2% of males selected
- 80% of females selected and 10% of males selected

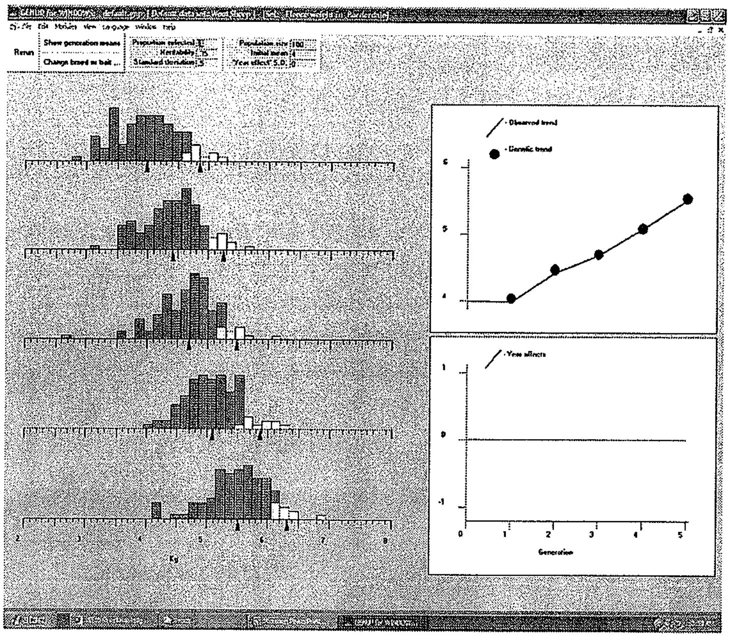
- 5 males and 50 females selected, 1 progeny per female
- 5 males and 50 females selected, 2 progeny per female

- Selecting for a trait with V_A=30 and V_E=70
- Selecting for a trait with V_A=10 and V_E=90

- Selecting for a trait with V_A=30 and V_E=70
- Selecting for a trait with V_A=3 and V_E=7

- Males and females first selected at two years of age
- Males and females first selected at one year of age

Response to selection I



Response to selection I