CORD HEUER

Massey University

Professor Cord Heuer is a veterinarian with an interest in teaching and researching the epidemiology of production animal diseases. Recent projects include Johne's disease, leptospirosis, cattle fertility, campylobacter in beef breeding cattle, abortions in beef cattle, lamb pneumonia, neosporosis, bovine viral diarrhoea, heifer mastitis and endometritis in dairy cows.

The feasibility of controlling Johne's disease in New Zealand

Johne's disease (JD), a chronic wasting disease of ruminants is caused by Mycobacterium avium ssp. paratuberculosis (MAP). No treatment exists and diagnostic tests perform poorly or are expensive. A recent survey of dry stock farms showed about 76% ewe flocks, 42% beef cow herds and 46% deer breeding herds are infected by MAP. About half of dairy herds are believed to be infected. However, clinical disease is rarely observed: 0.5-1% animals in infected herds develop clinical signs, and few farms experience outbreaks or consistently high losses. This raises the question whether large scale control measures are warranted in New Zealand. The deer industry has a voluntary control programme, some merino farmers use vaccination and other producers seek vet advice when JD is an acute problem. MAP has 'sheep' and 'cattle' strains. It appears about 80% infected beef cattle and all infected sheep have the 'sheep' type, suggesting cattle are infected by sheep when grazed together. Since beef cattle rarely suffer clinical JD, it may be the 'sheep' type is less virulent and equally or more immunogenic for cattle. If that is the case, co-grazing sheep and cattle may be used as a control of JD in cattle. Studies evaluating breeding for natural resistance were disappointing. Control measures like vaccination and 'test & cull' will show net economic benefits only when incidence of JD is high; vaccination of lambs at weaning is cost effective only if >2% ewes developed JD prior to vaccination; such a high incidence occurs in less than 1% ewe flocks in New Zealand.

MONDAY 12 MAY

2.20pm | **Room 1**

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ki Pūrehuroa

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Johne's disease in mixed species farming systems

Cord Heuer
Professor of Veterinary Epidemiology and Infectious Diseases

EpiCentre, IVABS, Massey University, Palmerston North

EpiCentre

The Bacterium

- Cause of Johne's disease (JD) or 'Paratuberculosis' (PTB)

Mycobacteria

Type 'bovine' | Type 'avium' (birds) | Type 'tuberculum' (human)

Cross-reactivity

Mycobacterium avium subspecies *paratuberculosis*

"MAP"

Clinical Johne's disease

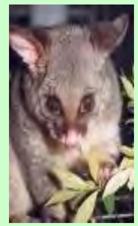
Cattle: >3 years

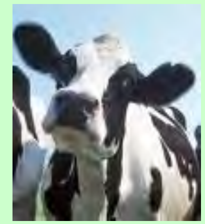
Deer: 1-2 years

Sheep: >1 year

NZ-specifics
who is at risk?



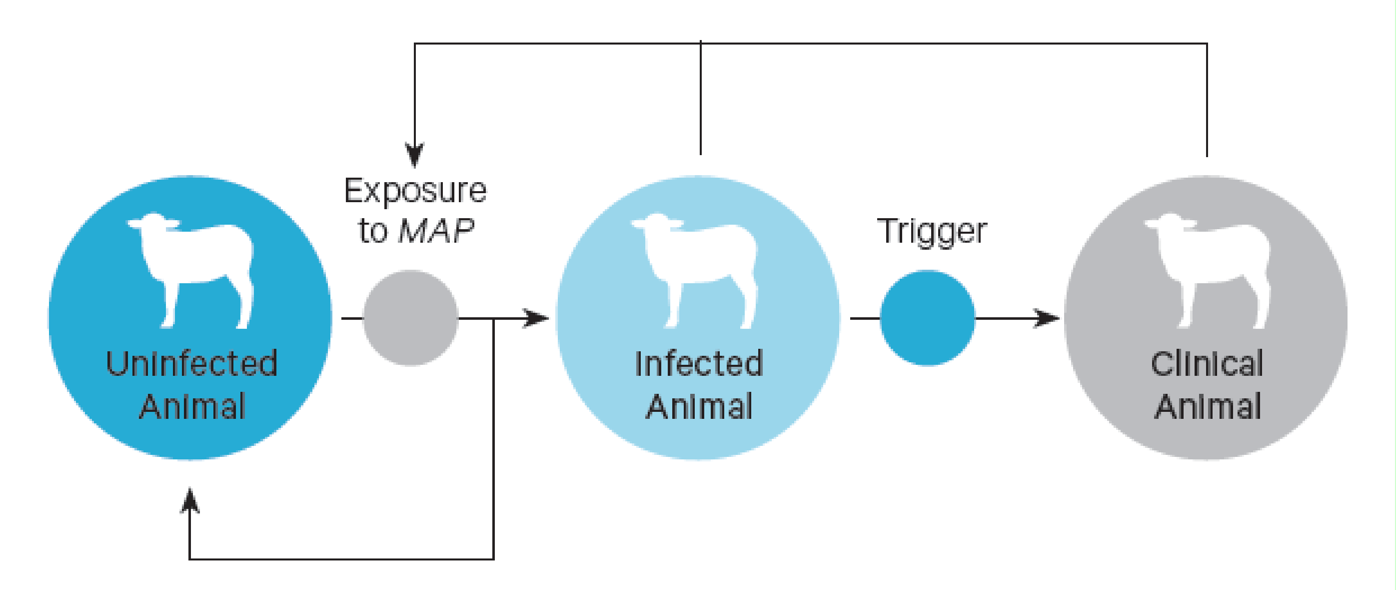




- **Species:**
  - deer, sheep, beef/dairy cattle, wildlife
- **Breed:** Jersey, Merino
- **Age:**
  - cattle (0-12m >> heifer >> cow)
  - sheep (lamb > weaner > hogget > ewe)
  - deer (calf > weaner > yearling)
- **Genotype:** assumed large individual variation in susceptibility/resistance
- **Immune status:** vaccination → reduction of clinical disease
- **MAP bacteria:** Is every bug equal? → strain variability

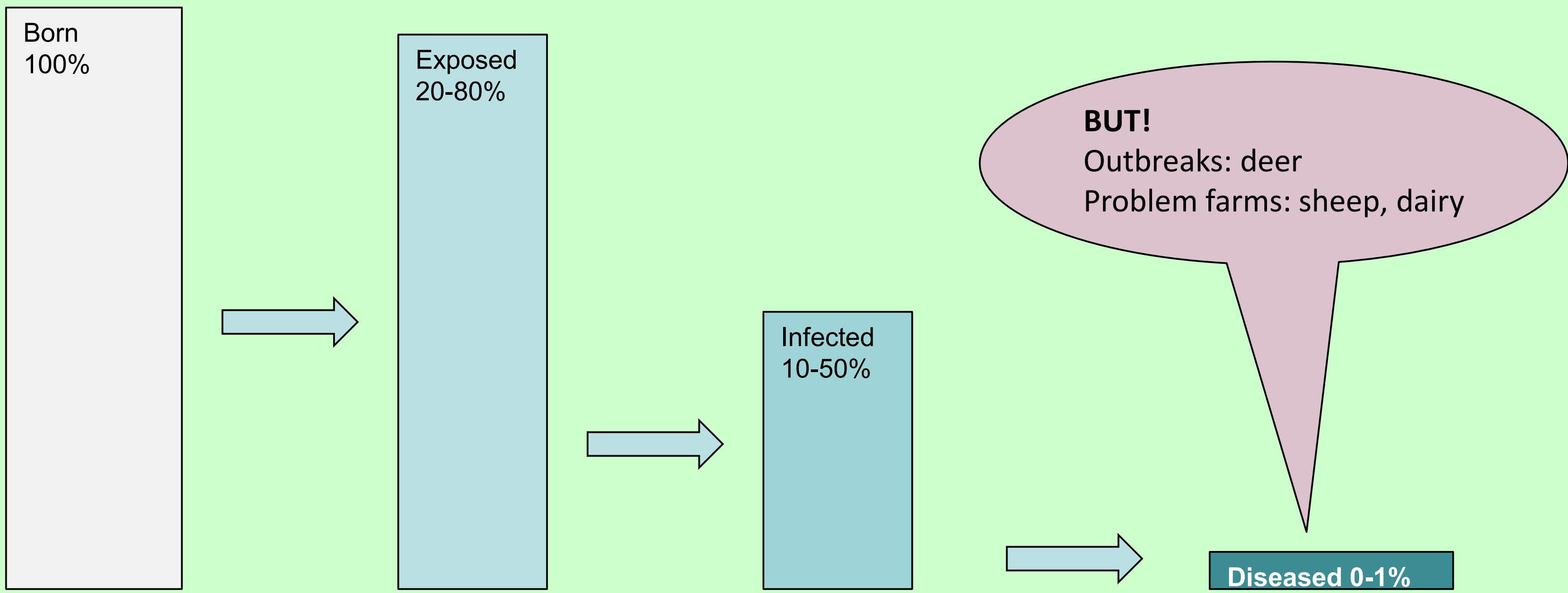
From exposure to disease

- Not all get infected, few get diseased



From exposure to disease

- Not all get infected, few get diseased



Why bother about Johne's disease?

- Public health → Crohn's disease no conclusive evidence yet
- Animal welfare
- Production loss

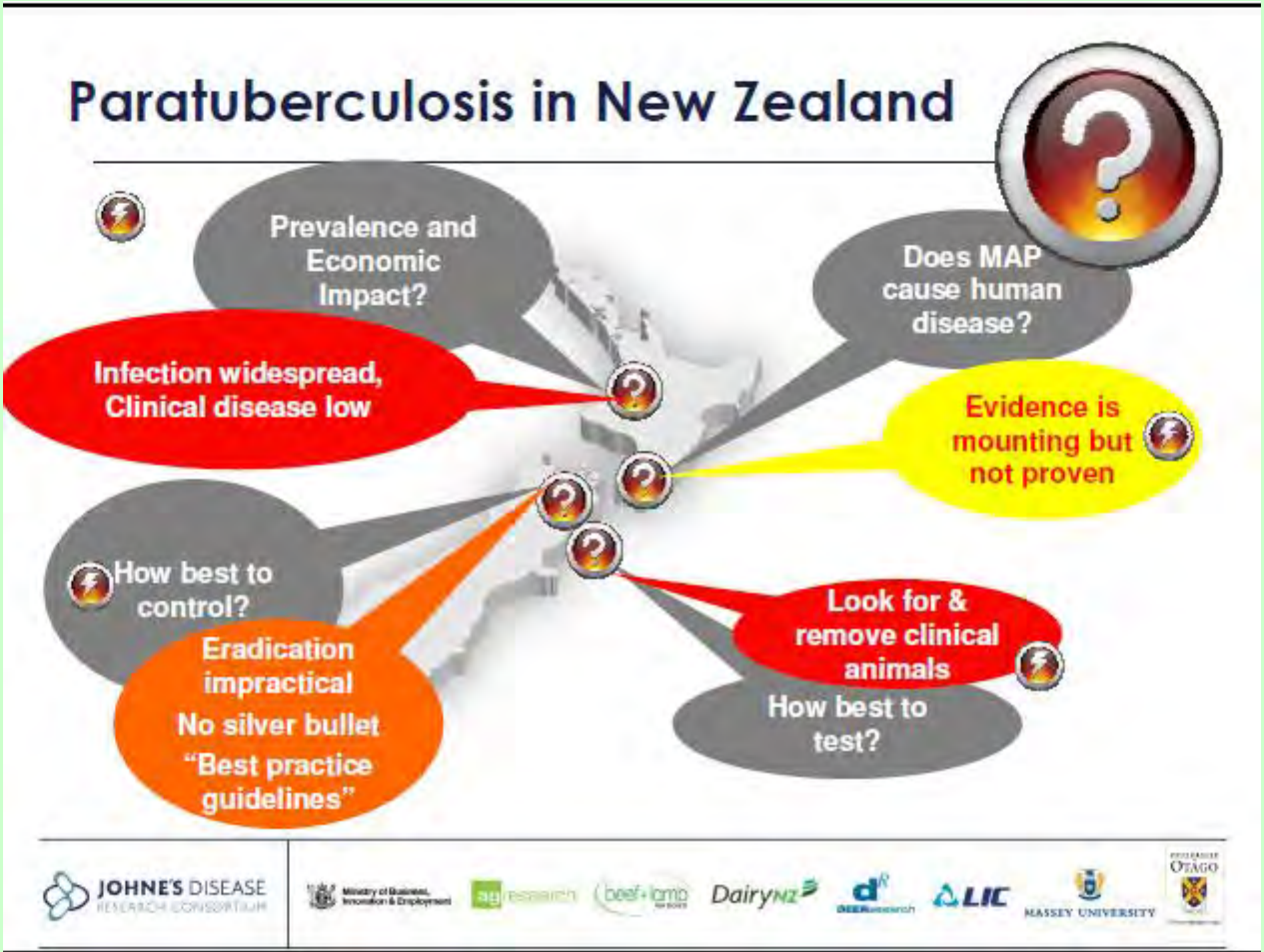
Whittington 2010

http://www.jdrc.co.nz

Website

http://www.jdrc.co.nz

Website



Agenda

- JD in New Zealand
- Diagnosis
- Transmission across species
- Farm-to-farm transmission
- Production effects
- Control

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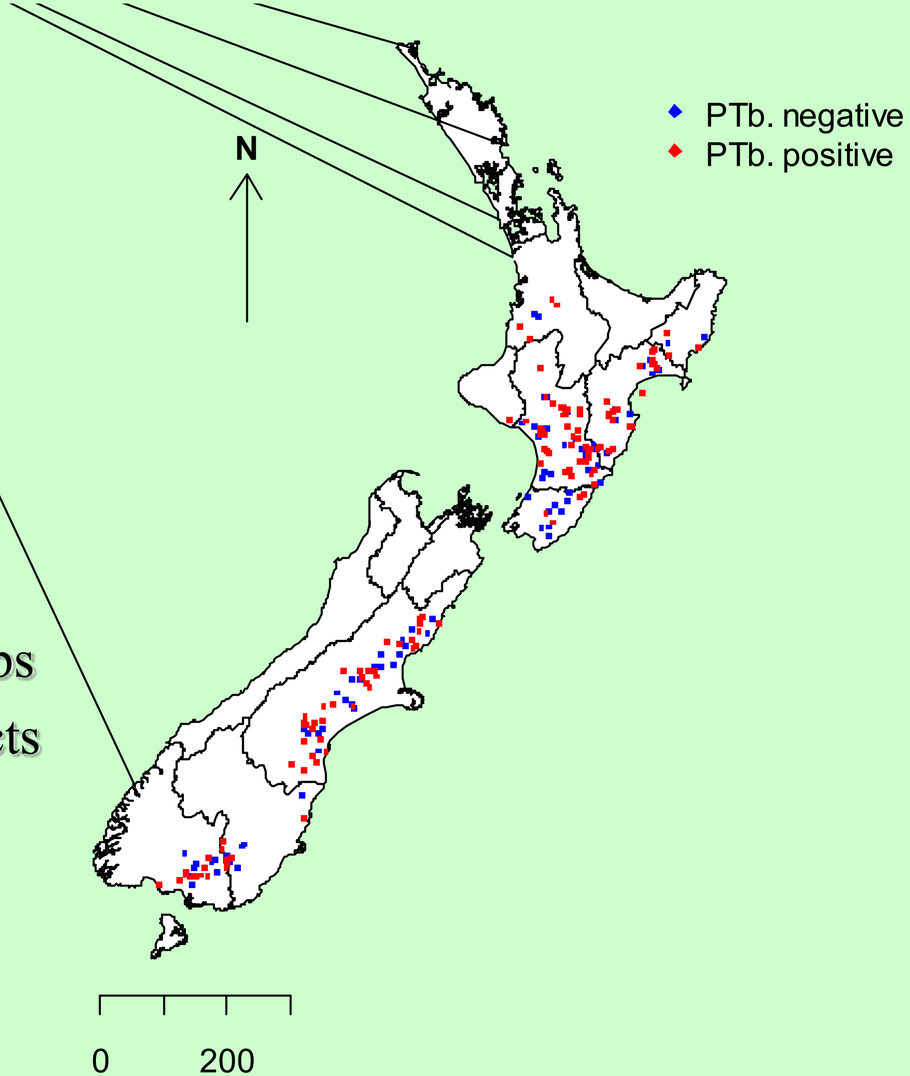
MAP Infection

- Flock/herd infection prevalence
  - 238 commercial farms
  - 107 Landcorp Ltd. Farms

  - 20 animals/species mob
  - Pooled FC
  - Individ. ELISA of neg. mobs
  - Random + low-BCS suspects

PTB status of 238 commercial properties

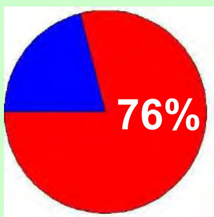
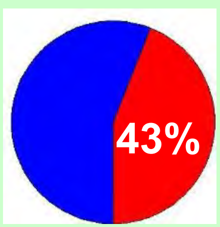
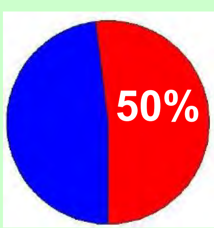


How many are infected in NZ?

Species		Herds	HTP	Animals	ATP
		Herd True Prevalence		Animal True Prevalence in infected herds/flocks	
Deer	Survey	99	50%	1,980	39%
	Landcorp	16	63%	226	36%
	Abattoir*	57	59%	148	76%
Sheep	Survey	162	76%	2,462	22%
	Landcorp	61	48%	514	24%
Beef	Survey	99	43%	842	16%
	Landcorp	49	43%	282	20%
Dairy	Landcorp	41	35%	312	26%
	LIC**	3,923	21%	NA	(~*9%*)

* Abattoir prevalence not adjusted for Se/Sp; ** Bulk tank testing, unadjusted

How many get diseased?

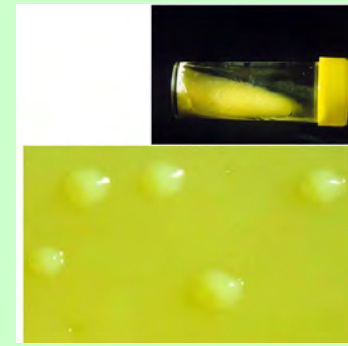
	Infected farms	Infected animals	Infected farms reporting cases	% clinical cases/year	Rate
Sheep		22%	54%	0.16% (0.09-0.24%)	1:625
Beef		16%	24%	0.04% (0.01-0.08%)	1:2500
Deer		39%	55%	0.32% (0.05-0.60%)	1:312
Dairy	21%	9%	35% ?	0.3 (0.1 – 0.6)	1:333

Diagnosis

Diagnosis

Whittington 2010

- Clinical signs:
- Necropsy:

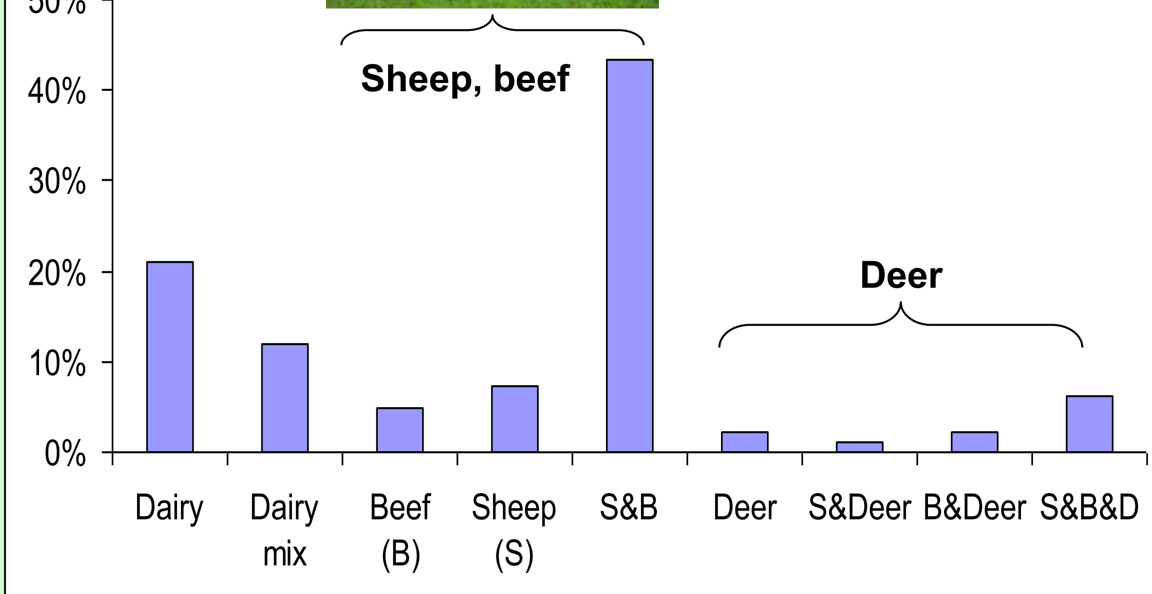


- Faecal culture:
- Faecal ‘*real time polymerase chain reaction’* (PCR) → detection of shedders
- Blood serology: ELISA/Parelisa® → poor in ‘normal’, good in clinical stage
- Other, rarely used tests:
  - Johnin skin test
  - Gamma interferon
  - Gel diffusion
  - Complement fixation test (CMT)
  - Liver biopsy **[currently investigated for sheep at Massey; Smith et al. 2014]**

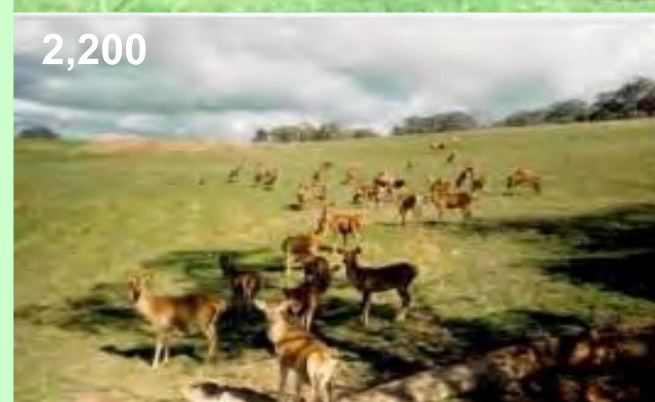
Transmission across species

NZ mixed species farming

- **JDRC Survey 2008: 1,934 farms (2,972 species mobs)**



(Verdugo et al. 2009)



Single- vs multi-species, island

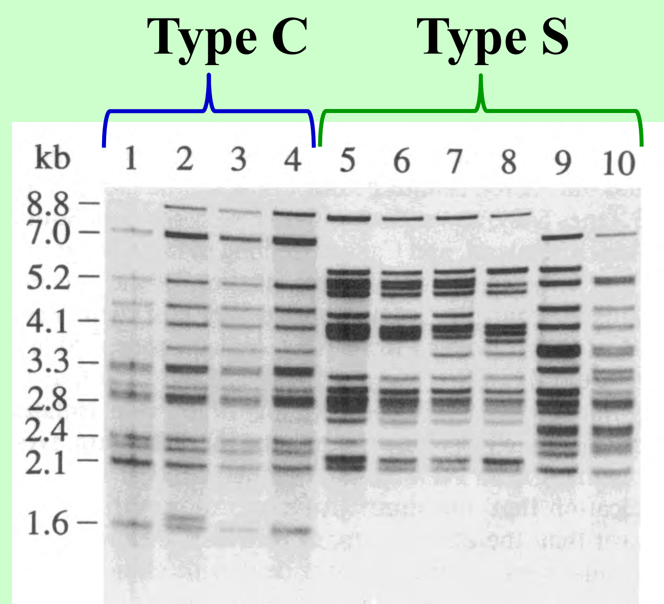
Species	Risk factor	Clinical disease	P
Sheep	Co-grazing with **deer**	**2-fold lower**	0.01
	Co-grazing with **beef**	**1.2-fold higher**	0.01
Dairy	no data		
Beef	Co-grazing	no effect (sparse data)	0.26
Deer	Co-grazing with **beef**	**2.2-fold higher**	0.01
	Co-grazing with **sheep**	**1.4-fold lower**	0.01

Strain type

O'Brien, Mackintosh, Griffin (2006), DeLisle, Collins

- **Type C** (Type II)
  - *'Found in infected cattle and most infected deer'*
- **Type S** (Types I and III)
  - *'Found in most infected sheep and occasionally in infected deer'*

IS900 typing →

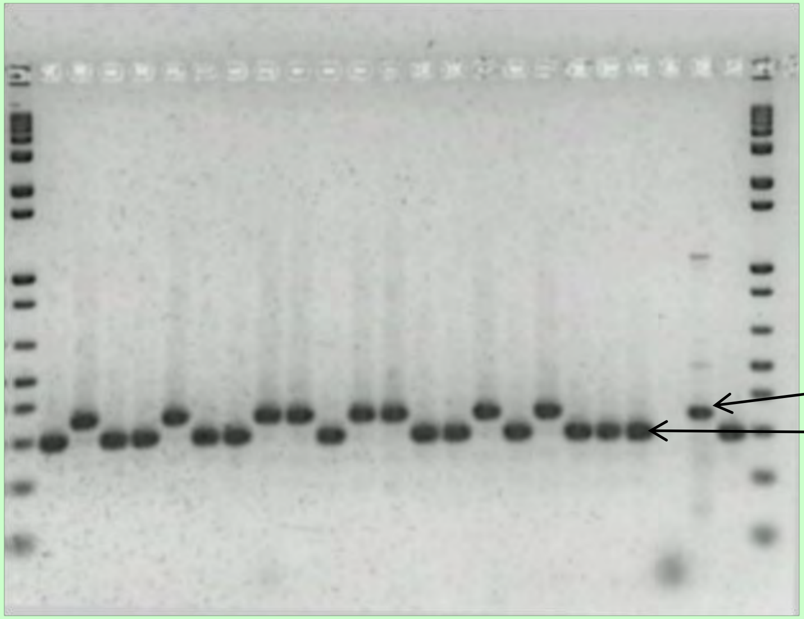


VNTR + SSR typing Des Collins et al. 2010

- VNTR = variable number of tandem repeats
- Based on repetitive DNA sequences that can be amplified by PCR (polymerase chain reaction)
- Refined by SSR (sequencing short repetitive base pair sequences)

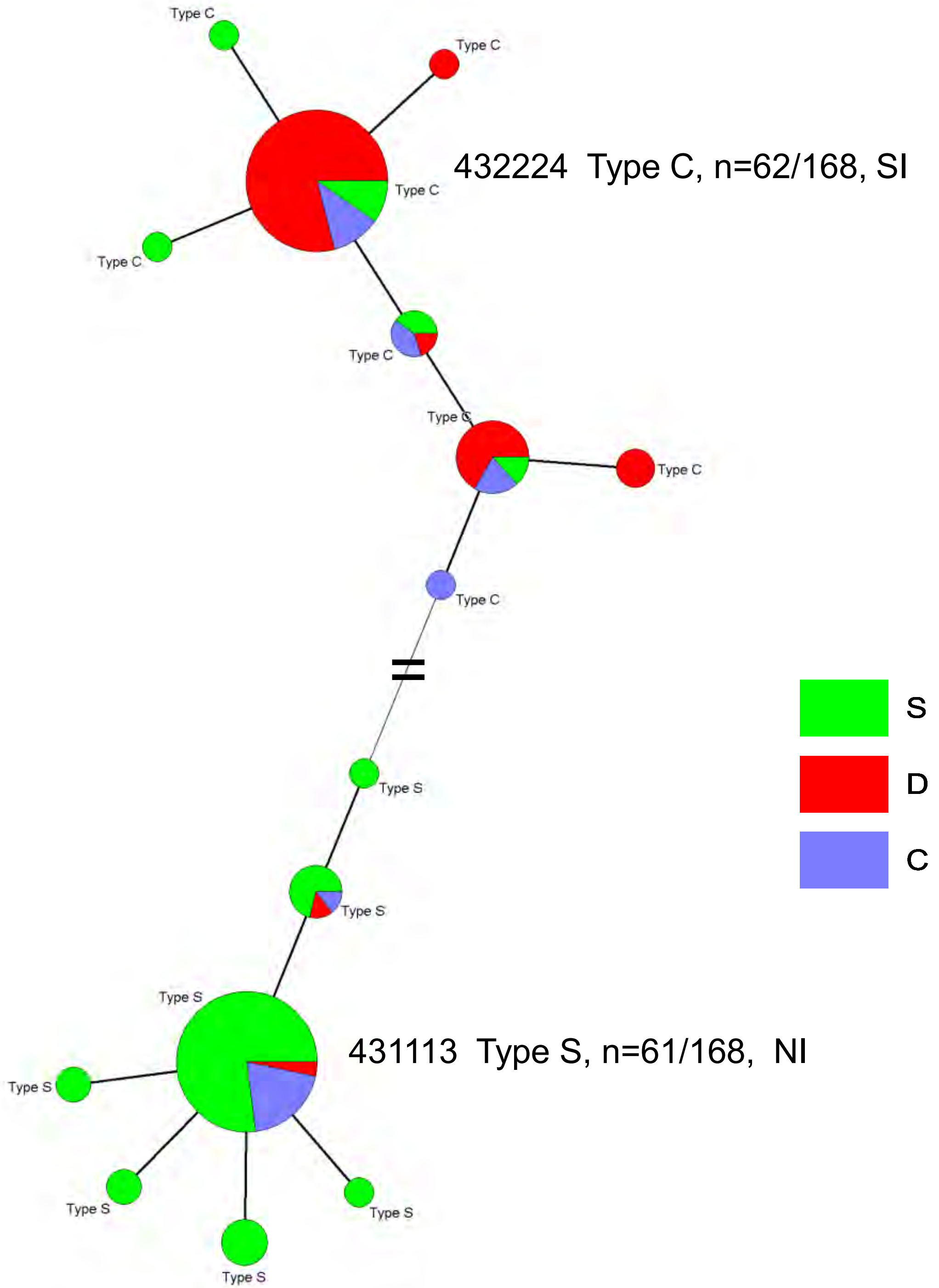
C-type:
65 isolates: 25 types

S-type:
58 isolates: 8 types

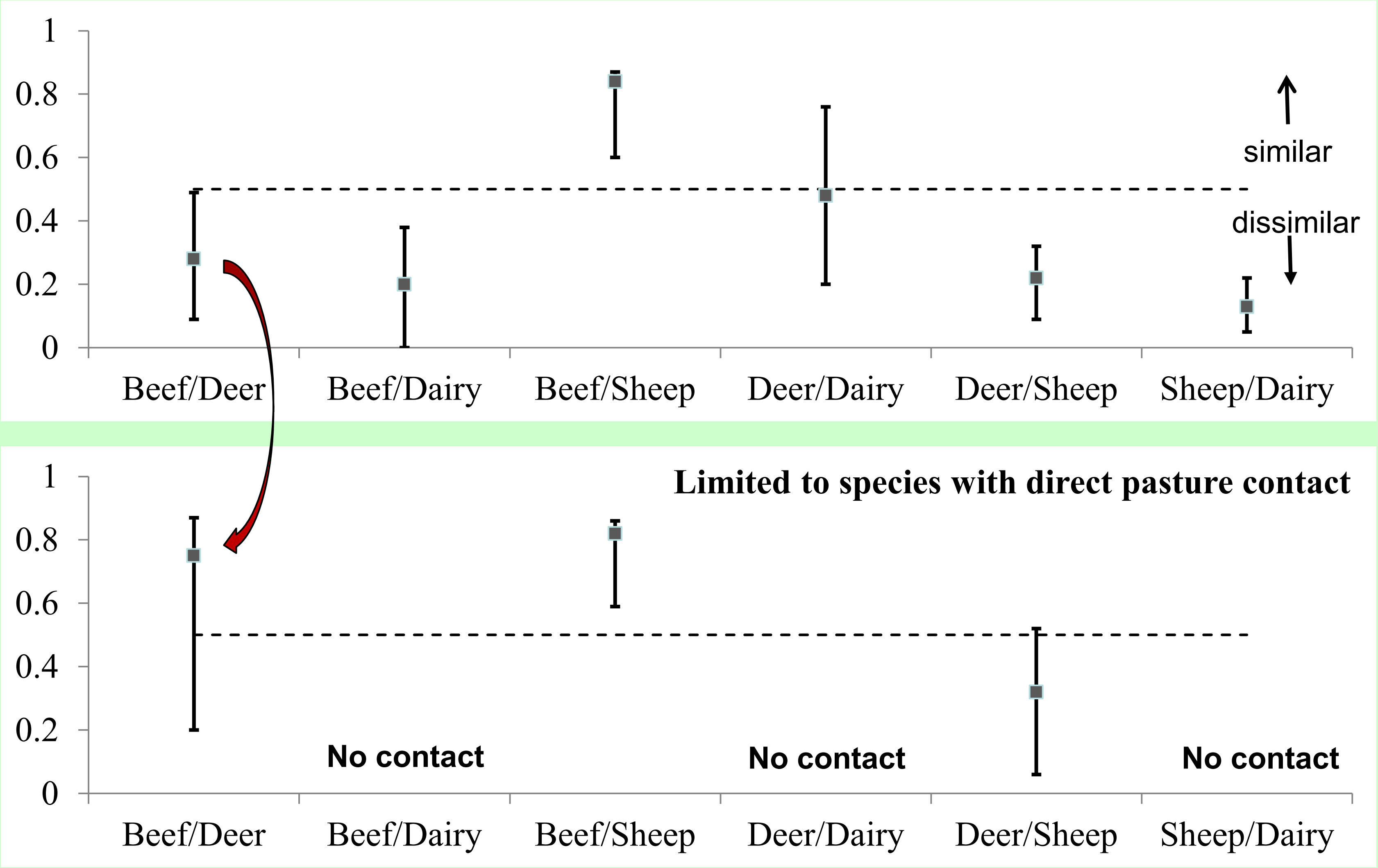


4 repeats
3 repeats

- 15 STs in 2 clusters (n=168):
  - Type C:
    - Deer, Dairy (S, C)
    - 8 types, 48 farms
    - 89 isolates (53%)
    - 12% NI – 88% SI
  - Type S:
    - Sheep (C, D, Dairy)
    - 7 types, 48 farms
    - 79 isolates (47%)
    - 75% NI – 25% SI
  - 1–62 isolates/ST



Strain types: transmission between species



Farm-to-farm transmission

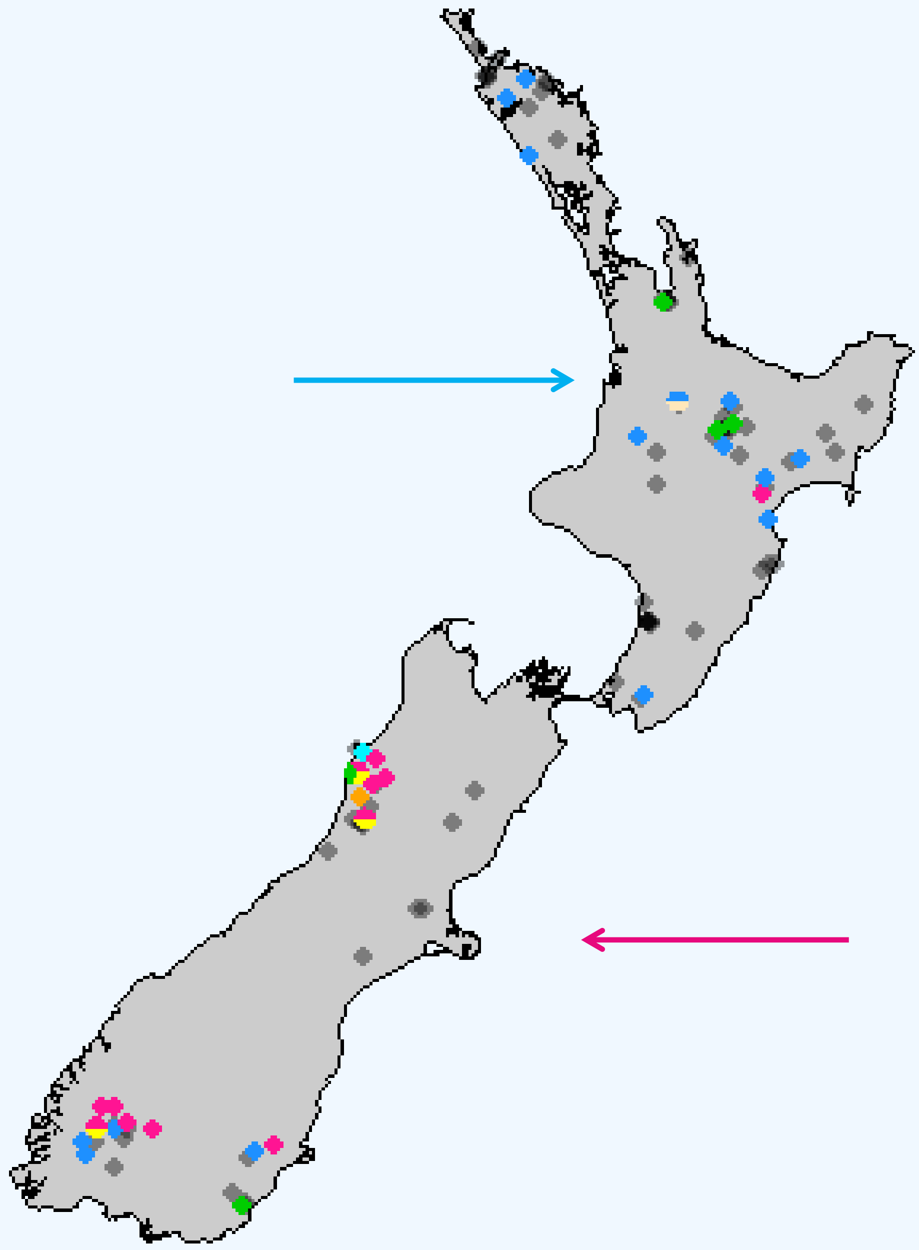
- Social Network Analysis (SNA)

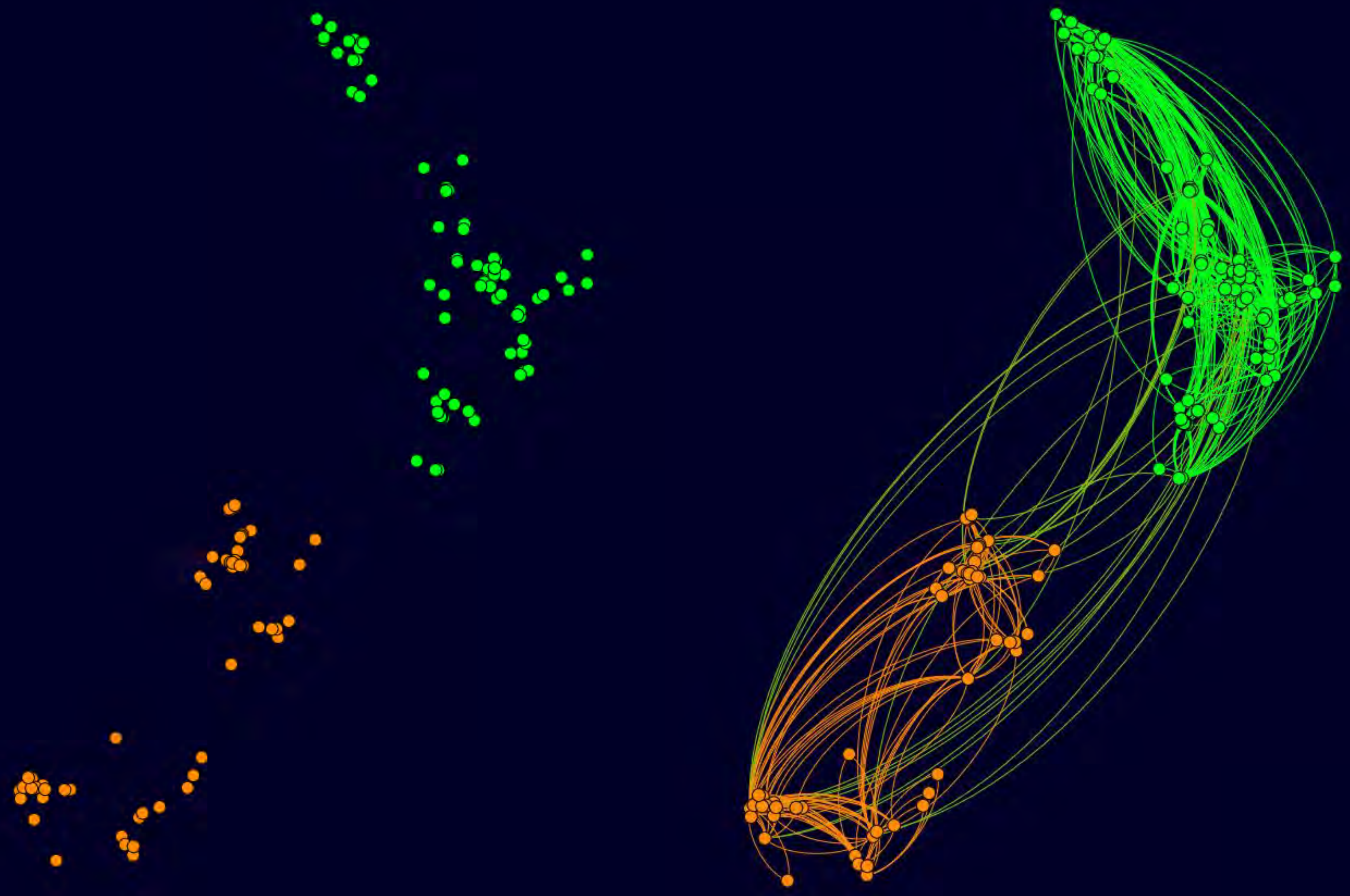
180 Farms:

112 LandCorp. Ltd.
68 other properties
3,531 Movements
July 2006 – June 2010

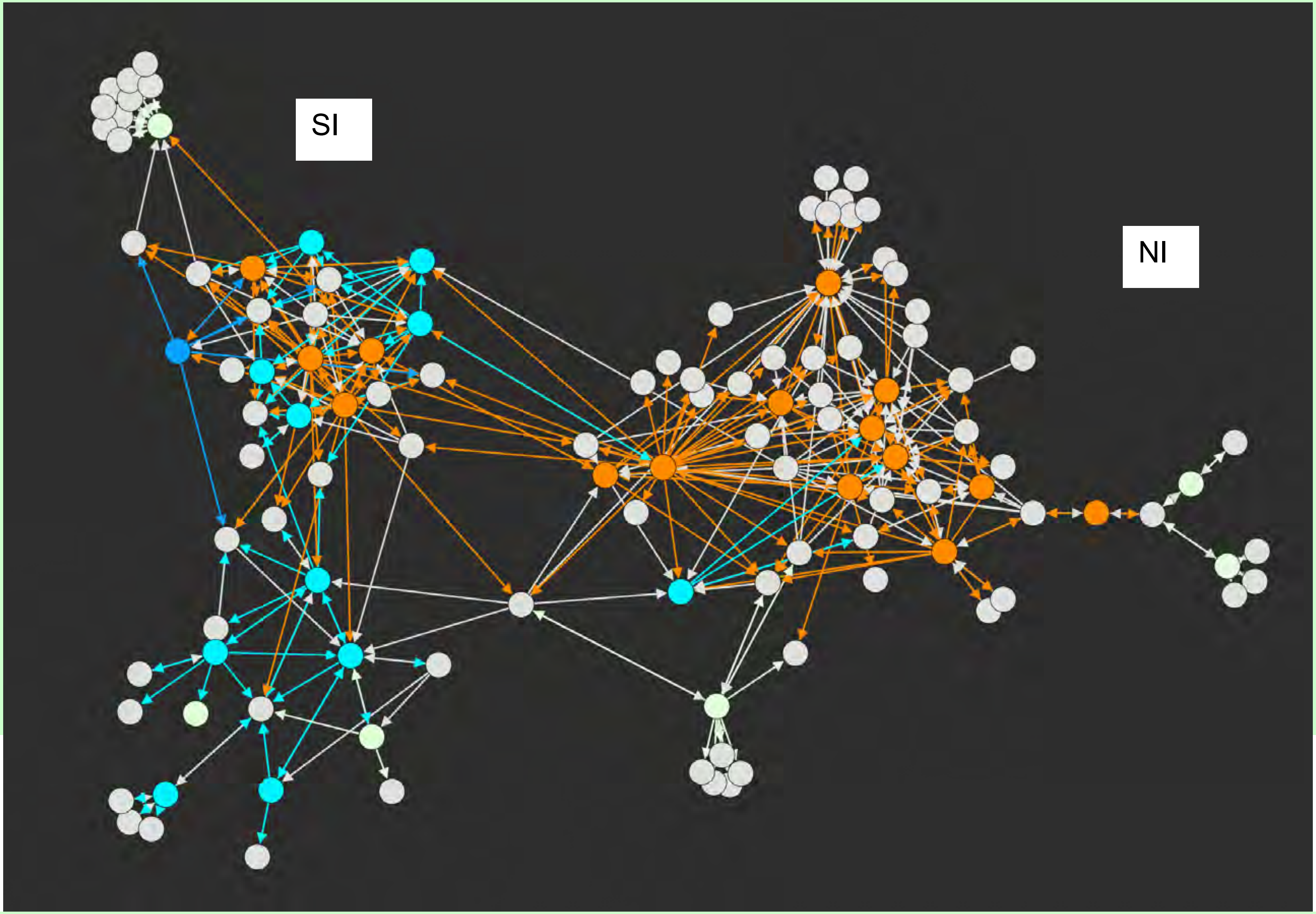
Network-Analysis:

7 Genotypes
45 Isolates
33 Farms

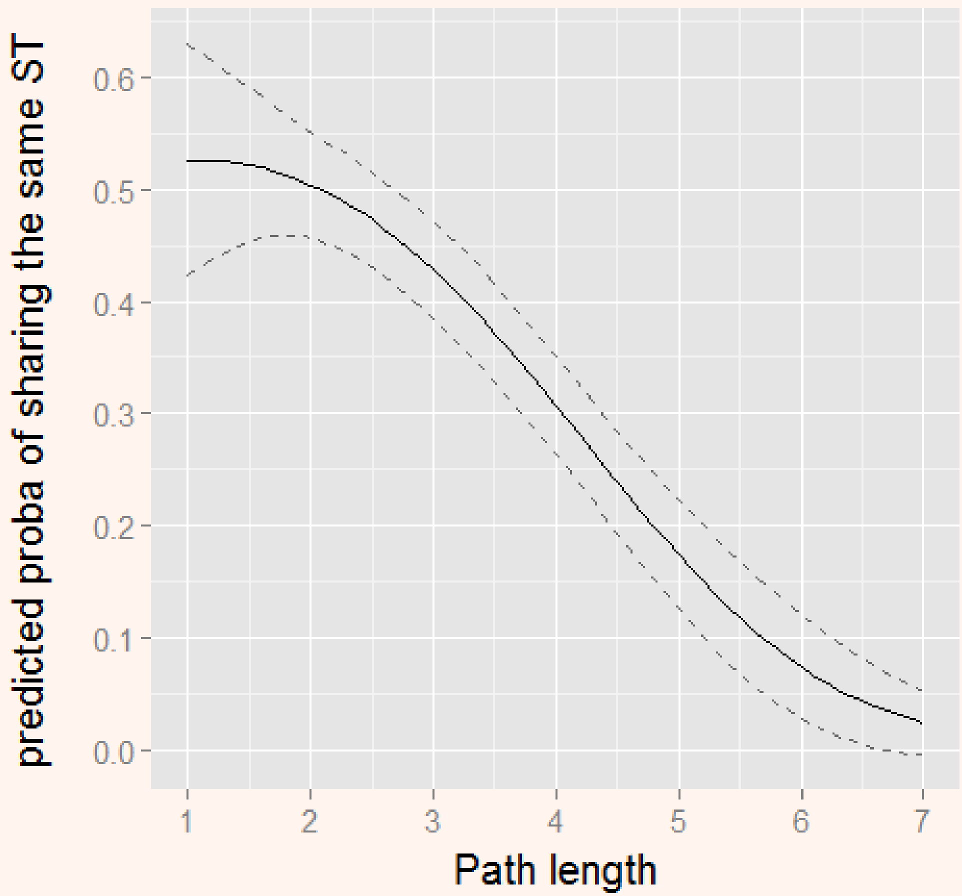




Visualization: 2 common strains



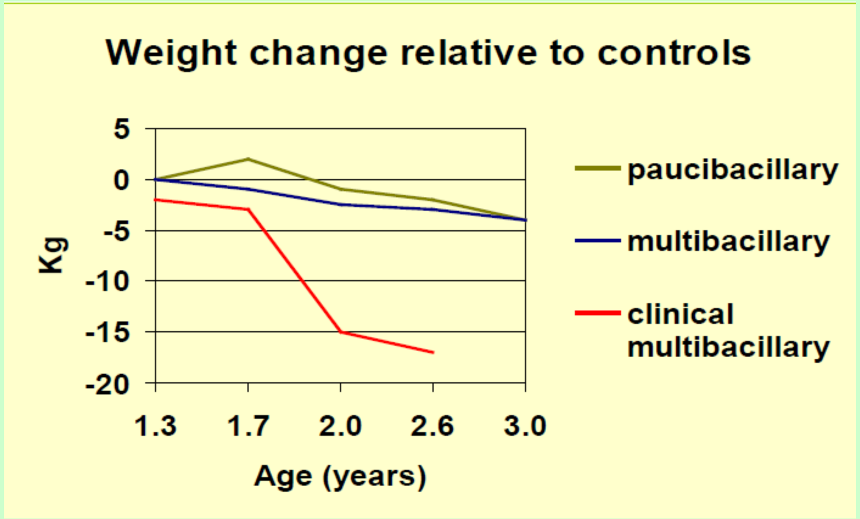
Probability of sharing same ST ~ path length + path length^2



The shorter the movement path, the more likely are they sharing the same strain

Production effects in sheep

- Premature mortality: NZ: <1% AUS: 2-15%
  - → reduced productive life (NZ: -6m)
- Growth rates: McGregor 2009 (AUS)
- Tailing rates NZ: JD-neg 136%, JD-affected 130% (-6%)



McGregor 2009

Bush et al (2006)

- 12 farms in southern NSW
  - 3,500 to 20,000 sheep
  - measured over 3 years
- mortality 2 to 15% p.a.
- gross margin decline 6.4 to 8.5%

amounts to $13,715 per farm per year

PTB-mortality in sheep in NZ

- **Problem farms**, high mortalities due to JD

Scientific Article

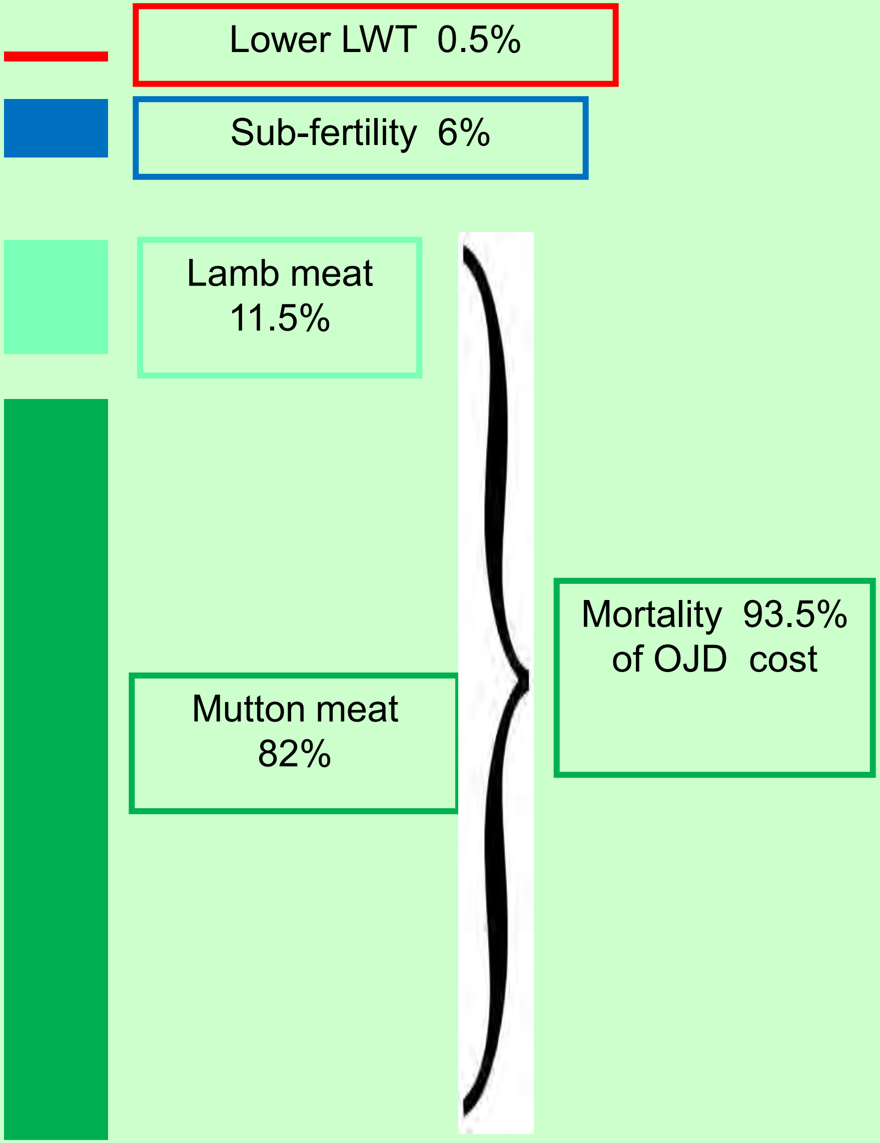
The effect of Johne's disease on production traits in Romney, Merino and Merino x Romney-cross ewes

CA Morris[*§], SM Hickey[*] and HV Henderson[*]

Research station, intensive monitoring 1975-1982:
8 yrs, 3633 ewes, all deaths or culled for emaciation → PM, histo

Results: clinical incidence of JD = 1%

Model outcomes: cost of Johne's



Prices 2012 (/head):
Prime lamb: $ 113.5
Mutton: $ 93

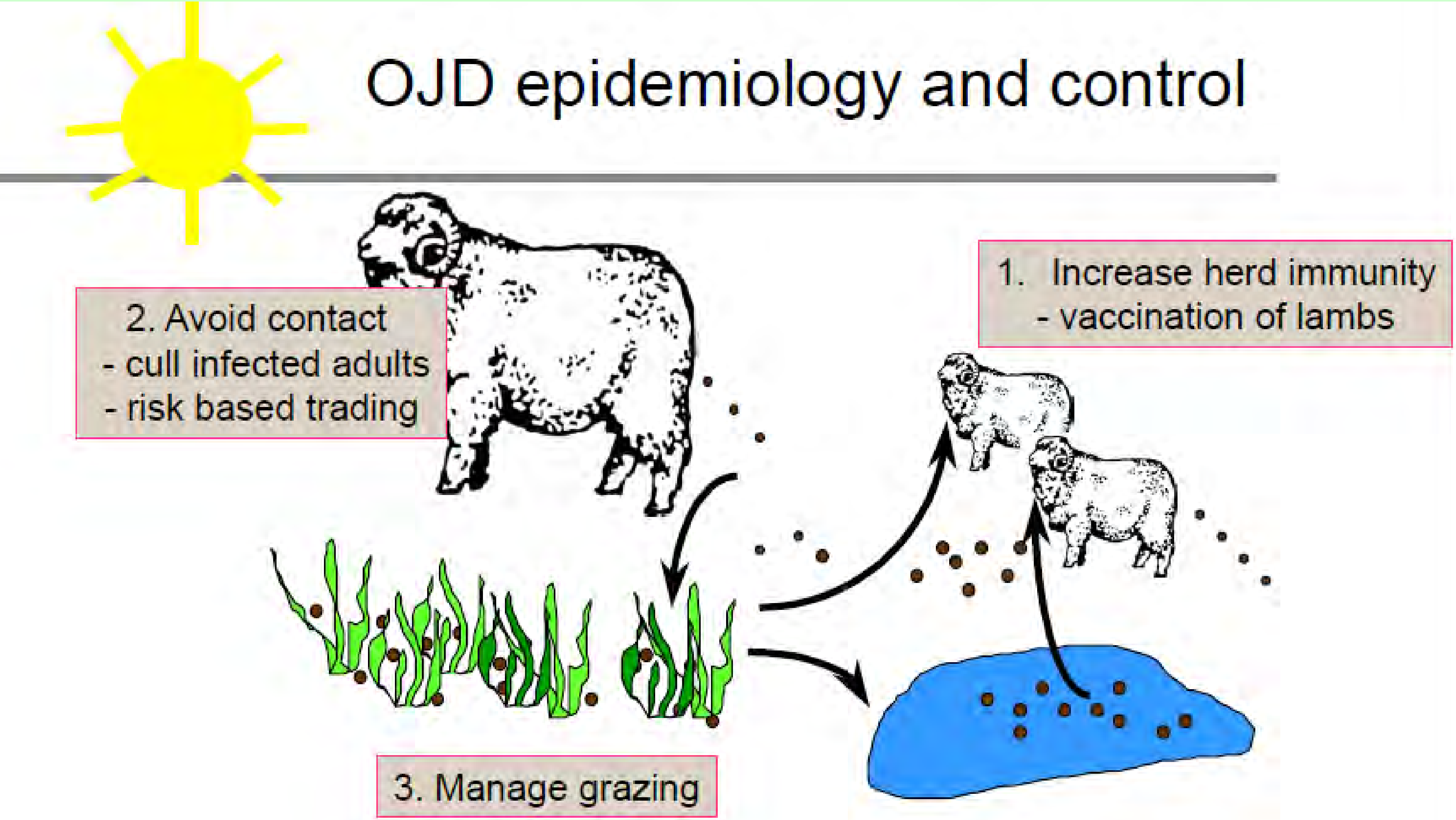
Source: Beef+Lamb Economic service

Annual cost of JD (2012)
NZD 3.2 / ewe

Estimate for 2013:
NZD 2.64

Control

Control Whittington 2010



Control

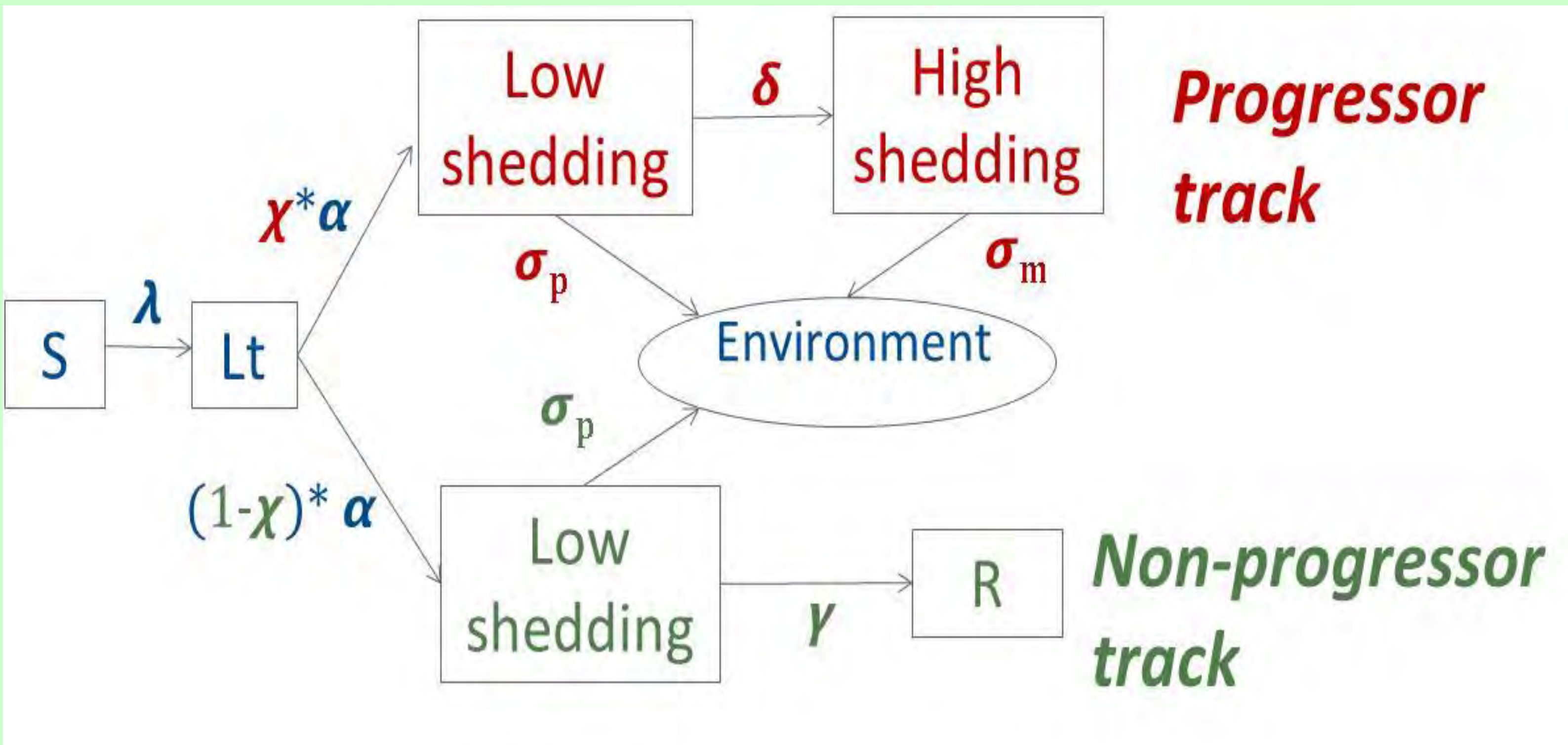
Options:

- Co-grazing ?
- Test & cull
- Early detection of ill-thrift → testing → removal of shedders
- Vaccination
- Biosecurity: prevent infectious contacts with other herds

Approximations:

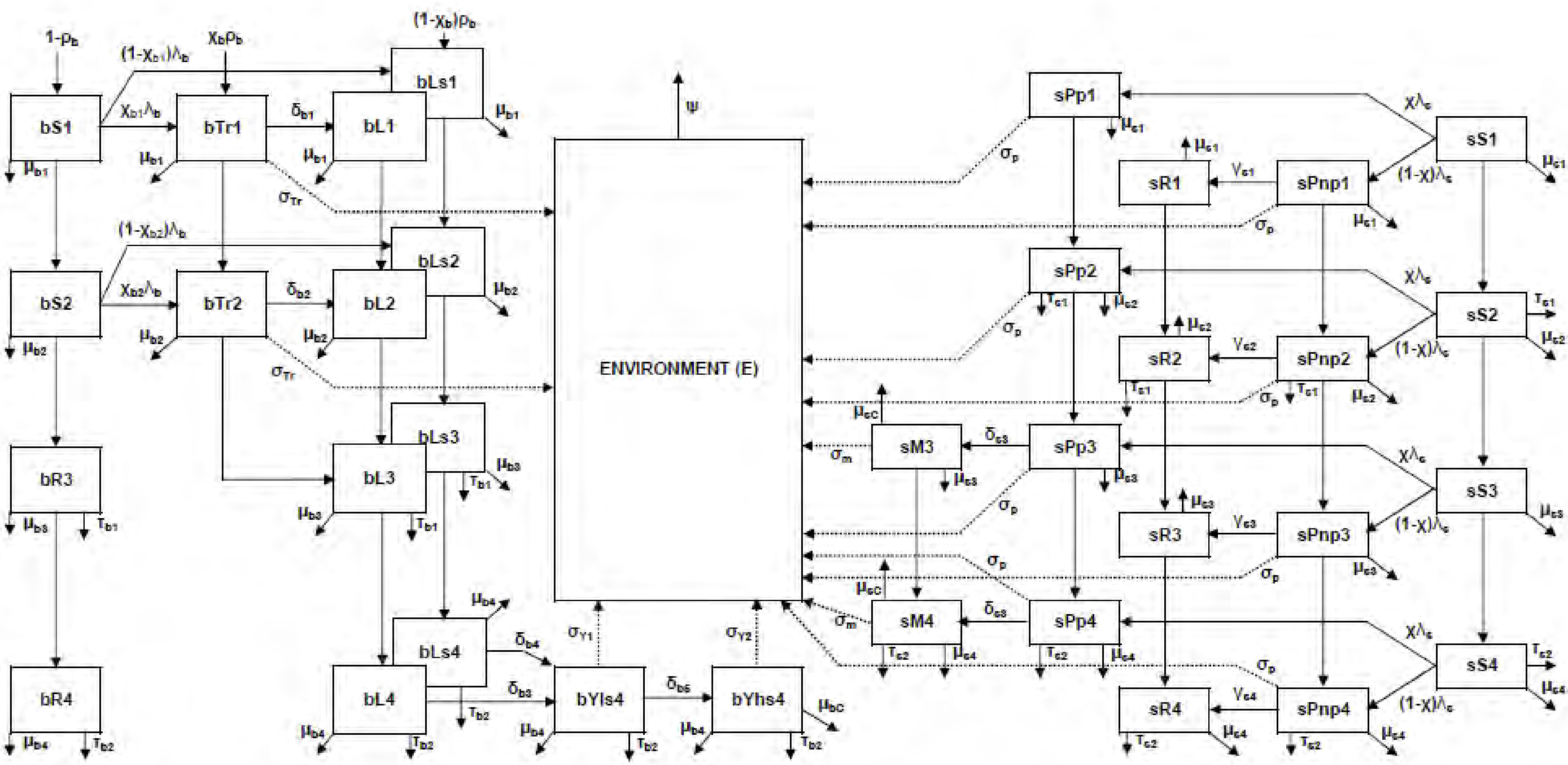
- Interventions (sheep, sheep&beef, deer)
- Benefit-cost of vaccination (sheep)

Sheep OJD Model



Sheep & Beef model Verdugo,PhD 2013

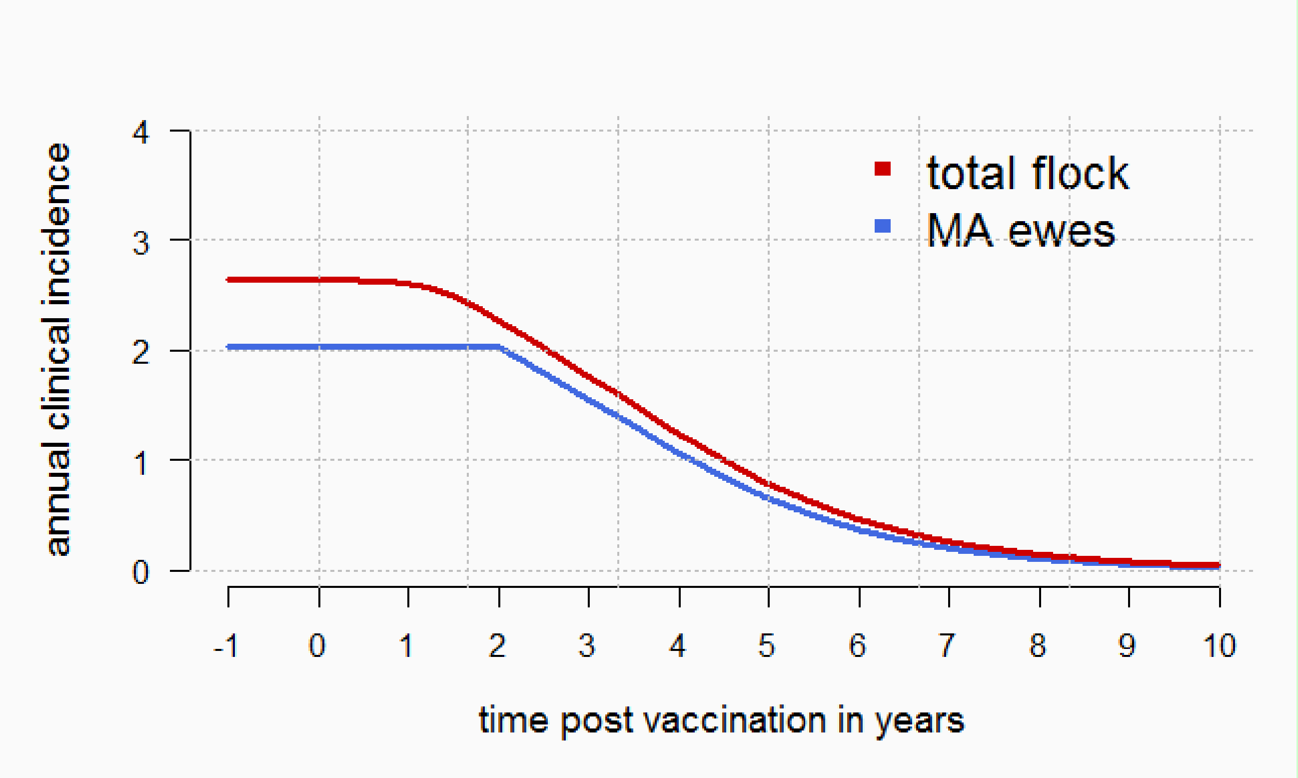
- Cattle (left) and sheep (right) with grazing contact (centre)
- Environment subdivided in paddocks



Effect of vaccination (sheep)

- We vaccinate 30% of the weaners at 3 months of age
- we keep only vaccinated animals for replacement

Infection dynamics



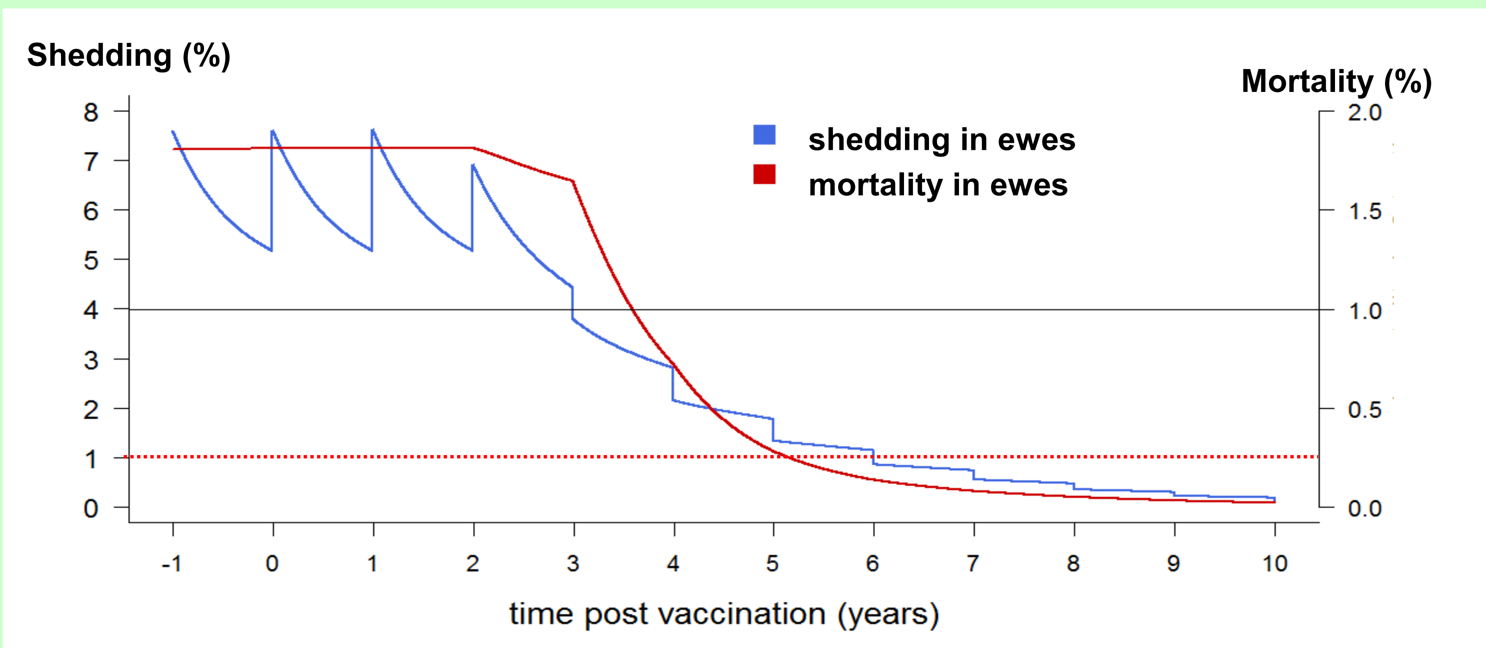
Cost effectiveness of vaccination

- Vaccine efficacy: **90% drop** in shedders and JD mortality

Reddacliff 2006

Annual cost of JD
$ 3.20/ewe

Cost of vaccine per head 3 $:
Vaccinate replacement: 0.37*3 = 1.11 $



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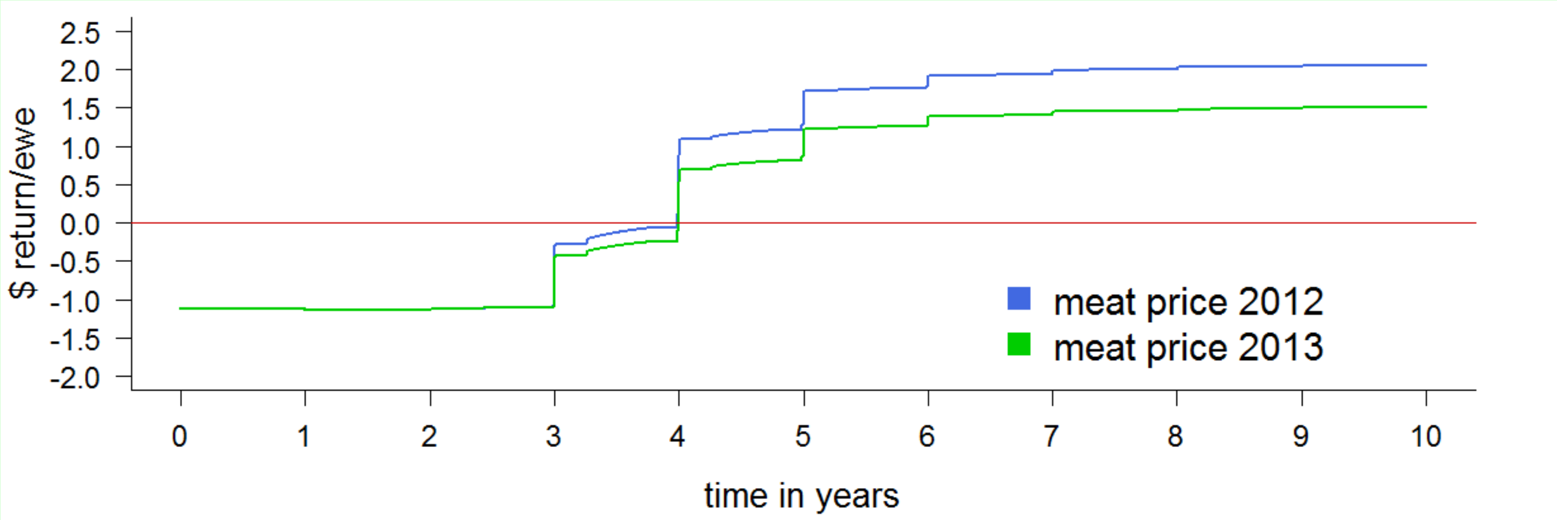
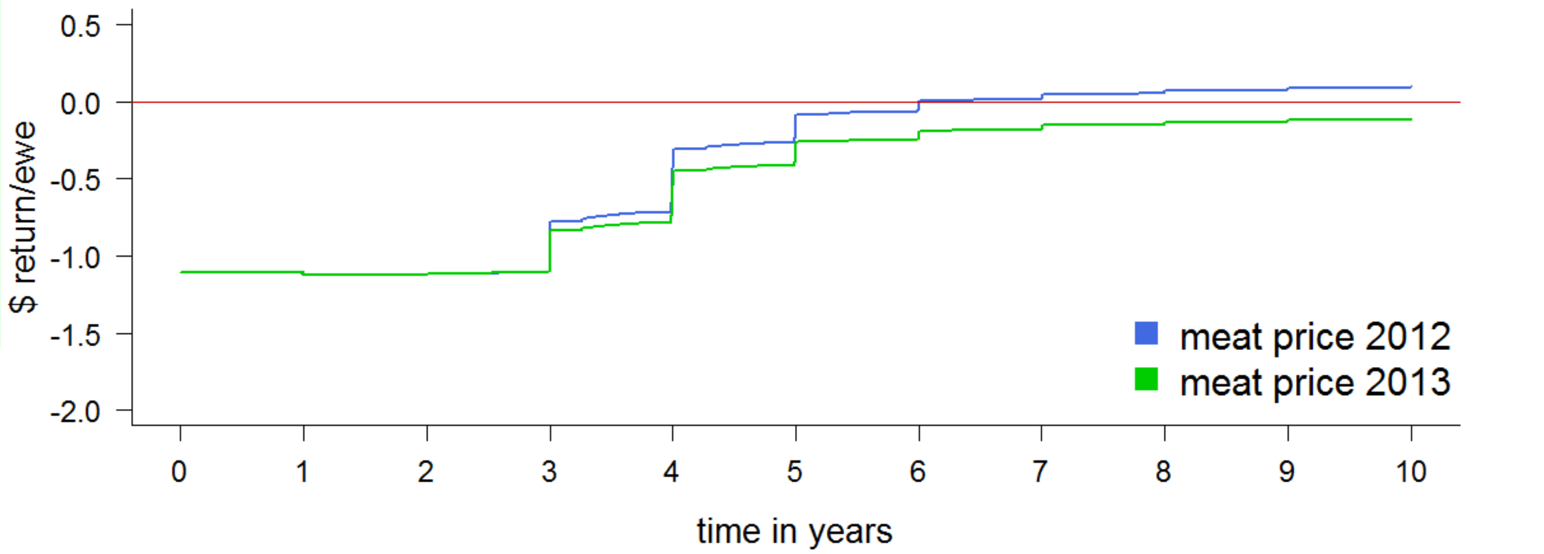
Cost effectiveness of vaccination

JD mortality 1.8%



JD mortality 0.75%



Test and cull strategy

- Drafting ewes in low BCS once a year (prior to lambing):
  - tail end selected and subjected to OJD testing (Elisa)
  - Negative: treated (anthelminthics) and remain in the herd (subject to similar culling pressure as other MA ewes)
  - Elisa positive selectively culled

- Assumption :
  - 80% of MB and 20% PB ewes are drafted
  - Sensitivity of ELISA: 65.1% for MB ewes
    32.3% for PB ewes

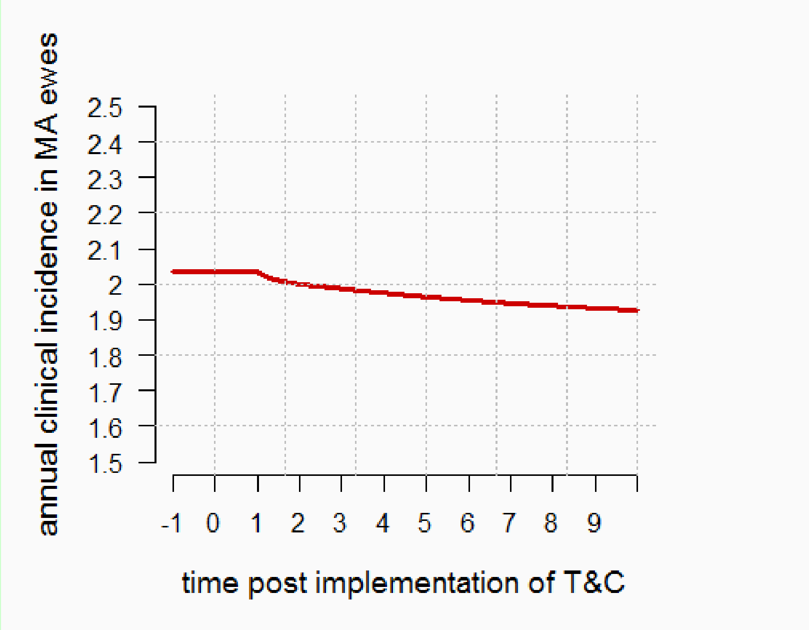
(Sergeant 2003, Elisa cutoff 2.4)

Test and cull strategy

In the MA ewes flock, only few animals are in low BCS and likely to be drafted for testing

categories	PB	MB
# of ewes/100 lambing ewes*	5	1

*numbers at the beginning of the culling period



→ limited impact on OJD. Not cost-effective (prelim. results)

Conclusions so far

- Vaccination:
  - cost–effective when OJD-mortality >1%
  - Long term process
- Test&Cull unlikely to be cost-effective
- Cost effectiveness: not the only incentive for control:
  - Perception (stigma)
  - Food safety & public health (Crohn's disease)
  - Animal welfare
- Lack of robust data on true impact of JD on farm

Te Kunenga ki Pūrehuroa

Massey University

Acknowledgements

JOHNE'S DISEASE RESEARCH CONSORTIUM

- Colleagues: Prof P.Wilson, Prof. M.Stevenson, Dr A.Ridler, A/Prof G.Jones, Prof N.French, N.Haack (Lab-Tec)
- PhD students: S.Norton, J.Hunnam, L.Stringer, C.Verdugo, N.Marquetoux, S.Smith, Funding: Alma Baker, JDRC, Merino Breeders Association
- Vets and farmers participating in surveys
- Overseas collaborators: R.Mitchell, Y.H.Schukken (Cornell), E.Sergeant, R.Whittington et al. (AU), W.Johnson (UCI/US)
- JDRC collaborators: G.DeLisle, D.Collins, M.Price-Carter, C.Mackintosh (AgRes.), P.Anderson, R.O'Brian, F.Griffin
- Samples tested at AgRes. (Wallaceville), NZVP (Palm.Nth.) and DRL Otago (Dunedin)

EpiCentre

Questions?

MAP-FREE BOTTLE

Nelly Marquetoux

JOHNES DISEASE
RESEARCH CONSORTIUM

Education
NEW ZEALAND