Animal movement between herds: the metapopulation dynamics of JD

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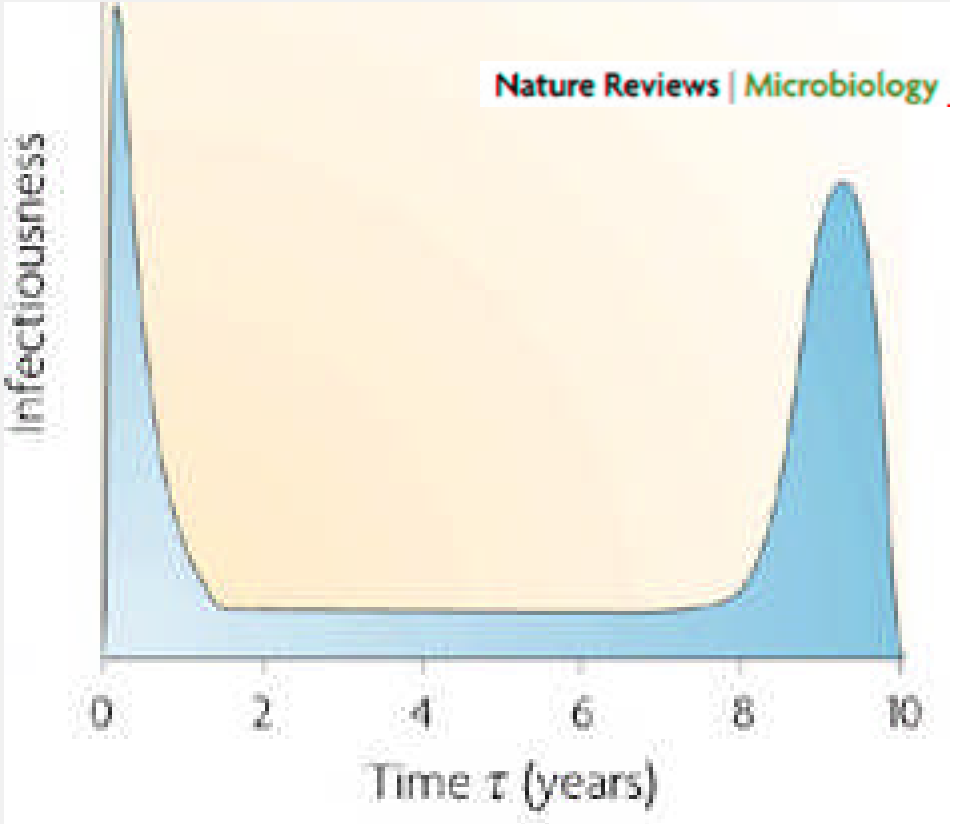
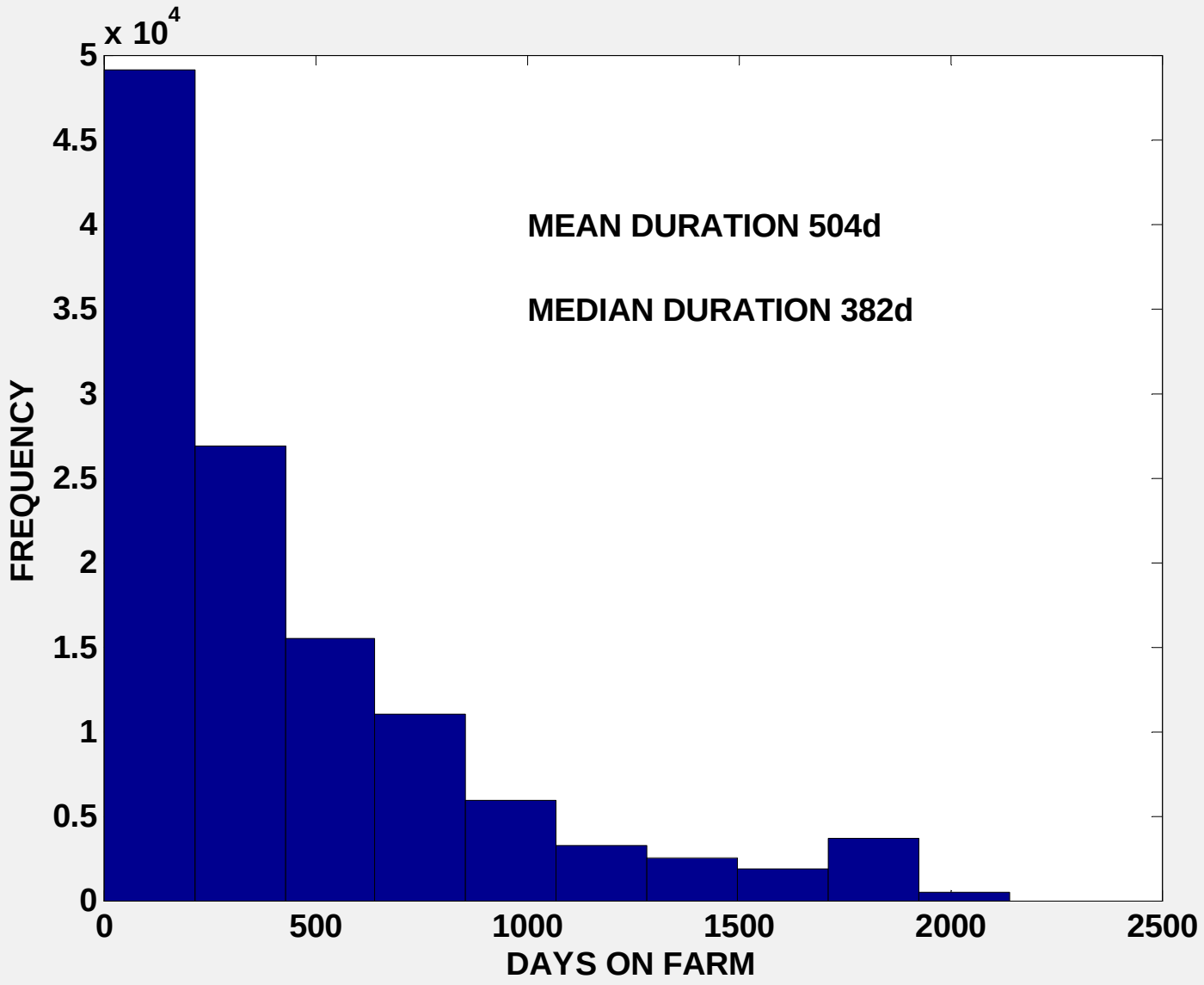
Organisational Scales

Long Term Dynamics

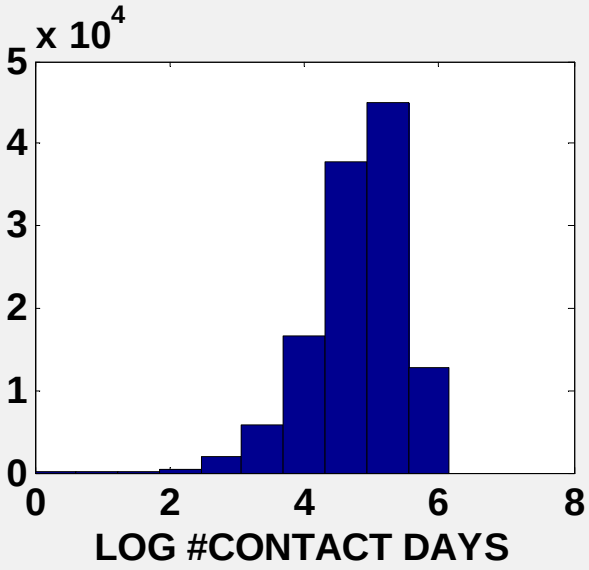


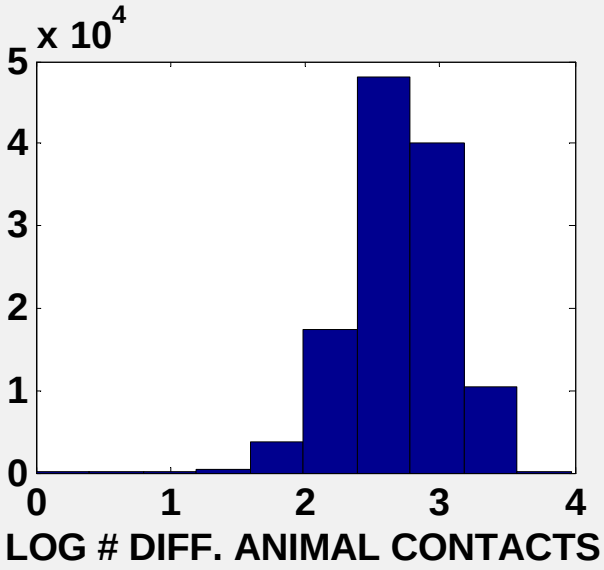
Meta-herd level

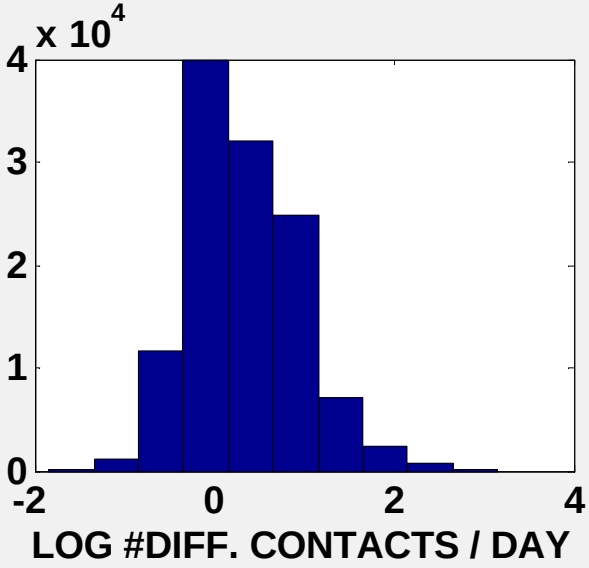
Study Design



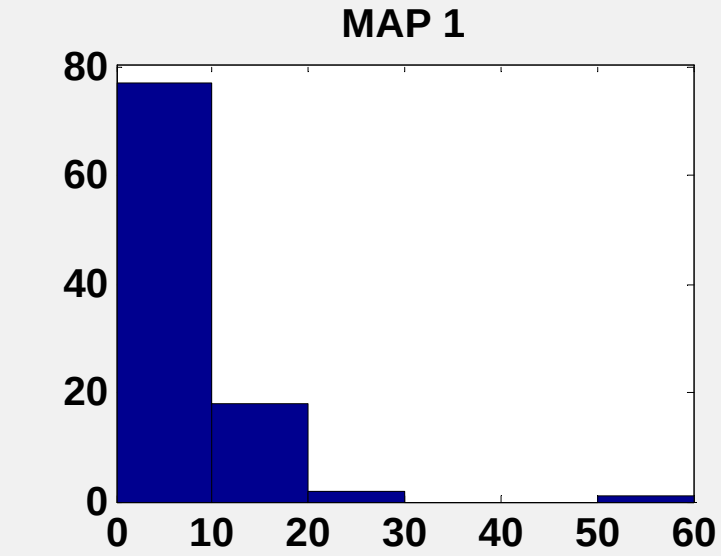
- *121,247 CATTLE ON 154 FARMS – negative exponential distribution of time on farm*

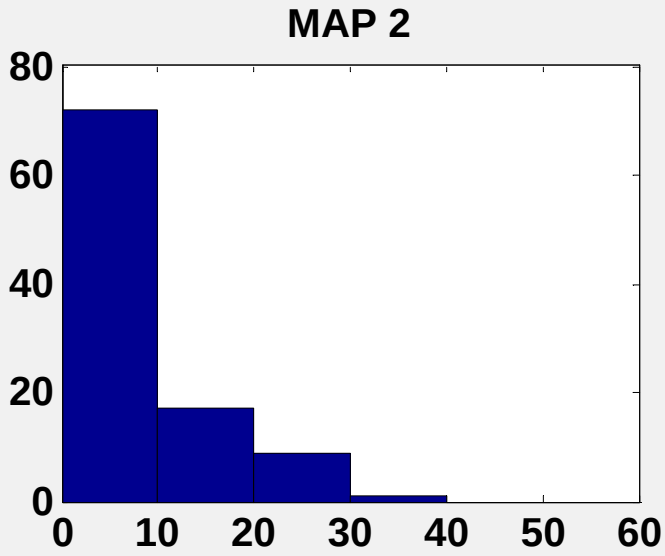


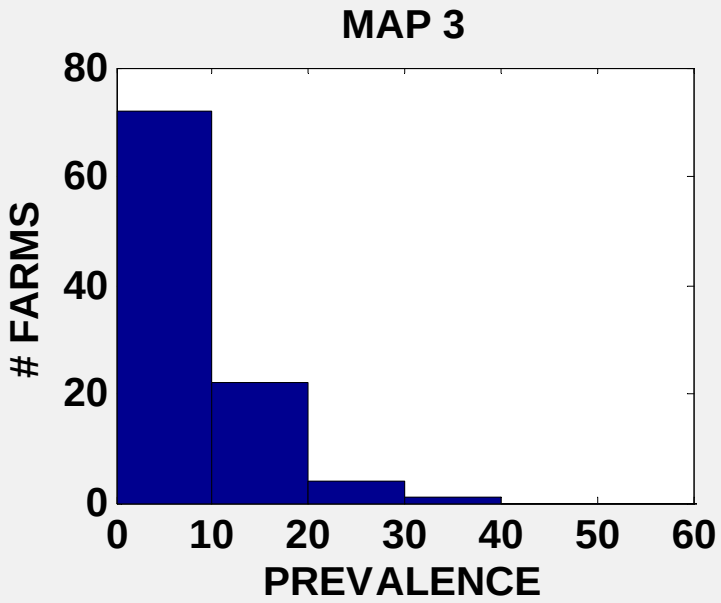




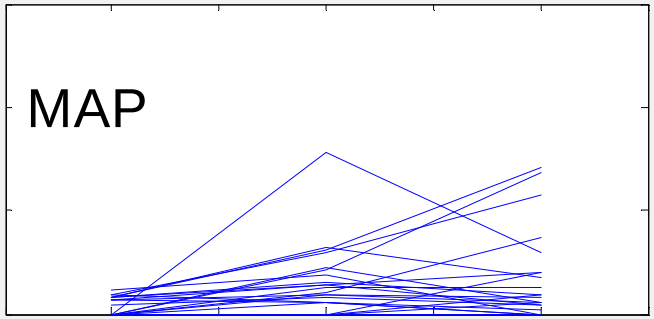
- *LOG-NORMAL DISTRIBUTION OF NUMBER OF CATTLE CONTACTED*

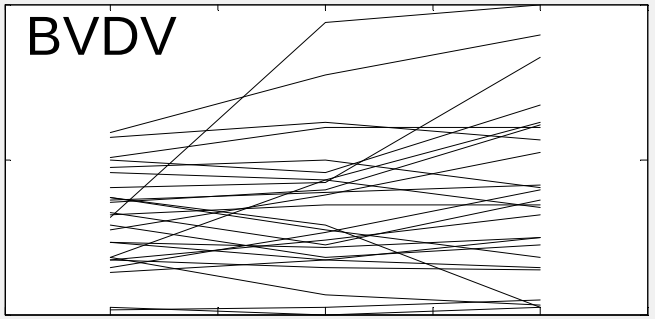


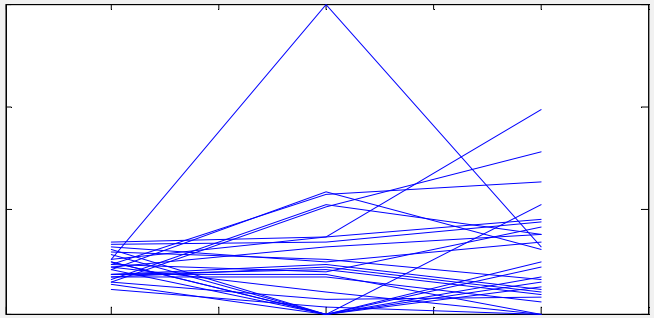


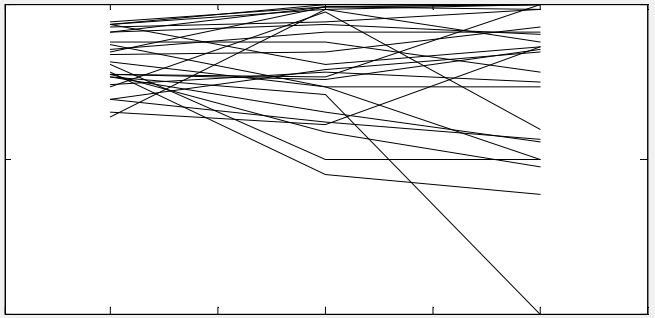


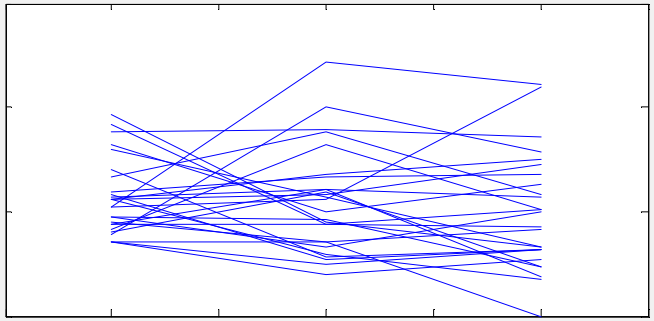
- *Lowest seroprevalence*
- *Very similar pattern to* Neospora caninum

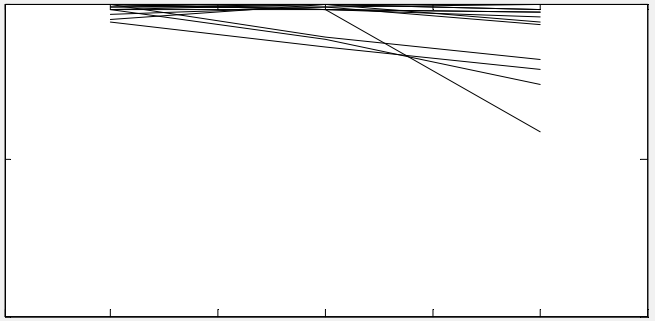

MAP


BVDV



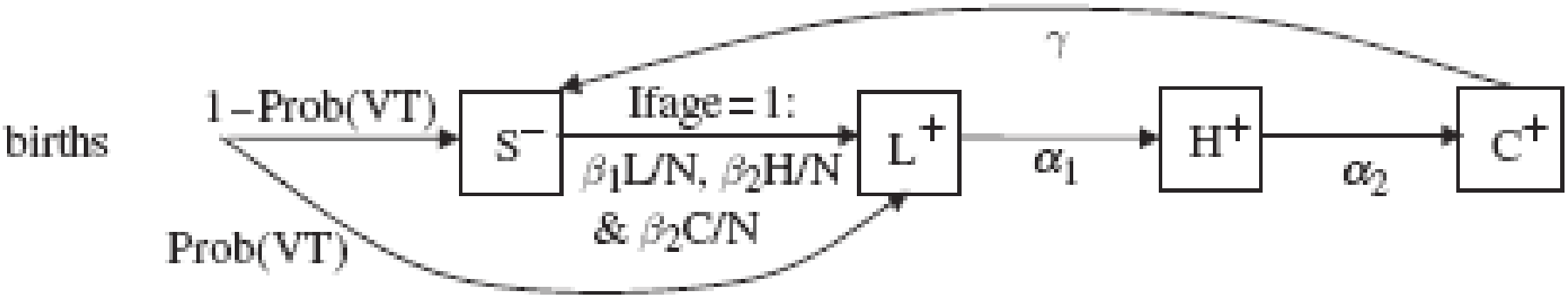






Longitudinal Herd Patterns

Modelling



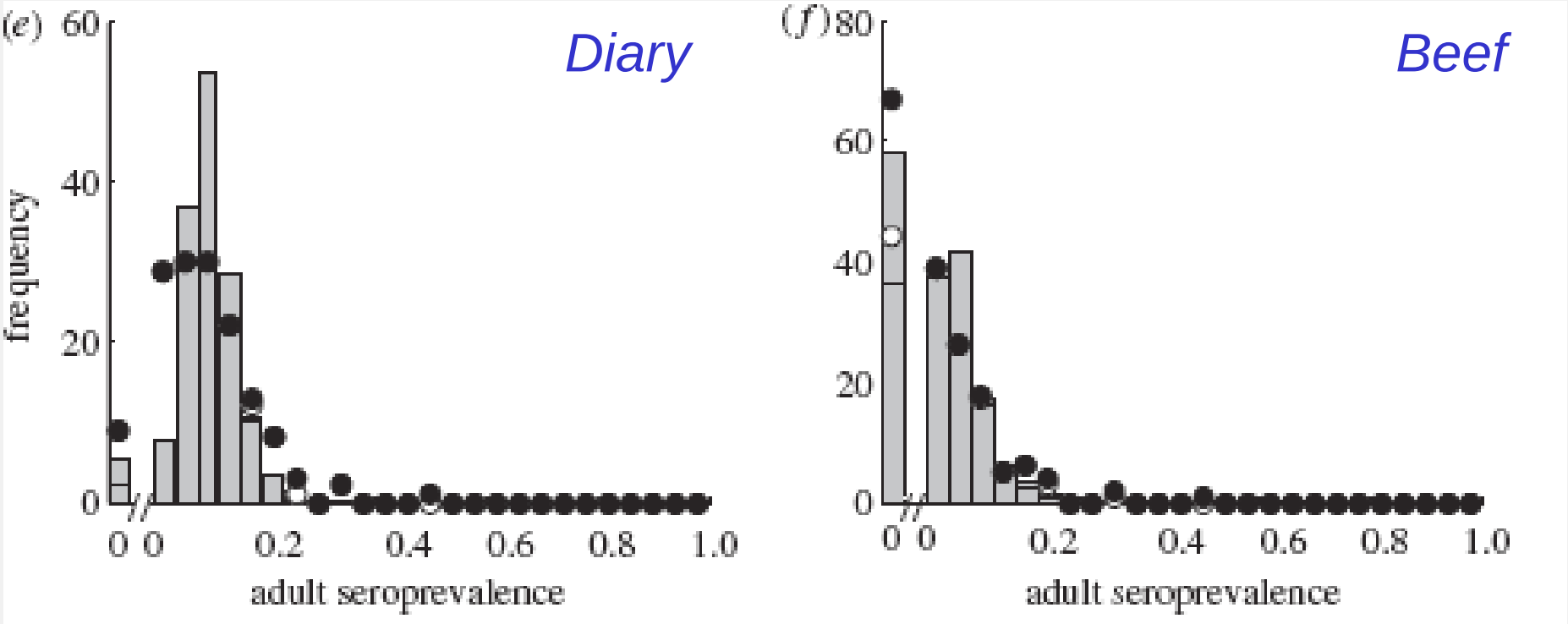
where:

$$\text{Prob(VT)} = \varepsilon_1 \frac{(L_{ad} + H_{ad})}{N_{ad}} + \varepsilon_2 \frac{C_{ad}}{N_{ad}}$$

- Four classes of infection state
  - Susceptible, low-shedding, high-shedding and clinical
  - L, H, C are infectious, and seropositive with sensitivities 10%, 75% and 85%

	Description	*Value*	*Source*
α_1	progression rate L to H	1/1100	estimated
α_2	progression rate H to C	1/2800	estimated ($1/\alpha_1+1/\alpha_2=3650$)
$\beta_{1,dairy}$	transmission rate from L	0.000784	estimated
$\beta_{1,beef}$	transmission rate from L	0.000754	estimated
$\beta_{2,dairy}$	transmission from H &C	0.00784	$=10*\beta_1$ (Mitchell *et al.*, 2008)
$\beta_{2,beef}$	transmission rate from H &C	0.00754	$=10*\beta_1$ (Mitchell *et al.*, 2008)
γ	death rate from C	1/90d	SAC (2001)
ε_1	vertical transition from L &H	0.09	Whittington & Windsor, 2009
ε_2	vertical transition rate from C	0.39	Whittington & Windsor, 2009
Se_L	test sensitivity for L	0.100	Whitlock *et al*. 2000
Se_H	test sensitivity for H	0.750	Whitlock *et al*. 2000
Se_C	test sensitivity for C	0.850	SAC (2001)
Sp	test specificity	0.997	

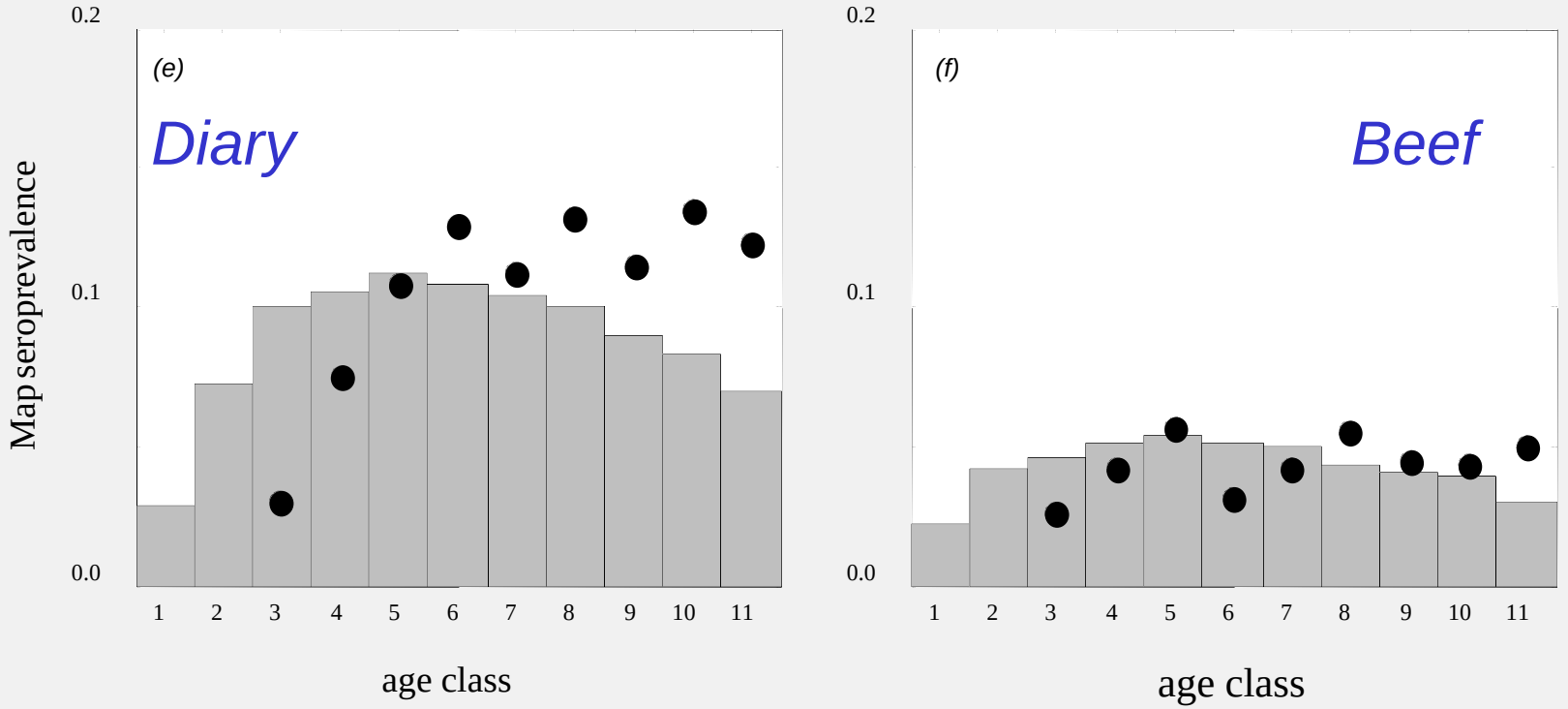
Farm distribution of seroprevalence



- Simulated – bars; observed
- Distribution of seroprevalence by farm different for diary & beef
- Match data well

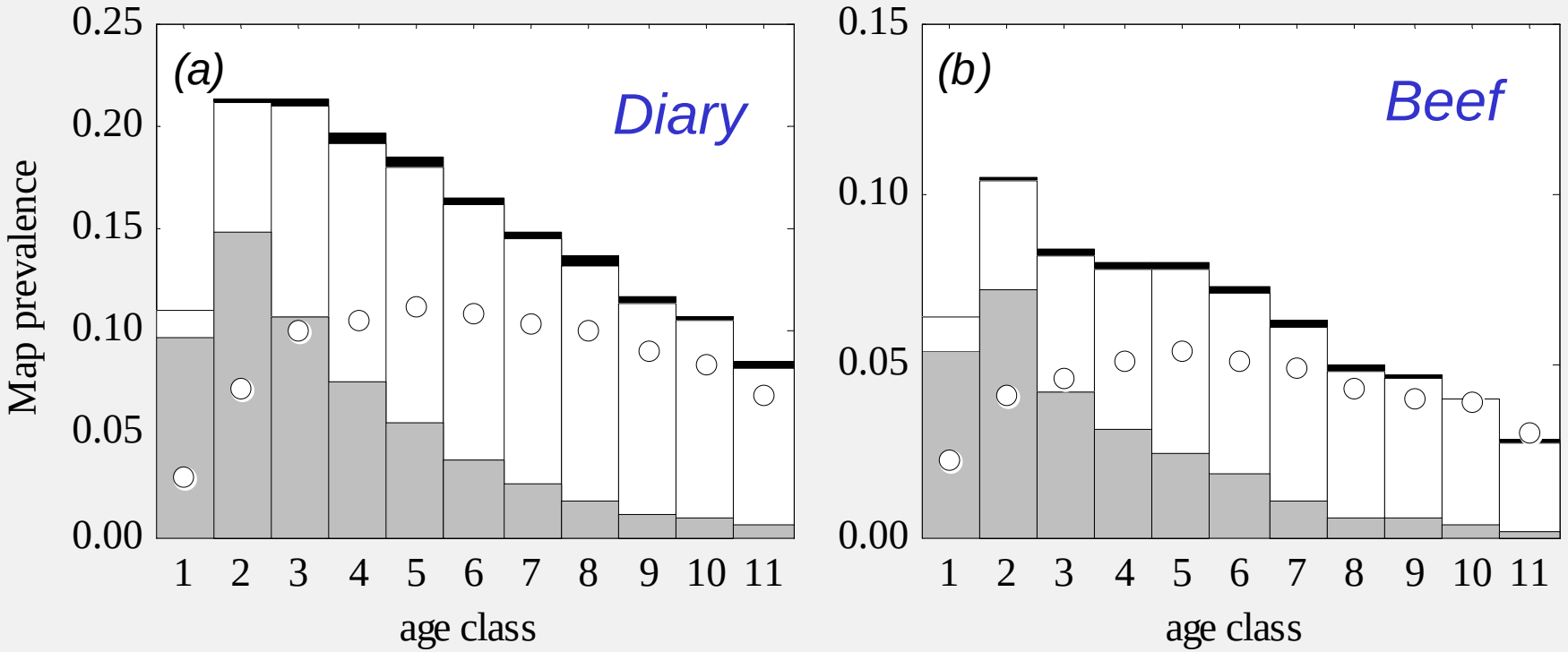
Farm and Individual Prediction

Age profiles of seroprevalence



- Simulated – bars; observed
- Discrepancy because no explicit age effect included
  - Sensitivity does not increase with age, no minimum time in each class

Age profiles of infection status



- Simulated true prevalence of
  - Low-shedding (grey), High-shedding (white) and Clinical (black)
- Simulated seroprevalence - circles

Source of Infection

herd type	class	within-herd transmissions	between-herd transmissions	transmission ratio
dairy	L	6589	46	143
	H	60096	31	1939
	C	1969	1	1969
beef	L	3892	305	13
	H	25787	161	160
	C	796	3	265

- Most between herd transmissions are L and H
- Within herd transmission higher in diary
- Between herd transmissions more common in beef

Modelling Conclusions

General Conclusions

Contexts

- Immunology ↔ Epidemiology ↔ Economics ↔

Ascaris

JD

Acknowledgements

References

Philosophical Transactions of the Royal Society of London, Series B

Mycobacterium avium paratuberculosis

PVM