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Is product threshold model better than additive threshold model for studying A.I. result?

in sheep

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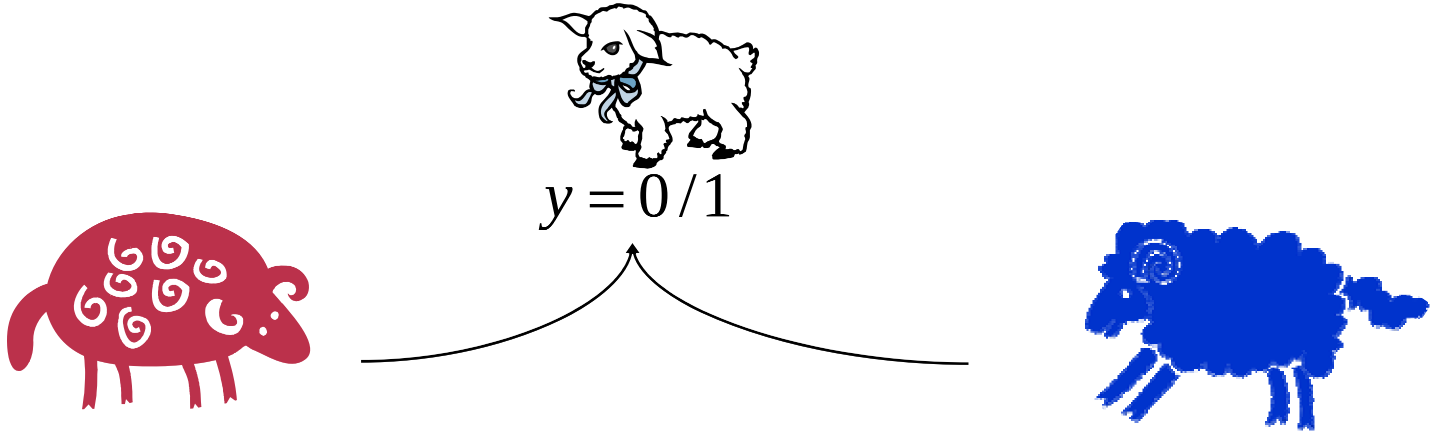
Problem



Female fertility
Genetic (A_f)
environmental (E_f)

Male fecundancy
Genetic (A_m)
environmental (E_m)

How to model a binary phenotype dependent on 2 individuals ?

Possible solution 1

Additive threshold model

$$P(\text{AI success}) = \Phi(\underbrace{A_f + E_f}_{\text{female}} + \underbrace{A_m + E_m}_{\text{male}})$$

$$\Phi(A_f + A_m + E)$$

Is it the right association ?

Possible solution 2

Additive threshold model

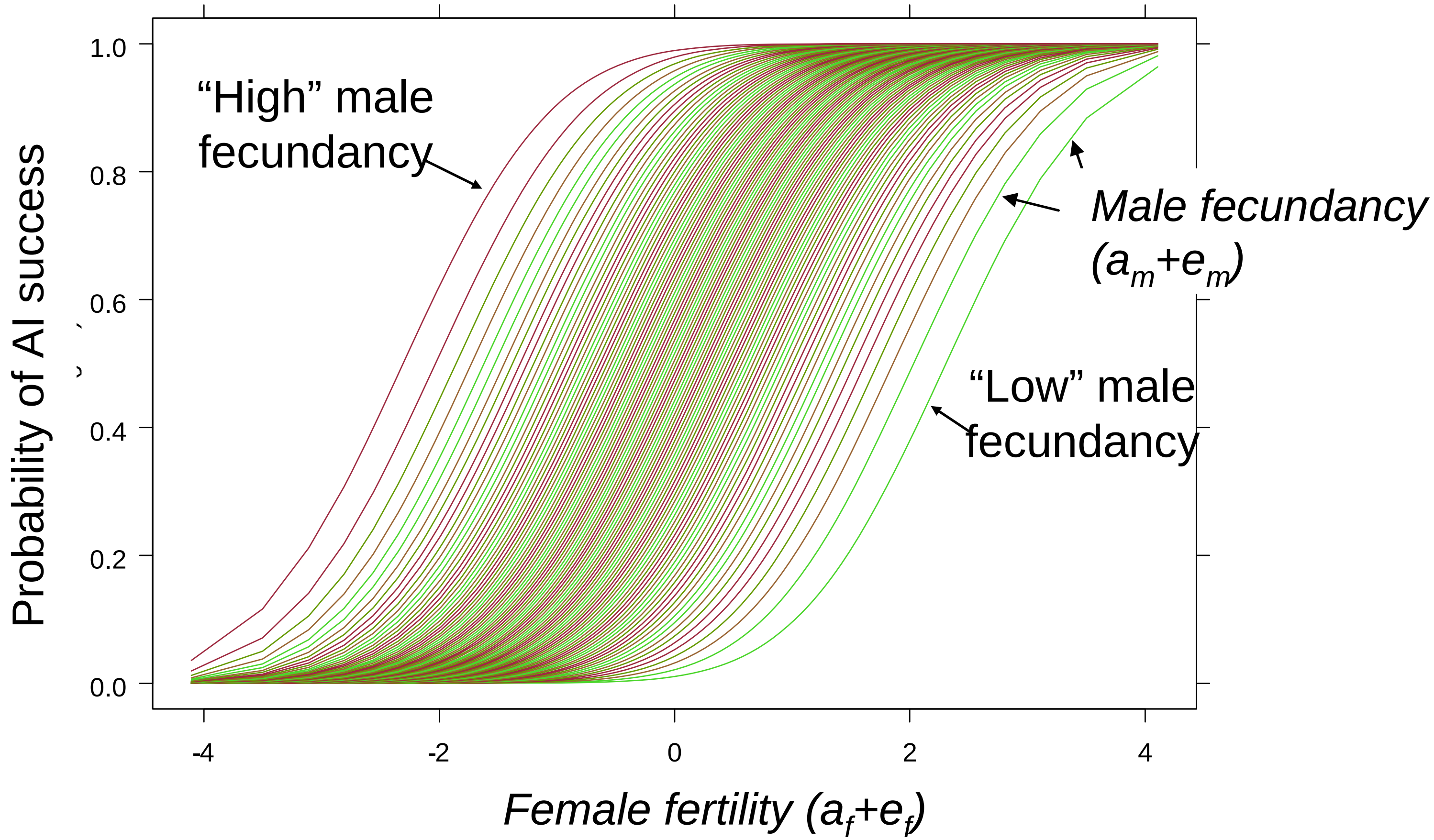
$$P(\text{AI success}) = \Phi(\underbrace{A_f + E_f}_{\text{female}} + \underbrace{A_m + E_m}_{\text{male}})$$

Product threshold model

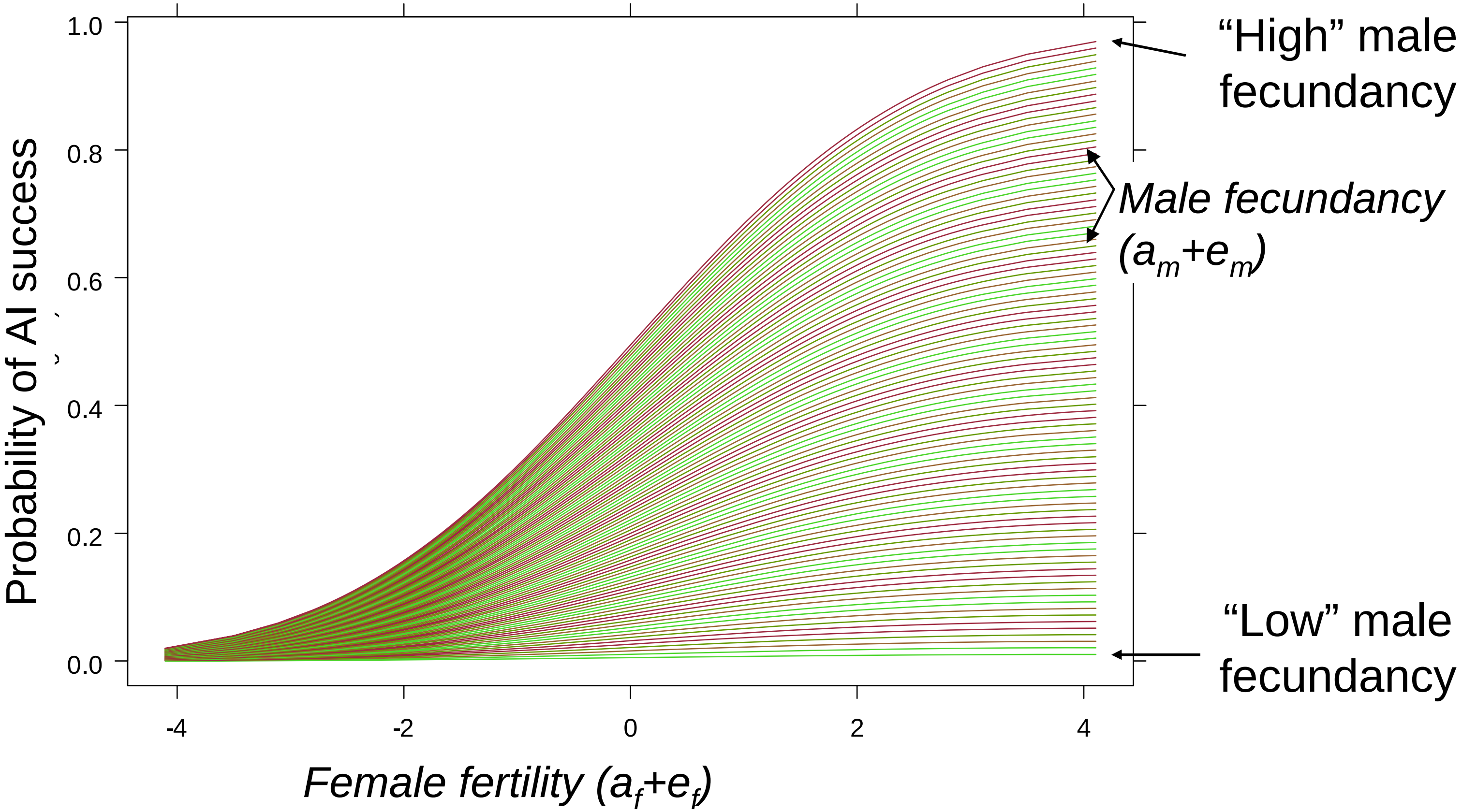
$$P(\text{AI success}) = P(\text{female fertility}) \times P(\text{male fecundancy})$$

$$\Phi\underbrace{\left(A_f + E_f\right)}_{\text{female}} \times \Phi\underbrace{\left(A_m + E_m\right)}_{\text{male}}$$

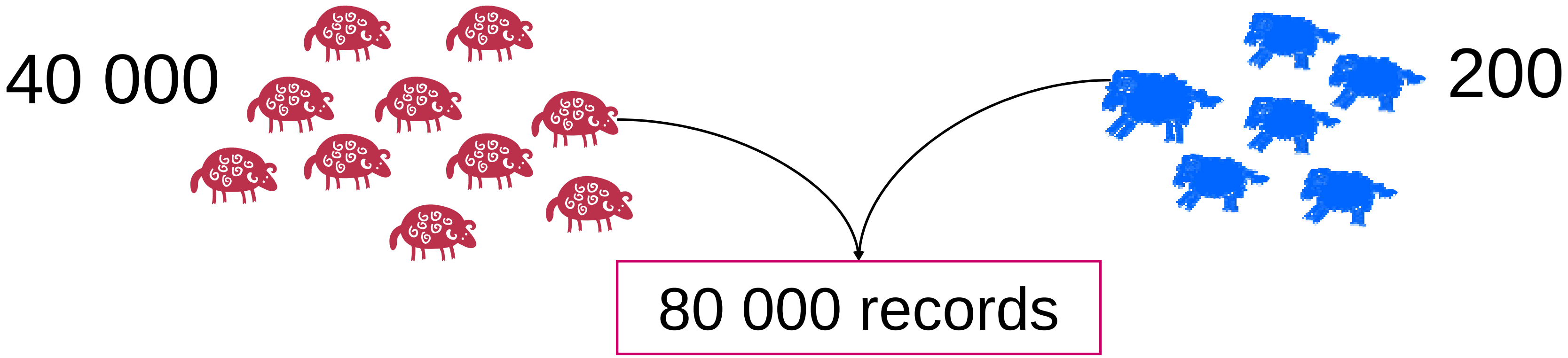
Consequences of the additive threshold model



Consequences of the product threshold model



Simulation design



$$\left.\begin{matrix} a_f \\ \text{year} \end{matrix}\right\} P_f \qquad P_m \left\{\begin{matrix} a_m \\ \text{year} \\ \text{age of the male} \end{matrix}\right.$$

$$P(\text{AI success}) = 50\%$$

Parameter estimations

Bayesian approach, Gibbs sampling,

Modification *TM program* (Andres Legarra)

- Product threshold model

  Parameters estimable?

  Program works?

Good estimations

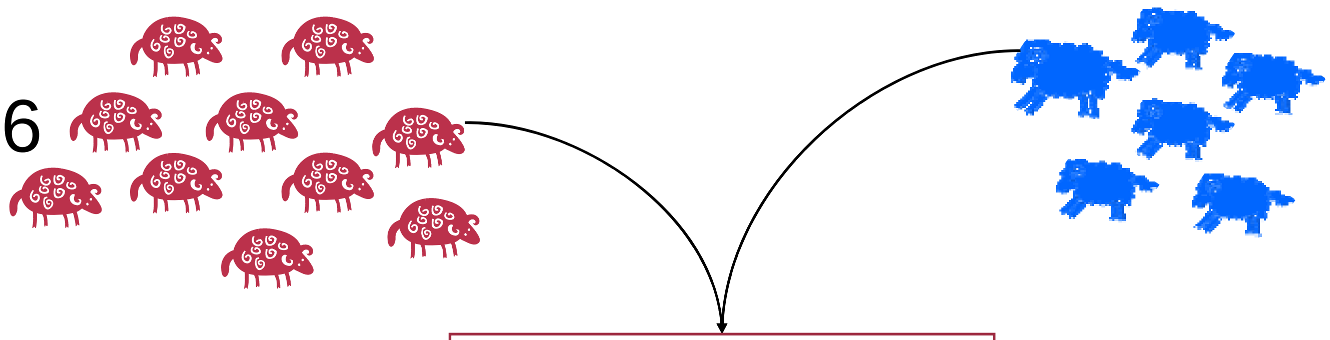
		Simulated	Result	
Genetic Male fecundancy variance		0.25	0.25	[0.21,0.29]
Genetic Female fertility variance		0.36	0.36	[0.33,0.41]
Genetic correlation		0.30	0.21	[0.03,0.41]
year effect	Male	-1.50	-1.46	[-1.52,-1.41]
		0.50	0.53	[0.47,0.60]
	female	1.50	1.54	[1.47,1.63]
		1.00	1.00	[0.97,1.04]
Male age effect		2.00	1.99	[1.94,2.03]

Good correlation between BV

Correlation EBV		EBV
Real BV	Male fecundancy	0.97
	Female fertility	0.94

Field data

74 136



963

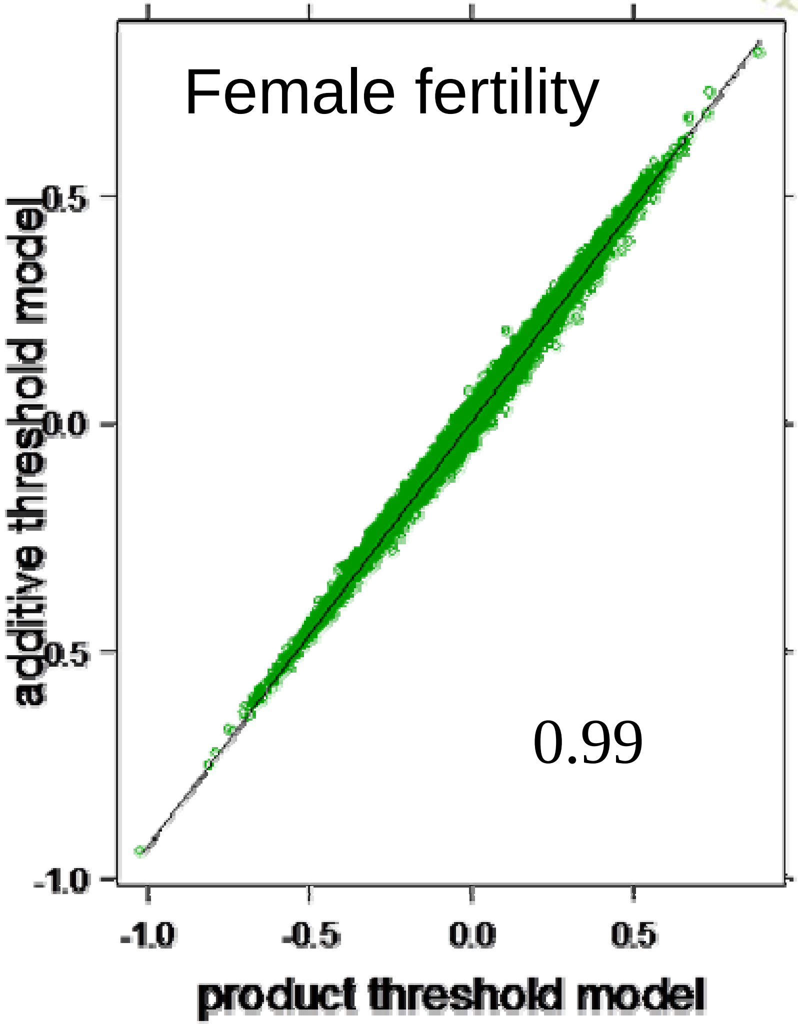
135 623 sheep AI

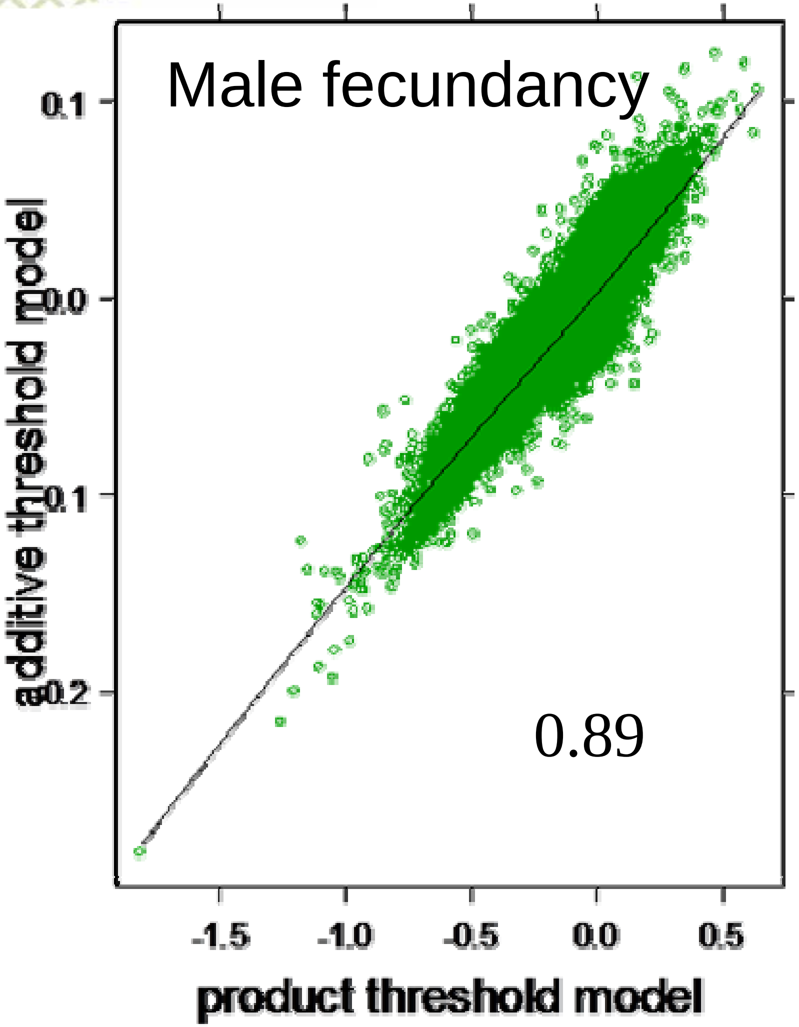
AI success=57%

models

- Product threshold model
- Additive threshold model

Field data: preliminary results





Discussion / conclusion

Advantage	Disadvantage
In accordance with biology	Estimate parameters for the unobserved phenotypes
Easy to implement	0.75=0.87*0.87
Estimate effects for male and female separately	Convergence limit: extreme case problem