

Investigating the maths inside:

Prawns for profit

Activity 4

Selective breeding

What do you know about the phrase ‘selective breeding’?

What makes ‘first cousins’ different to ‘double cousins’?

Why do farmers need to exercise some degree of care when their animals produce offspring?

# Prawns that grow faster, not necessarily bigger!

In the wild, black tiger prawns take about 18 months to become fully grown. It is estimated that 40 to 50% of wild prawns do not make it to full size.

The prawns in the video are part of a selective breeding program. One of the aims of the program is to produce prawns that grow quickly to the ideal size. Australian scientists and farmers have managed to breed domesticated black tiger prawns that reach the ideal size in 5 months. More than 90% of the farmed prawns reach this size prior to being harvested.

This has been achieved by carefully choosing prawns that have grown quickly and using those prawns to breed prawns that would also (hopefully) grow quickly.

The adult prawns shown swimming around in indoor tanks in the video are called ‘brood stock’. Some of them are 35cm long! The offspring of the brood stock become the prawns in the large outdoor ponds from which the crop is harvested.

# A challenge for scientists and farmers:

# Avoid defects that result from inbreeding

One of the difficulties of selective breeding can be inbreeding. This can happen when animals that are closely related are mated. In the video, the indoor tanks contain carefully chosen mating pairs. Scientists use the DNA of these prawns to show that they are not closely related.

The prawns in the large outdoor ponds may be very closely related. They are harvested prior to reaching sexual maturity. Then the pond is emptied. This avoids inbreeding in the ponds.

## Calculating the inbreeding coefficient

In 1922, Sewall Wright came up with a mathematical method for describing the closeness of the biological relationship between two individuals. It is called the *coefficient of relationship*. He also defined the *coefficient of inbreeding* so that a single individual could be described on a scale from 0% to100%. A value close to 0% indicates that the individual’s ancestors are distantly related, whereas a value close to 100% indicates a high level of inbreeding.

This article explains the *coefficient of relationship* and the *coefficient of inbreeding:*

<https://en.wikipedia.org/wiki/Coefficient_of_relationship>

# Example 1: Half siblings

# Prawns A, B and C are completely unrelated (and not inbred).

# Prawn A is mated with Prawn B to produce Prawn D.

# Prawn B is mated with Prawn C to produce Prawn E.

Later, Prawn D is mated with Prawn E to produce Prawn F.

Calculate Prawn F’s inbreeding coefficient.

**Solution:**

This could be represented as follows:



F is said to be ‘inbred’ because B is a common ancestor.

There are **three** ancestors of F in this inbreeding loop: F-D-B-E-F.

F’s **inbreeding coefficient** is calculated as follows:



**Note:** If A, B or C were also inbred, then F’s coefficient would be higher

**Problem 1: First half cousins**

A and B are mated and produce E. B and C are mated and produce F.

Later, D and E are mated and produce H. F and G are mated and produce I.

Later, H and I are mated and produce J.

Draw a diagram and show that the **inbreeding coefficient** for J is 3.125%.



**Problem 2: Parent and offspring**

A and B are mated and produce C.

Later, A and C are mated and produce D.

Draw a diagram and show that the **inbreeding coefficient** for D is 25%.

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# Example 2: Full siblings

# A and B are mated and produce C.

Later they are mated again and produce D.

Later, C and D are mated and produce E.

Calculate E’s inbreeding coefficient.

**Solution:**



E is said to be ‘inbred’ because A and B are common ancestors.

There are **three** ancestors of E in the inbreeding loop E-C-A-D-E.

In addition here are **three** ancestors of E in the inbreeding loop E-C-B-D-E.

F’s **inbreeding coefficient** for this is calculated as follows:



**Problem 3: Uncle and niece (or aunty and nephew)**

# A and B are mated and produce C.

Later they are mated again and produce D.

Later, D and E are mated and produce F.

Later, C and F are mated and produce G.

Show that G’s inbreeding coefficient is 12.5%.

**Problem 4: Full first cousins**

A and B are mated and produce D. Later they are mated again and produce E.

Later, C and D are mated and produce G; and E and F are mated and produce H.

Later, G and H are mated and produce I.

Show that I’s inbreeding coefficient is 6.25%.

**Problem 5: Full first double cousins**

A and B are mated and produce E. Later they are mated again and produce F.

At the same time C and D are mated and produce G. Later they are mated again and produce H.

Later, E and G are mated and produce I; and H and F are mated and produce J.

I and J are full first double cousins. I’s 4 grandparents are the same as J’s 4 grandparents.

Later, I and J are mated and produce K.

Show that K’s inbreeding coefficient is 12.5% (which is the same as uncle and niece).

Reconsider the questions at the beginning of the module.

Write a short report to explain why farmers need to exercise a degree of caution when breeding stock for their farms.