Selection and genetic gain - exercises

1. Consider a population of hens with an average production of 180 eggs per year and a phenotypic standard deviation of 40 eggs.

a) Construct a normal distribution curve that fits these data.

b) What is the percentage of hens producing more than 240 eggs annually?

c) Suppose that all hens producing less than 140 eggs are culled.

(i) What percentage of the hens are kept for breeding?
(ii) What will the selection intensity be in this case?
(iii) How much will the mean of the breeding group exceed the population mean?

2. You have a population with 10 000 cows. Average production for the 2 000 best cows is 5 500 kg. The phenotypic standard deviation for milk yield is 1 000 kg.

a) What is the average milk yield for the whole population?

b) What is the average milk yield for the 4 000 best cows?

c) At what milk yield do we have the lower limit for the 4 000 best cows?

3. In a herd we have 100 ewes which are producing 1.8 lambs per year (sex ratio 1:1). Calculate the selection difference for weaning weight (at 120 days) if 20% of the ewes are replaced every year. The heritability for weaning weight is 0.3 and the additive genetic variance σ_A^2 = 4.8 kg.

4. Future cow dams are selected in a population with dairy cows on the basis of their own milk yield. The population mean is 5 500 kg fat corrected milk and 60% of the cows need to be selected. The phenotypic standard deviation is 500 kg and the heritability 0.25. The average age of the cows when the next generation of breeding animals are born is 4.5 years.

a) What is the mean for the selected group?

b) What is the annual selection effect achieved by this selection?

5. In a population the following parameters have been calculated for a certain trait:
Mean, μ = 105 units
Phenotypic standard deviation, σ_P = 12 units
Genetic standard deviation, σ_A = 6 units

a) What will the selection effect be after one generation if we select, by individual selection, the best half of the population?

b) What is the percentage of animals we have to select if we want to have a selection effect of 1% per year and if the generation interval is 4 years?

6. Testing and selection is going to be carried out for a trait with heritability (h^2) = 0.4 and phenotypic standard deviation (σ_P) = 10 kg. The animals which are tested are raised under standardized conditions on a testing station. The station has a testing capacity for 2 000 animals and 100 animals are going to be selected.

What will the accuracy (r_{TI}) and the selection intensity (i) be if the testing station is used for:

a) Performance testing?

b) Progeny testing based on 10 progenies (half-sibs) per tested male?

c) What will the expected effect of selection (ΔT) be ***per generation*** for a) and b) respectively?

d) Compare and discuss the two testing alternatives with regard to ***annual*** genetic change.

7. The following parameters have been estimated for weight gain (X_1) and feed consumption (X_2) in pigs:

$\sigma_{P_1}^2 = 45 g/day$ $\quad$ $\sigma_{P_2}^2 = 0.2\ MJ/kg\ weight\ gain$

$h_1^2 = 0.35$ $\quad$ $h_2^2 = 0.40$

$r_{p_{12}} = -0.80$ $\quad$ $r_{g_{12}} = -0.85$

a) Assume that only weight gain is recorded and selected for directly and that 20% of the animals are selected. What will the indirect selection effect per generation be for the trait feed consumption?

b) How efficient will the indirect selection be compared to direct selection for feed consumption? The intensity of selection is assumed to be equal for indirect and direct selection.

8. In a field study within a cow population, the following parameters were estimated from data for milk yield in the first lactation:

Trait		h^2	Mean	Phenotypic Standard dev.
Fat corrected milk (4%), kg	X_1	0.25	4775	738
Fat yield, kg	X_2	0.25	193	31.0
Protein yield, kg	X_3	0.25	153	24.5

50% of the best cows were selected to produce replacements females for the next generation (this is true for all traits).

Genetic correlations:

Trait	FCM (4%), kg	Fat yield, kg	Protein yield, kg
FCM (4%), kg	1	0.95	0.90
Fat yield, kg		1	0.82
Protein yield, kg			1

a) Calculate, from the information given above, the direct effect of selection on X_1 and the indirect effects of selection on X_2 and X_3 when only kg fat corrected milk (FCM) is recorded.

b) Calculate the direct effect of selection for fat yield (X_2) and the indirect effects of selection on X_1 and X_3 when only fat yield is recorded.

c) Calculate the direct effect of selection for protein yield (X_3) and the indirect effects of selection on X_1 and X_2 when only protein yield is registered.

d) Compare the effects of selection for direct and indirect selection for all traits.

9. How will the expected genetic gain and its components be affected if we change a selection programme from progeny testing to performance testing?

10. Suppose that $\sigma_T = \sigma_A = 1000$ pounds
For cows: $r_{TI} = 0.69$
For bulls with 200 daughters each: $r_{TI} = 0.96$

What will the expected genetic gain be per generation if 1% of the bulls and 50% of the cows are selected?

11. In a population with 1500 lambs we have, for breeding purposes, selected the best 20% of the female lambs and the best 2% of the male lambs regarding weight at 120 days. What will the expected annual genetic gain for weight at 120 days be if $h^2 = 0.3$, $\sigma_P = 4$ kg and the generation intervals for females and males are 4 and 1.5 years, respectively?

12. The following information is obtained in a breeding programme where selection for milk yield is based on breeding values.

Path in selection	**% selected**	**Generation interval, years**	$\mathbf{r_{TI}}$
Father - son	5	8	0.877
Father - daughter	20	6	0.877
Mother - son	10	7	0.598
Mother - daughter	80	7	0.500

$h^2 = 0.25$; $\sigma_P = 800$ kg; Population mean (μ) = 5000 kg

Calculate the expected genetic gain per year, both in absolute value and in % of the mean.