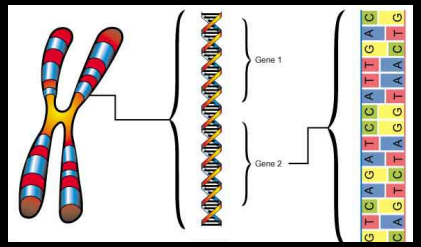


Manaaki Whenua
Landcare Research

How Many Are There?
Using DNA & Statistics to Estimate Population Size

Hester Roberts ,
Andrew Gormley,
Jackie Whitford,
Graham Nugent

Motivation 1: Ferret Abundance

- In most areas, possums are maintenance host of wildlife TB
- Can ferrets maintain TB?

7 APR 1995

Tb link not proven

CHRISTCHURCH (PA) — Some farmers are convinced that ferrets are transmitting bovine tuberculosis to stock but a Landcare Research scientist says there is no proof.

Peter Caley, carrying out research at two sites in North Canterbury, said farmers had told him ferrets in the area had been associated with all recent herd breakdowns in the district.

"However, association is not proof of transmission," Mr Caley said.

The main aim of Mr Caley's research is to see whether changes in the abundance of ferrets resulted in a decrease in poacher rates in cattle.

"Hence, we are testing the assumption that ferrets are, indeed, transmitting Tb to cattle," he said.

He said it was also important for the management of the disease to find out whether the prevalence of Tb decreased in ferrets when ferret populations were controlled.

Research also aimed to determine whether controlling ferret numbers caused rabbit populations to increase significantly.

The work complements that being done by Grant Norbury and other Landcare Research scientists in Central Otago and the Mackenzie Basin where they are examining the

NEWS

Ferrets' major role as disease carrier

By SEAN STEPHENS

FARMERS have been saying it for years, and the Animal Health Board now agrees. Ferrets play a major role in spreading TB in North Canterbury.

The predator now forms the

LIFE

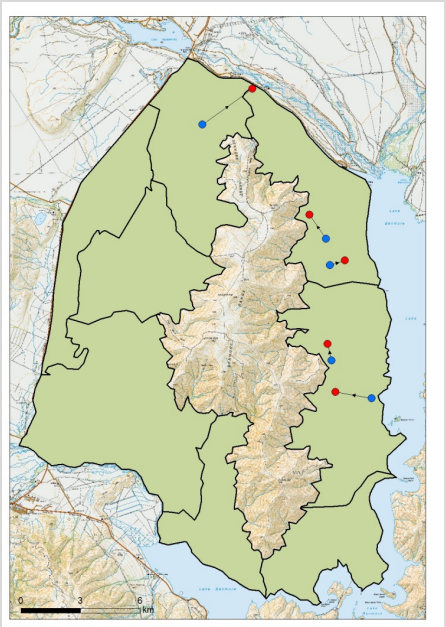
Ferreting out the truth about Tb

COUNTRY DIARY

The ferret: 600 trapped near Culverden.

Motivation 1: Ferret Abundance

- Central Otago – few possums but still TB in ferrets
- What is ferret density?

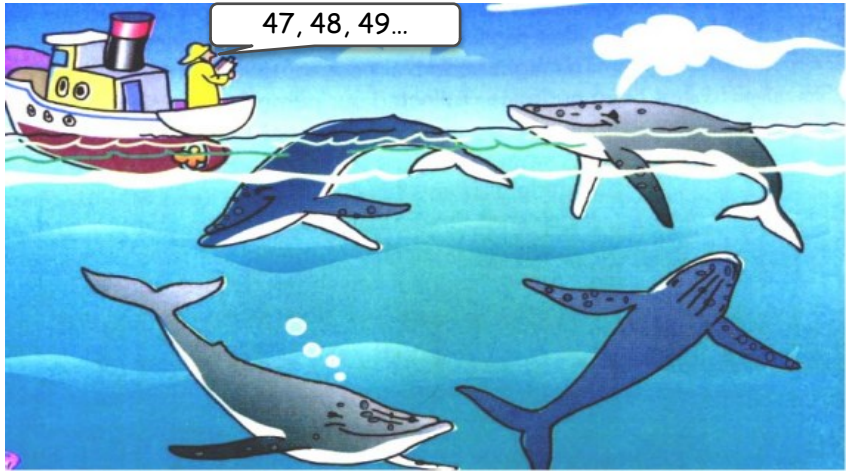


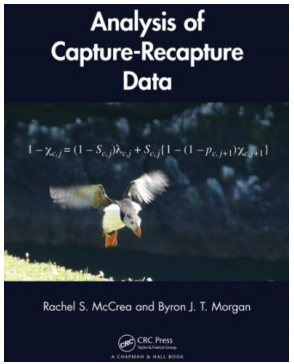
Motivation 2: Pig Abundance

- What happens if we detect TB in spill-over hosts?
- Even if possums are free of TB it may persist in other long-lived animals (pigs/deer)
- Need to know population size to help determine scale of potential issue

How many are there?

- Figuring out the size of a population is hard!
  - Counted all individuals?
  - Counted each individual only once?
- Can use field and analytical methods to account for detection
  - E.g. **Mark-recapture**

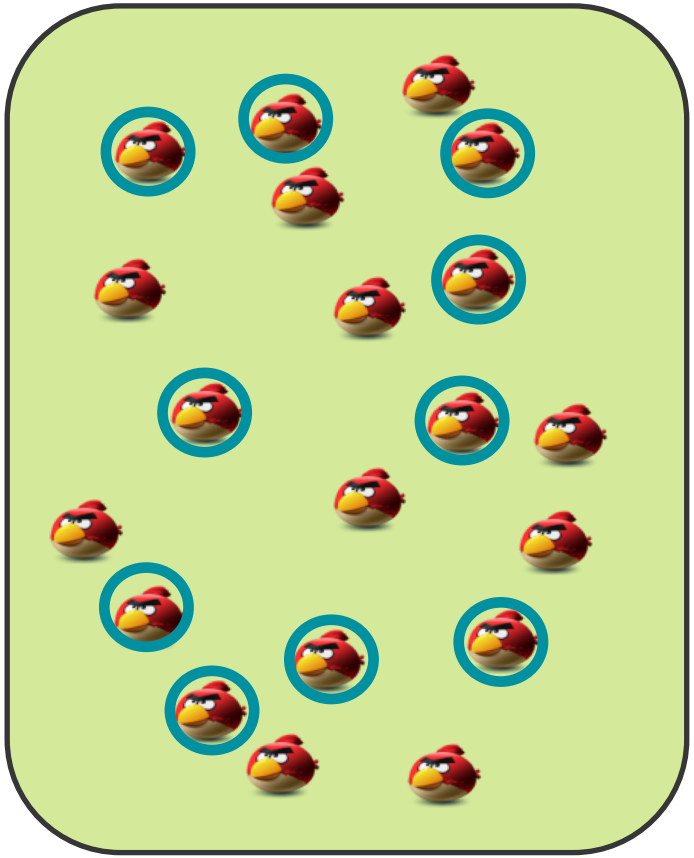




Mark-Recapture

- Requires 2+ samples
- Sample 1:
  Catch M animals, mark them, then let them go.

Sample 1:
$M = 10$ marked animals

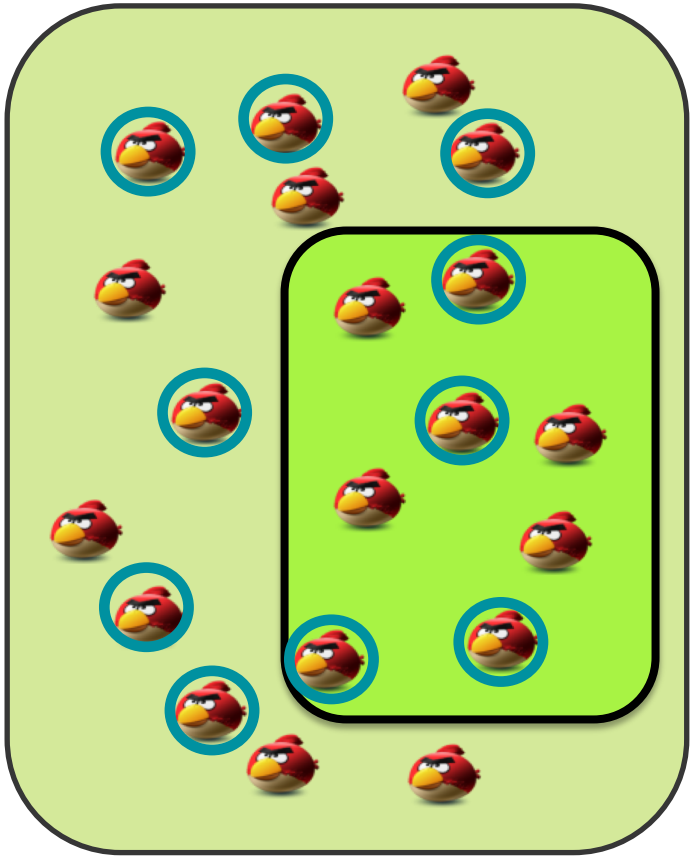


Mark-Recapture

- Requires 2+ samples
- Sample 1:
  Catch M animals, mark them, then let them go
- Sample 2:
  Size n; m will be marked previously

Sample 1:
M =10 marked animals

Sample 2:
n = 8 animals
m = 4 have marks



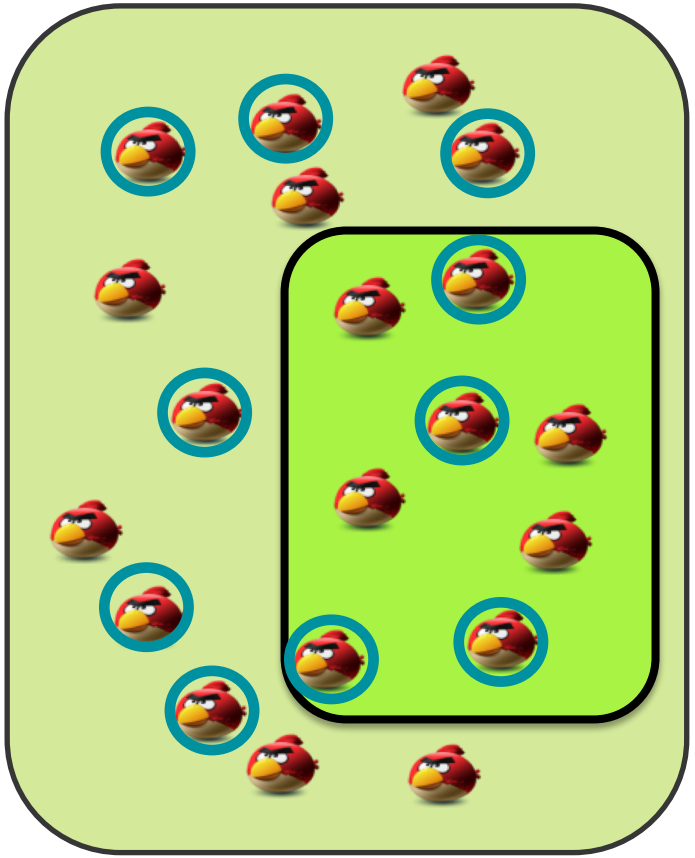
Mark-Recapture

- Proportion of sample 2 with marks *should* equal proportion of population with marks

$$\frac{M}{N} = \frac{m}{n}$$

Sample 1:
M =10 marked animals

Sample 2:
n = 8 animals
m = 4 have marks



Mark-Recapture

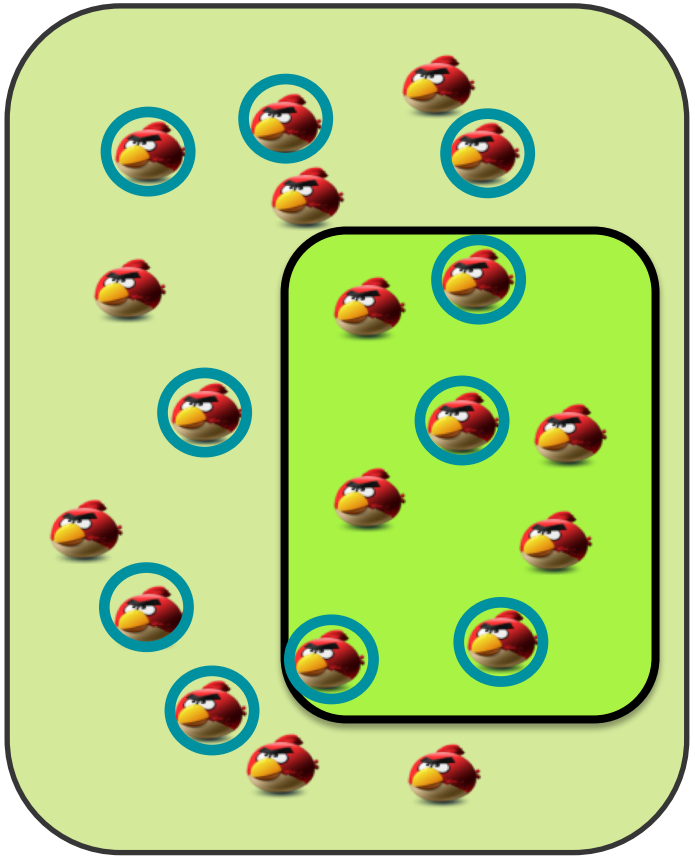
- Proportion of sample 2 with marks *should* equal proportion of population with marks

$$\hat{N} = \frac{n}{m} M$$

Sample 1:
M =10 marked animals

Sample 2:
n = 8 animals
m = 4 have marks

$$\hat{N} = \frac{8}{4} 10 = 20$$



Estimating Pest Mammal Abundance

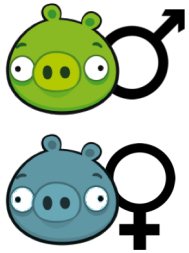
- Often we use **relative abundance**
  - Wax tag/chew-card index
  - Trap catch index
  - Camera index

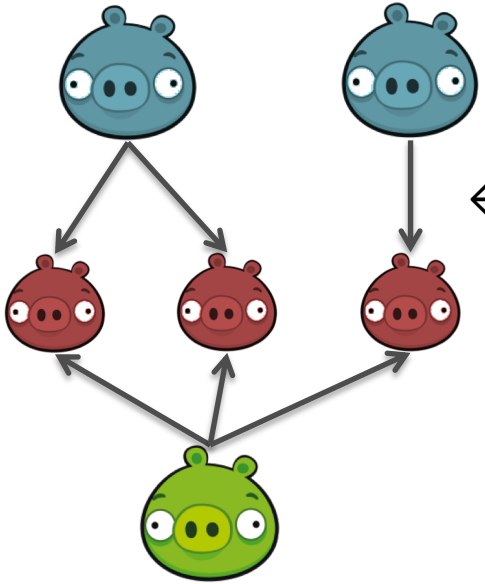
- A higher index = more animals… (hopefully)

- Current methods are difficult for ferrets and pigs

Close-Kin Mark-Recapture

- Offspring carry the ‘marks’ of each parent in their DNA





← **Parent-Offspring-Pairs** (POPs)

- Number of adults in population

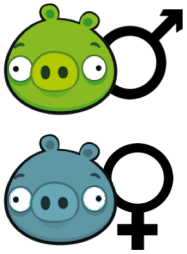
$$\widehat{N_a} = \frac{2n_a n_j}{POPs}$$

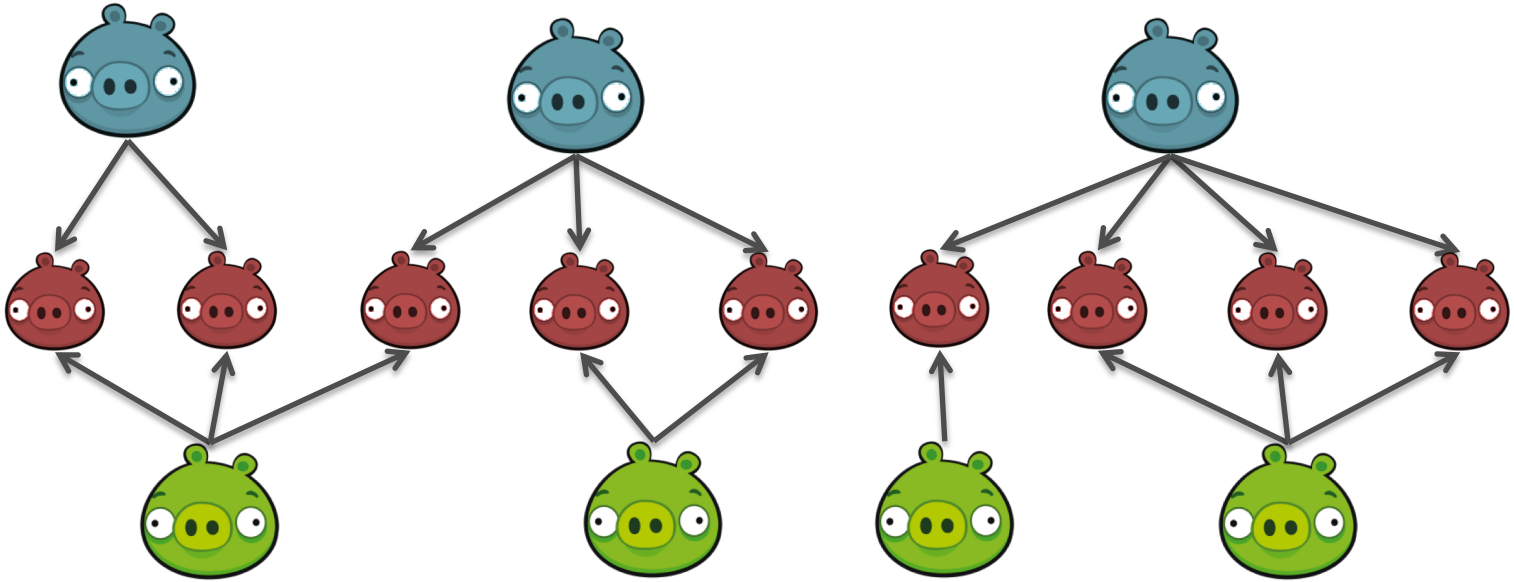
Close-Kin Mark-Recapture

- **Full sample…**

$$\widehat{N_a} = \frac{2n_a n_j}{POPs}$$

$$\widehat{N_a} = \frac{2\times7\times9}{18} = 7$$

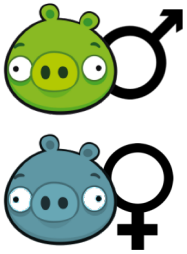


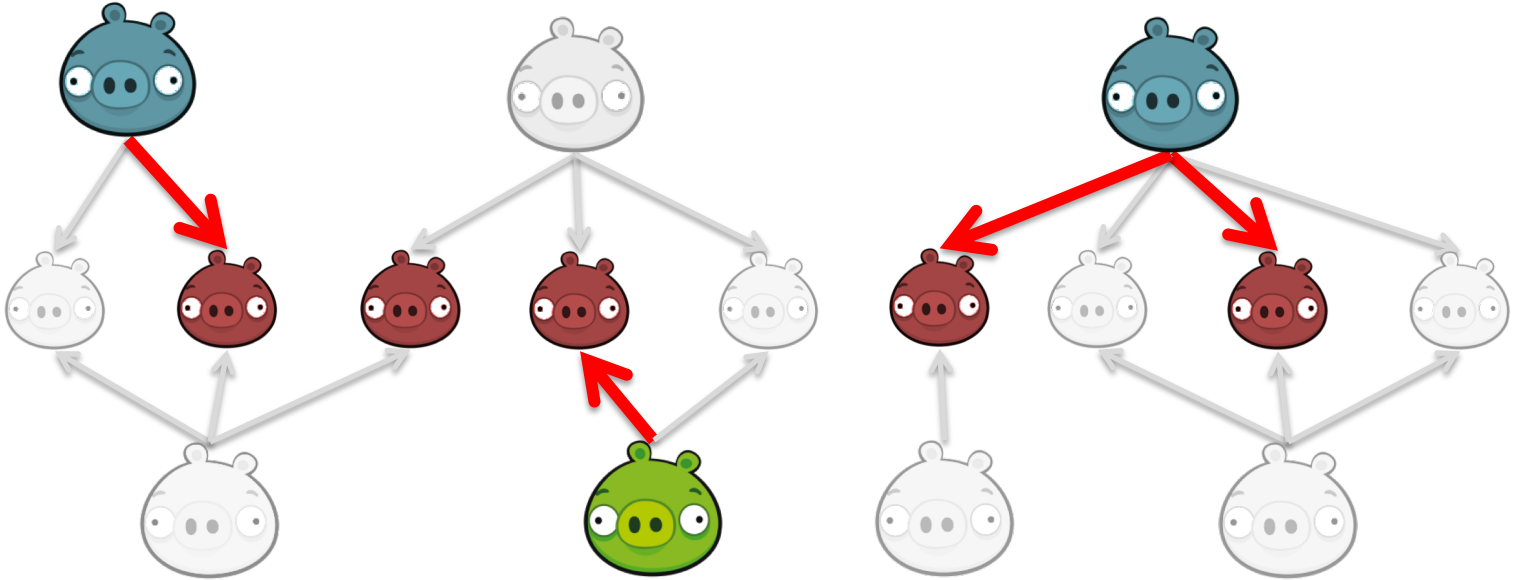


Close-Kin Mark-Recapture

- **Partial sample**

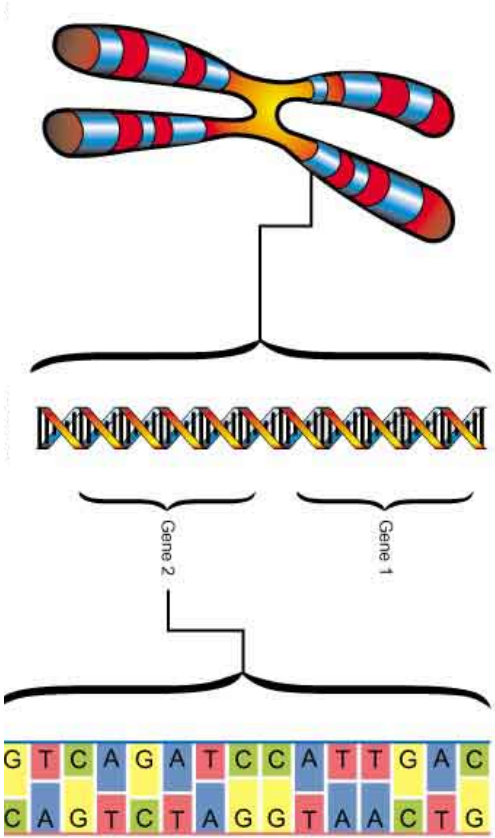
$$\widehat{N_a} = \frac{2\times3\times5}{4} = 7.5$$





Genetics 101

- Each cell nucleus contains **chromosomes**
- Each chromosome has 1000s of **genes**
- Each gene is a chain of coded information made up of building blocks
  - A/G/T/C

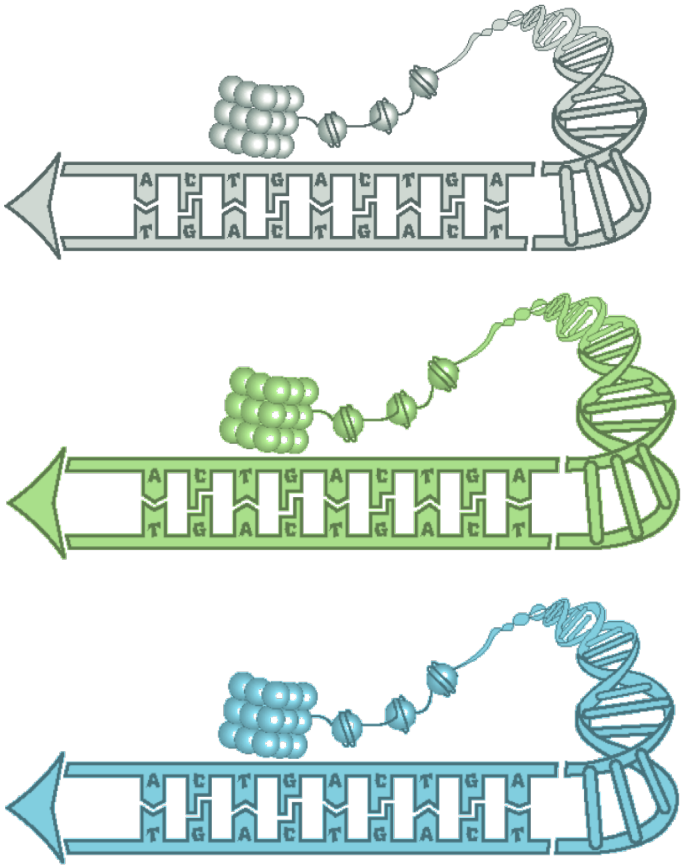


Genetics 101

- The different ‘choices’ at for a gene are called **alleles**

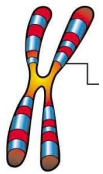
Eye-colour

- Choices are grey, green, blue, brown, etc



Genetics 101

- Mammals have ‘pairs’ of chromosomes
- Inherit one from mother, one from father
- Therefore offspring will have **at least 1** match with each parent



Mother

11	15

Father

14	16

Offspring

11	14

11	16

15	14

15	16

Genetics 101

- Parent-Offspring-Pairs have at least one allele in common at each locus

Sample 1 

Locus		
01	11	15
02	14	23

Sample 2 

Locus		
01	12	15
02	14	21

Match!

Genetics 101

- But can have matching by chance

Sample 1 

Locus		
01	11	15
02	14	23

Sample 2 

Locus		
01	12	15
02	14	21

Genetics 101

- But can have matching by chance
- So examine lots of loci to reduce chance of false positives.

Sample 1 

Locus		
01	11	15
02	14	23
03	13	13
04	22	23
05	7	10
06	17	19
07	16	24
08	7	9

Sample 2 

Locus		
01	12	15
02	14	21
03	14	16
04	22	25
05	9	11
06	18	19
07	18	21
08	7	8

Genetics 101

- Looking in lots of places can increase chance of false negatives
- Genotyping error
- Allelic dropout

Sample 1 

Locus		
01	11	15
02	14	23
03	13	14
04	22	23
05	7	10
06	17	19
...		
101	7	9

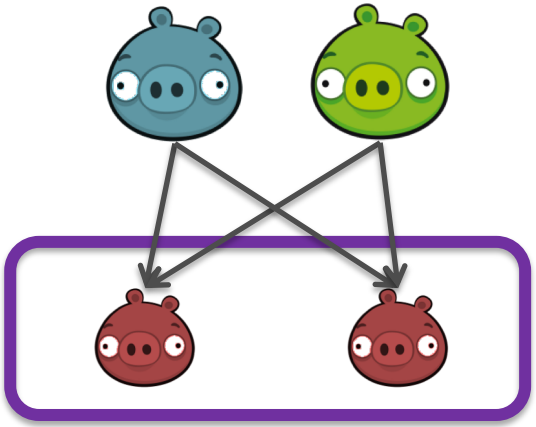
Sample 2 

Locus		
01	12	15
02	14	21
03	14	16
04	22	25
05	9	9
06	18	19
...		
101	7	8

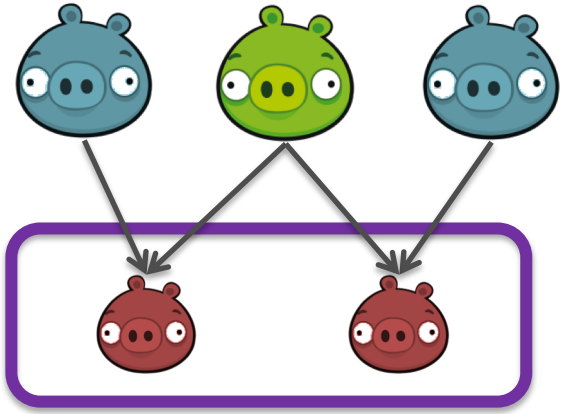
Close-Kin Mark-Recapture

- Other relationships have different rates of matching

- Full-Siblings (two parents in common)
  - No matches on 25% of loci
  - One match on 50% of loci
  - Two matches on 25% of loci



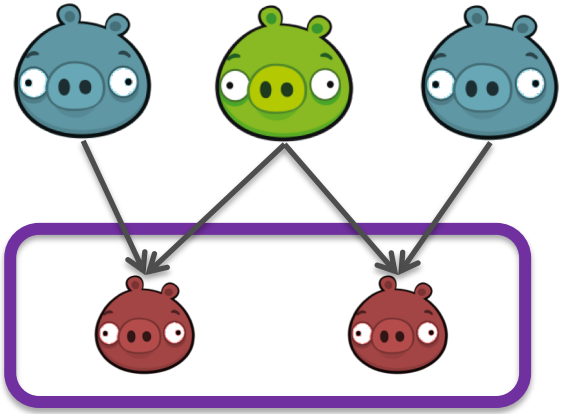
- Half-Siblings (one parent in common)
  - No matches on 50% of loci
  - One match on 50% of loci



Close-Kin Mark-Recapture

- Complicated if multiple generations in sample

- Half-Siblings (one parent in common)

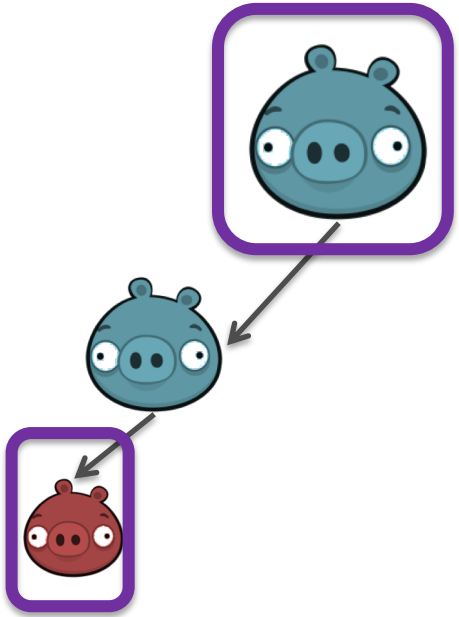


No matches on 50% of loci
One match on 50% of loci

Need:

- Age data
- Population dynamics model

- Grandparents/grand-child



OSPRI Funded Project

- Ferrets (Central Otago)

- Pigs (Hauhungaroa)

- Time sampling to have juvenile and adult cohort only
  - Lots of Parent-Offspring-Pairs
  - Age structure of adults known
- In-breeding means difficulty of genetic matching

- Under-sampling of juveniles
  - OSPRI want older animals during TB surveys
- Parent may be dead – need to include population dynamics

Summary: Close-Kin Mark-Recapture

- It works!
  - Demonstrated on white-sharks & bluefin- tuna
- Well suited to pest species
  - Can collect data using dead animals
- Potentially cost effective
  - Only one sample
  - Cheaper DNA methods
  - Better matching
- Issues of in-breeding