

A model for predicting the impact of gastro intestinal nematode infestation on dairy sheep production

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INRA
SCIENCE & IMPACT



OVERVIEW

- **Context**
- **Model (bird's eye view)**
 - Nutrients flow
 - Immune response
 - Epidemiology
- **Sensitivity analysis**
 - General approach
- **Next steps**

CONTEXT

The impact of gastrointestinal nematodes (**GIN**) on sheep production

- **GIN** typical life cycle features a free living stage of larvae in the pasture and a reproductive stage within the host (Hurquart, 1998).
- The cost of **GIN** infestation is estimated in the order of million of euros in many countries (Waller P, Chandrawathani P 2005)
- Resistance to anthelmintics increases further the economic loss (Waller, 2006)
- Genetic selection towards **GIN** resistance/resilience could be an alternative strategy which do not suffer long term loss of efficacy (Kemper et Al. 2009)

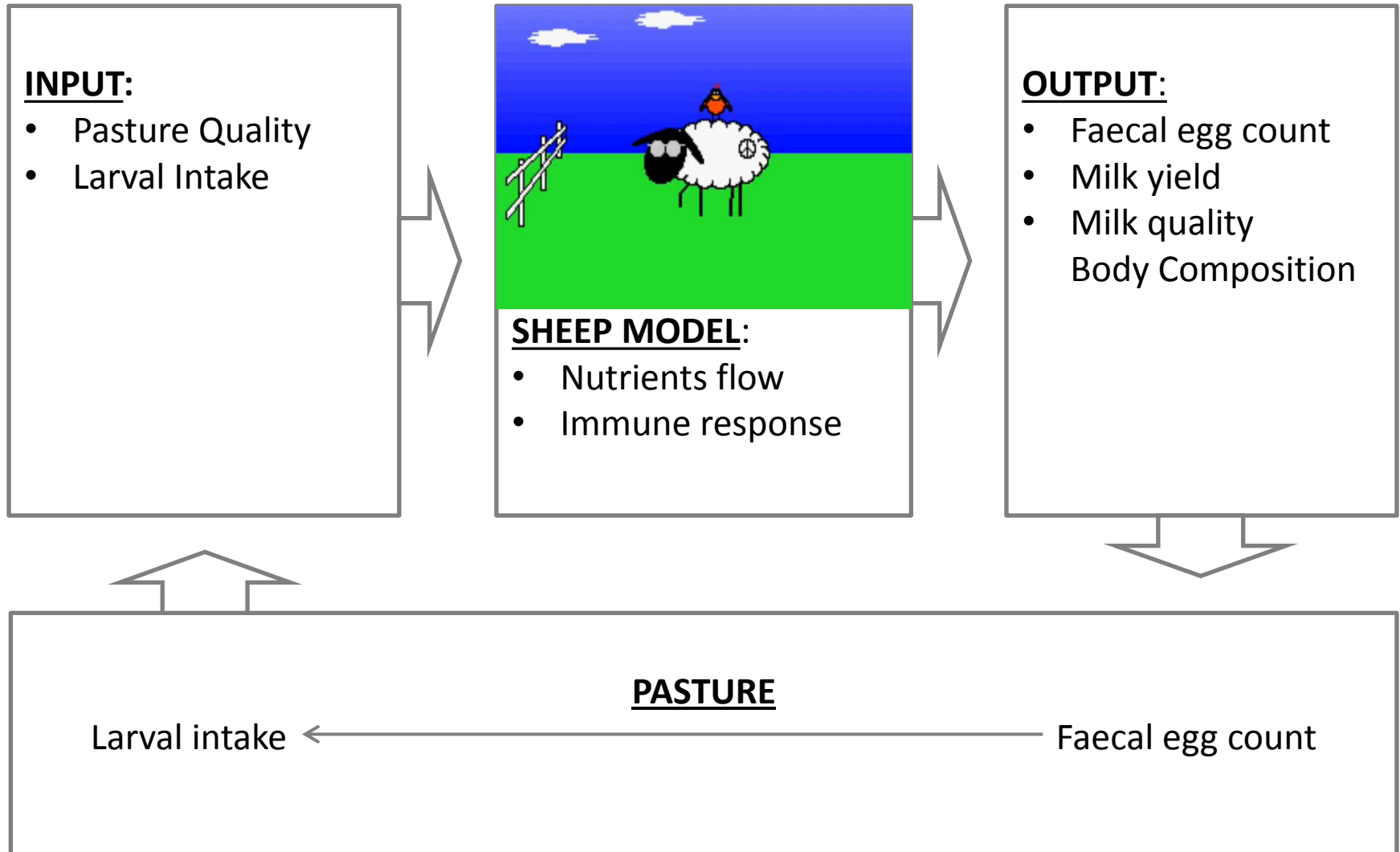


OVERVIEW

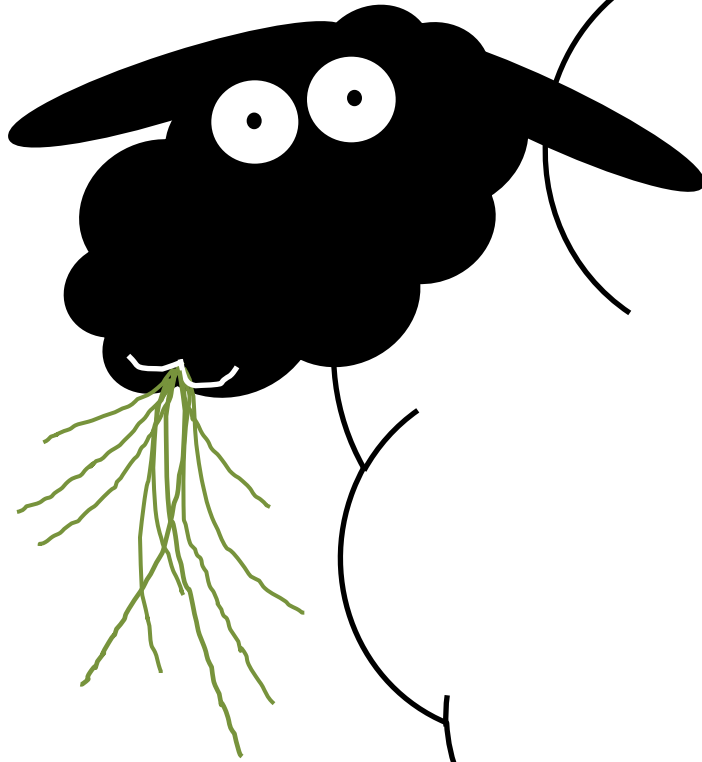
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MODEL: Bird's eye view



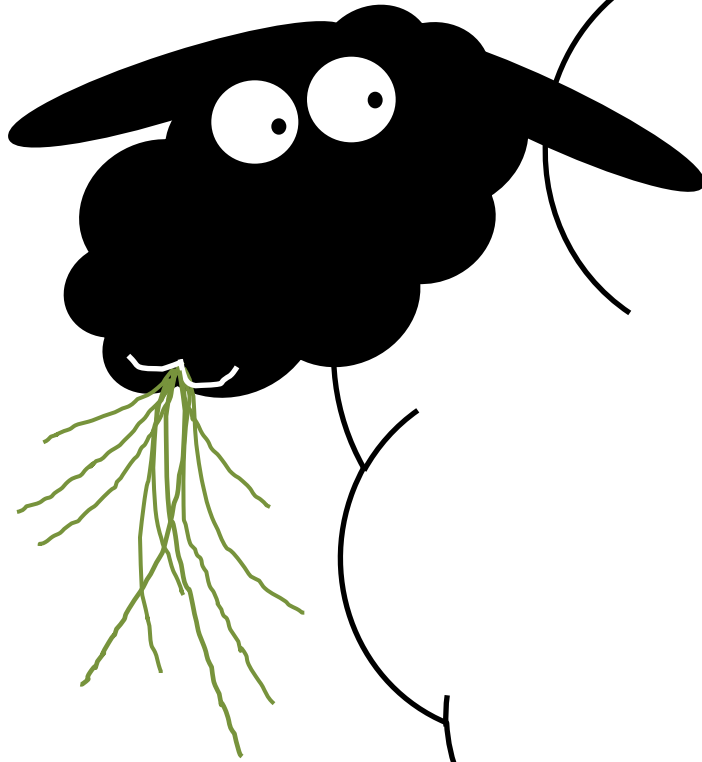
MODEL: Nutrients flow



FEED INTAKE:

- Daily feed intake is defined by the daily total requirements of energy
- The maximum feed intake is constrained by the bulk capacity
- Drops during late pregnancy and early lactation
- Anorexia reduces feed intake as a function of immunity acquisition

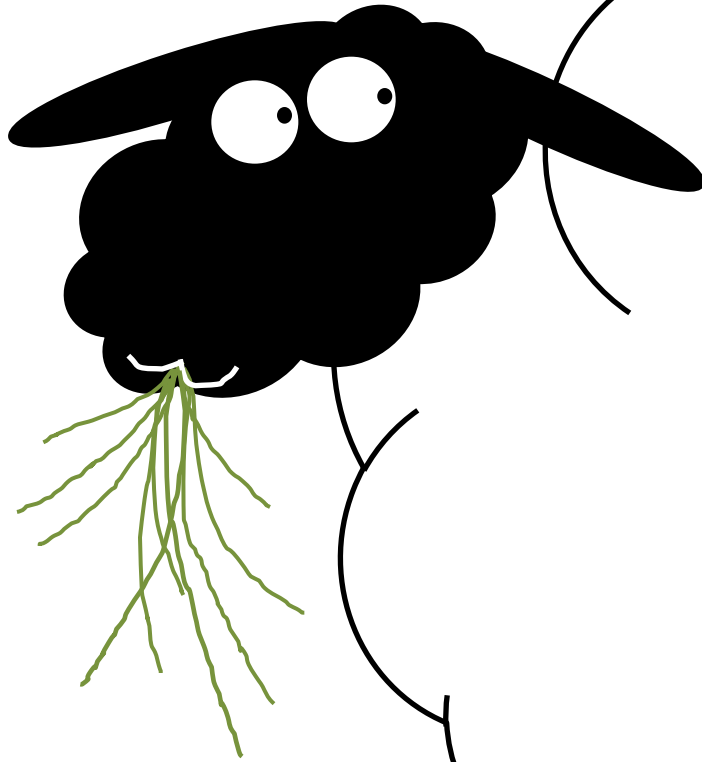
MODEL: Nutrients flow



AVAILABLE NUTRIENTS: ENERGY

- Available energy is the sum of energy intake plus the energy mobilized from fat deposits
- The mobilization of fat depends on both the current physiological state of the animal (lactation) and the energy balance

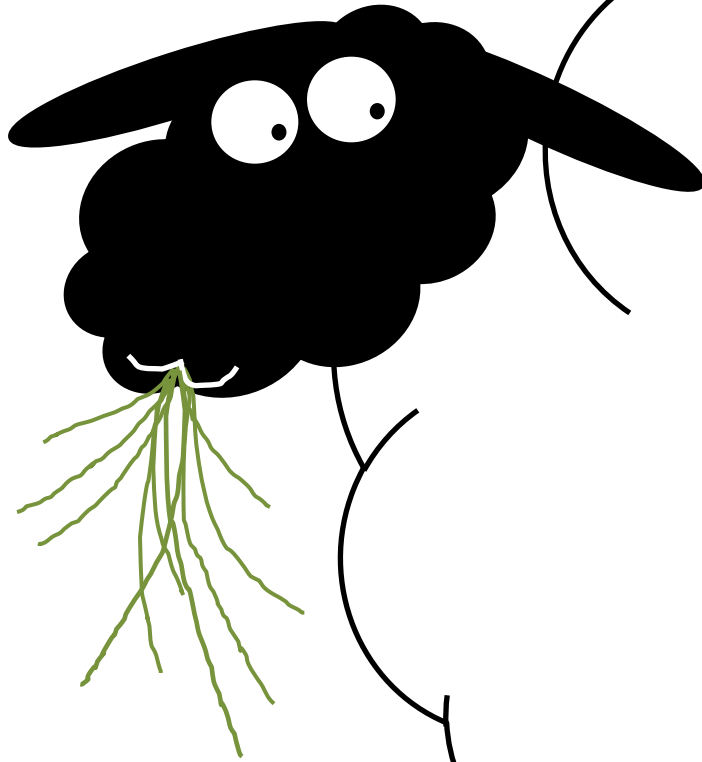
MODEL: Nutrients flow



AVAILABLE NUTRIENTS: PROTEIN

- Available protein is the sum of protein intake plus the protein mobilized from protein deposits
- The parasite burden causes a proportional protein loss
- The mobilization of protein depends on the protein balance only

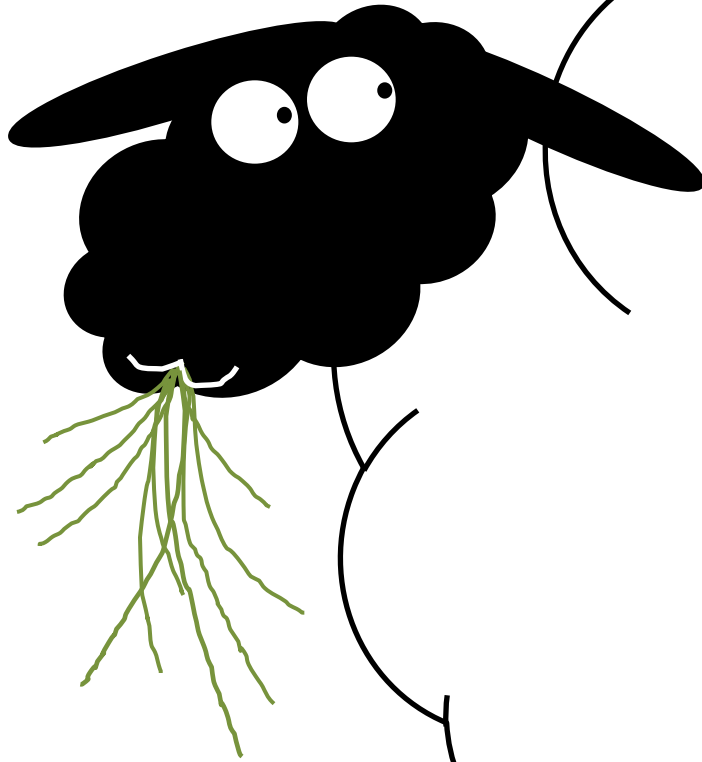
MODEL: Nutrients flow



NUTRIENTS ALLOCATION: ENERGY

- Allocation to maintenance has top priority
- Excess energy is deposited as adipose tissue

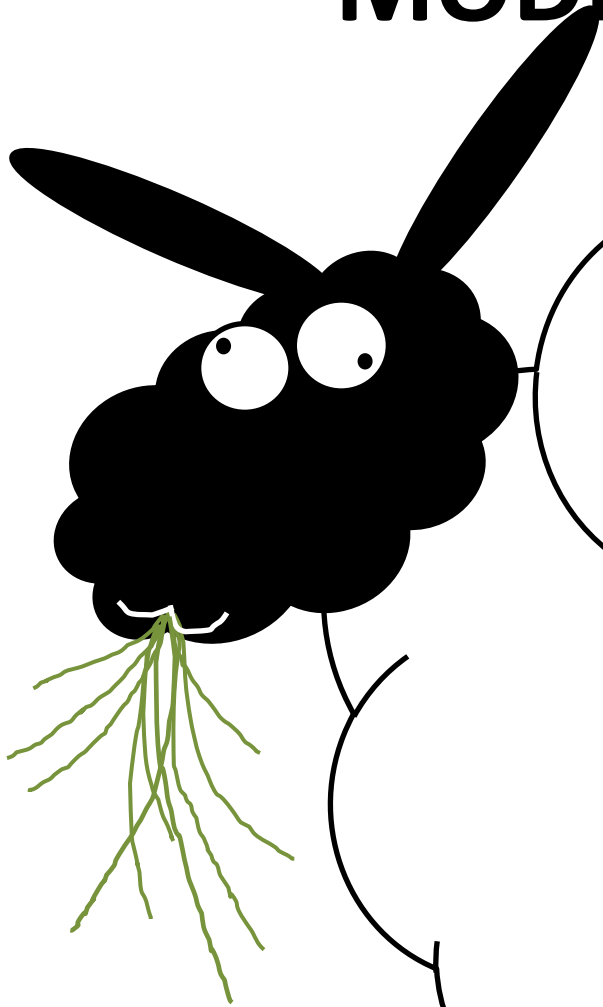
MODEL: Nutrients flow



NUTRIENTS ALLOCATION: PROTEIN

- Competition for protein occurs between milk production and immunity:
 1. Allocation to milk maximizes milk yield
 2. Allocation to immunity reduces protein loss
- Excess protein is deposited as muscular tissue

MODEL: Nutrients flow

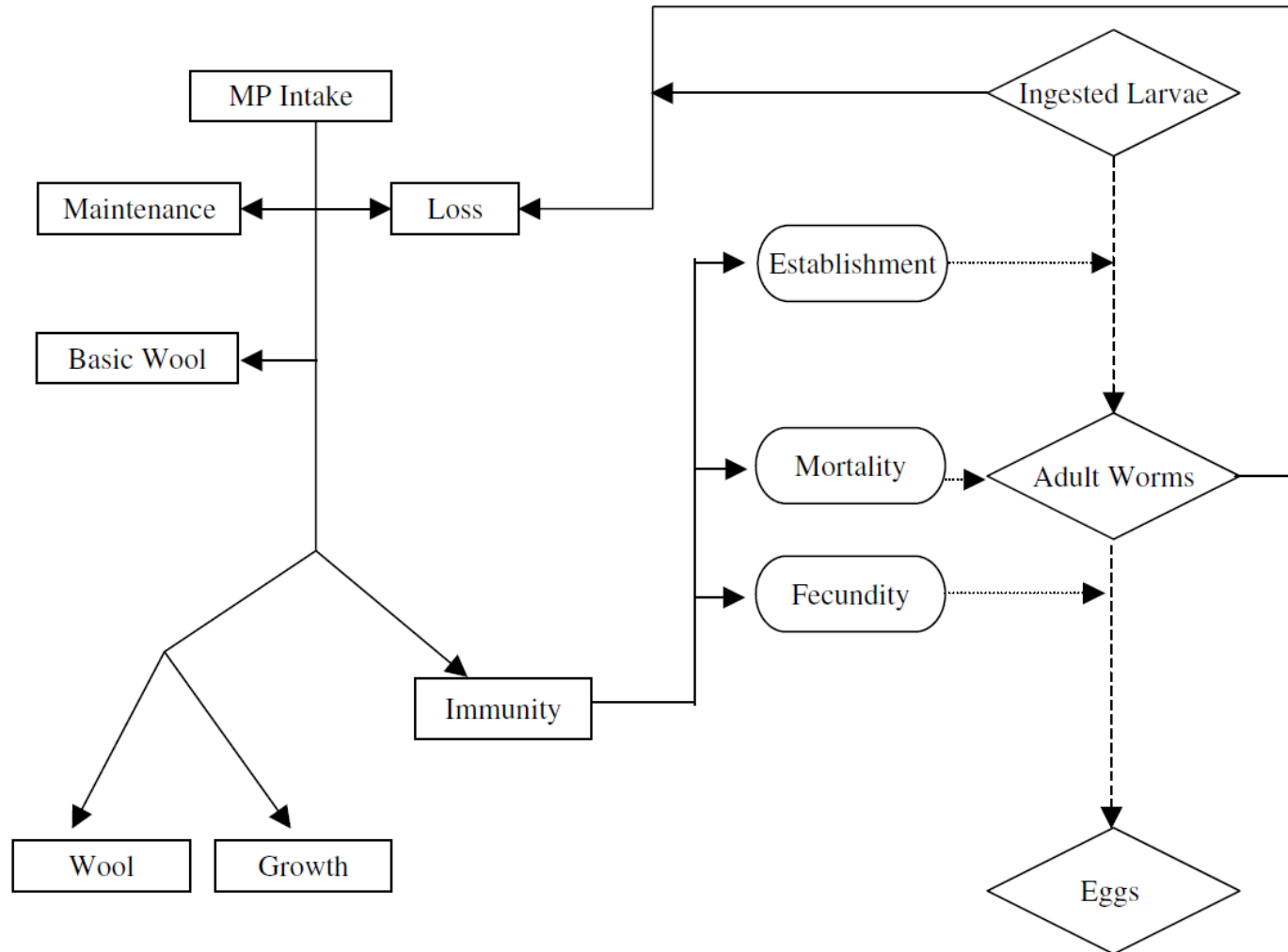


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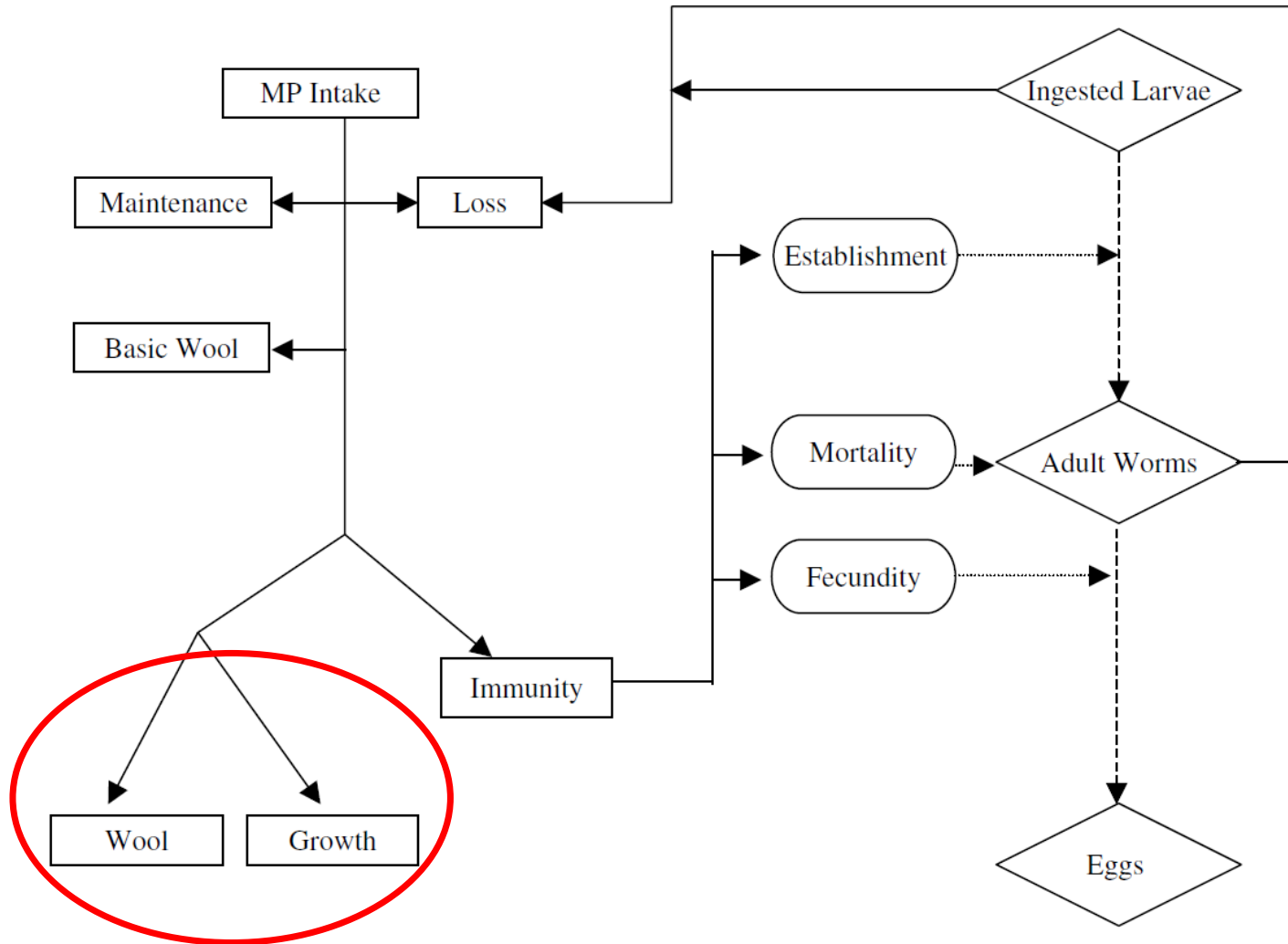
MODEL: Immune response

(Vagenas et Al. 2007)



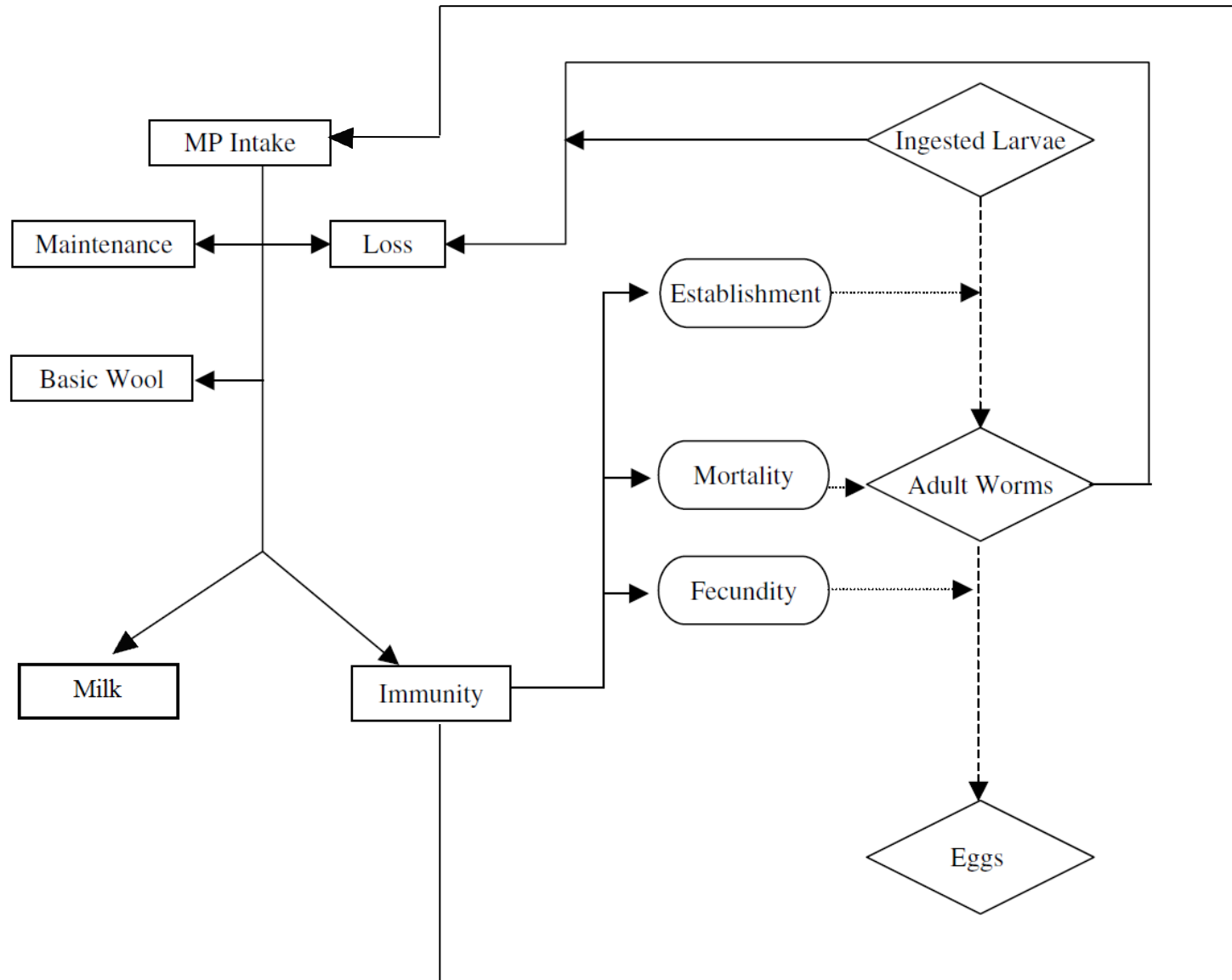
MODEL: Immune response

(Vagenas et Al. 2007)



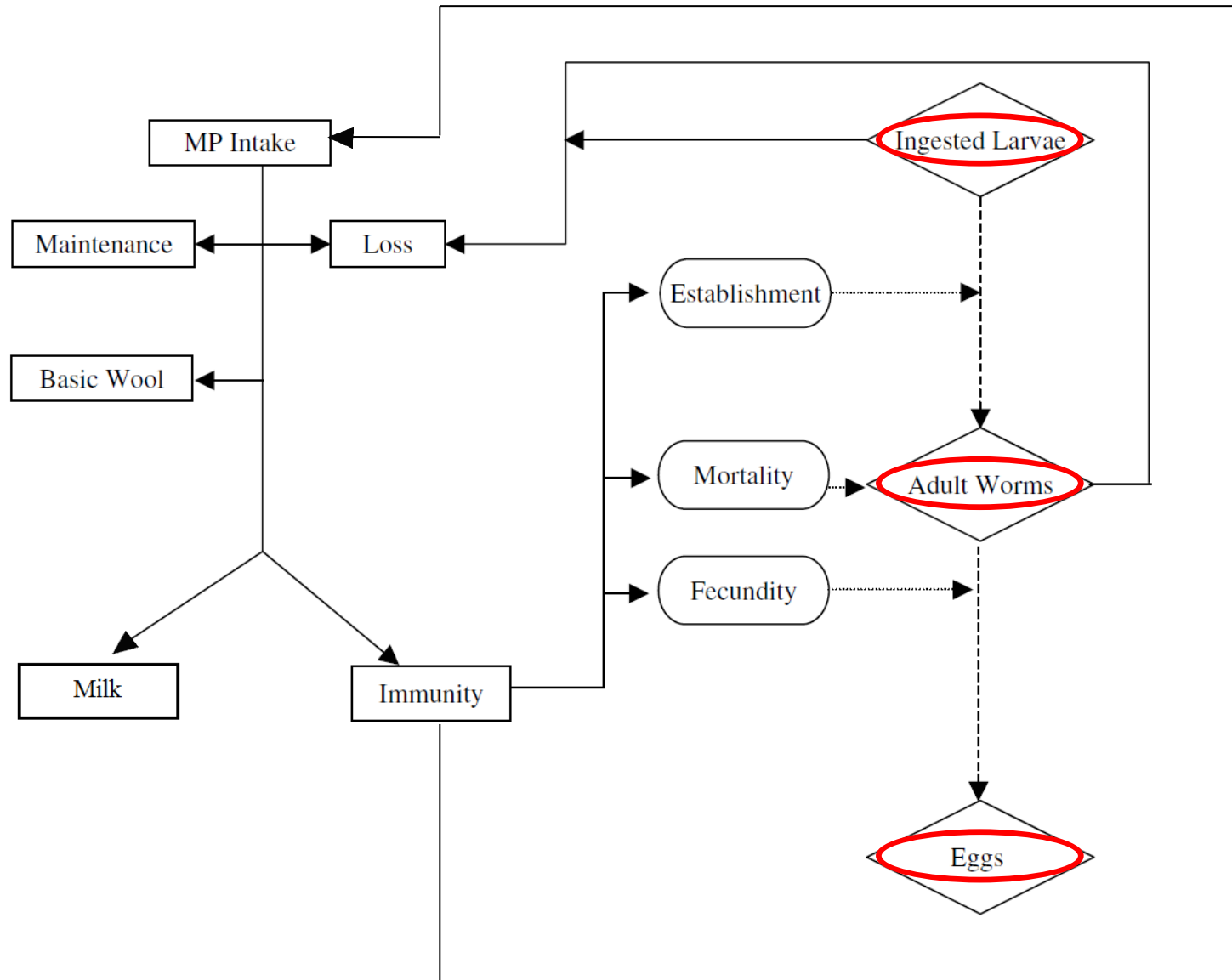
MODEL: Immune response

(Modified from Vagenas et Al. 2007)

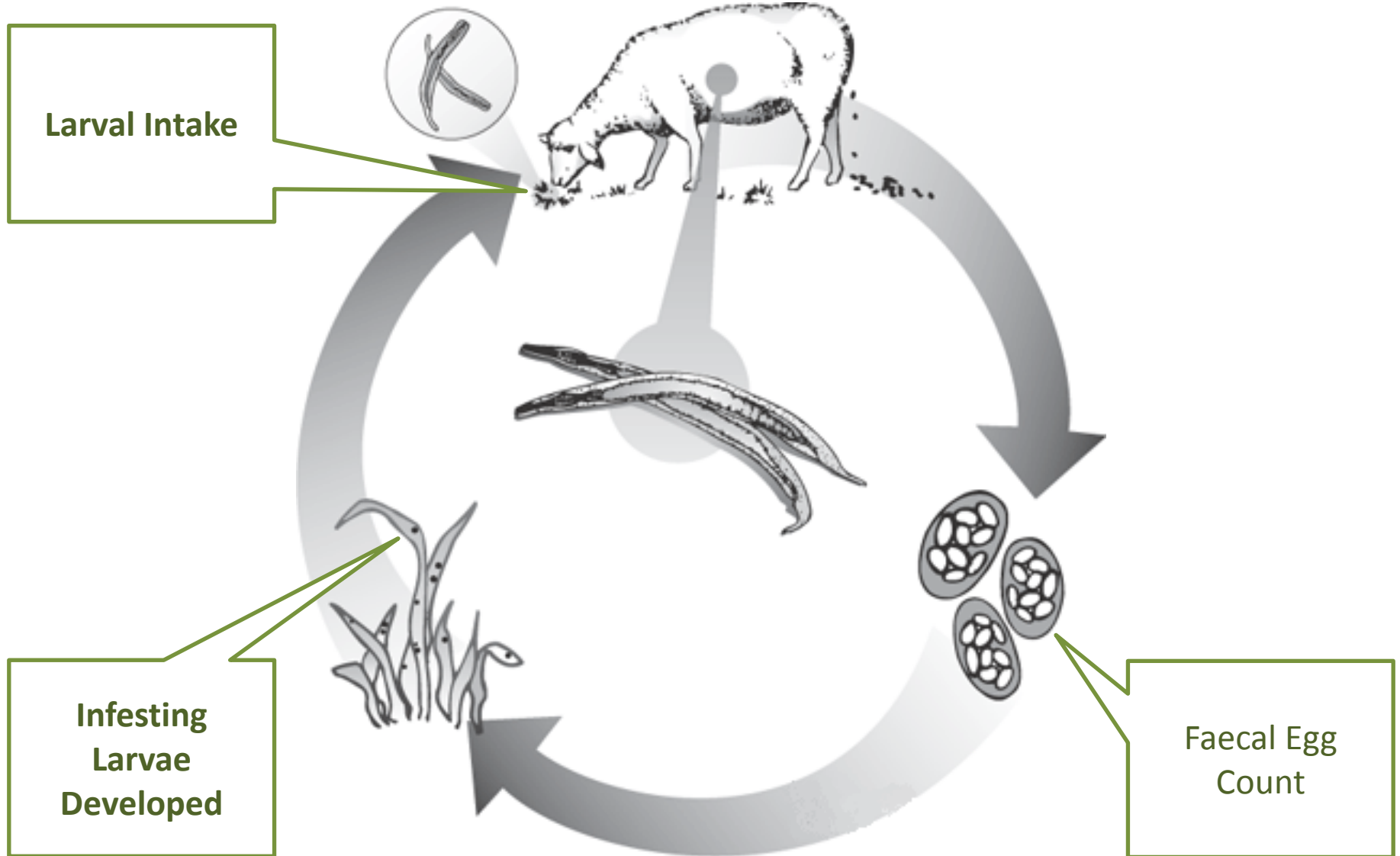


MODEL: Immune response

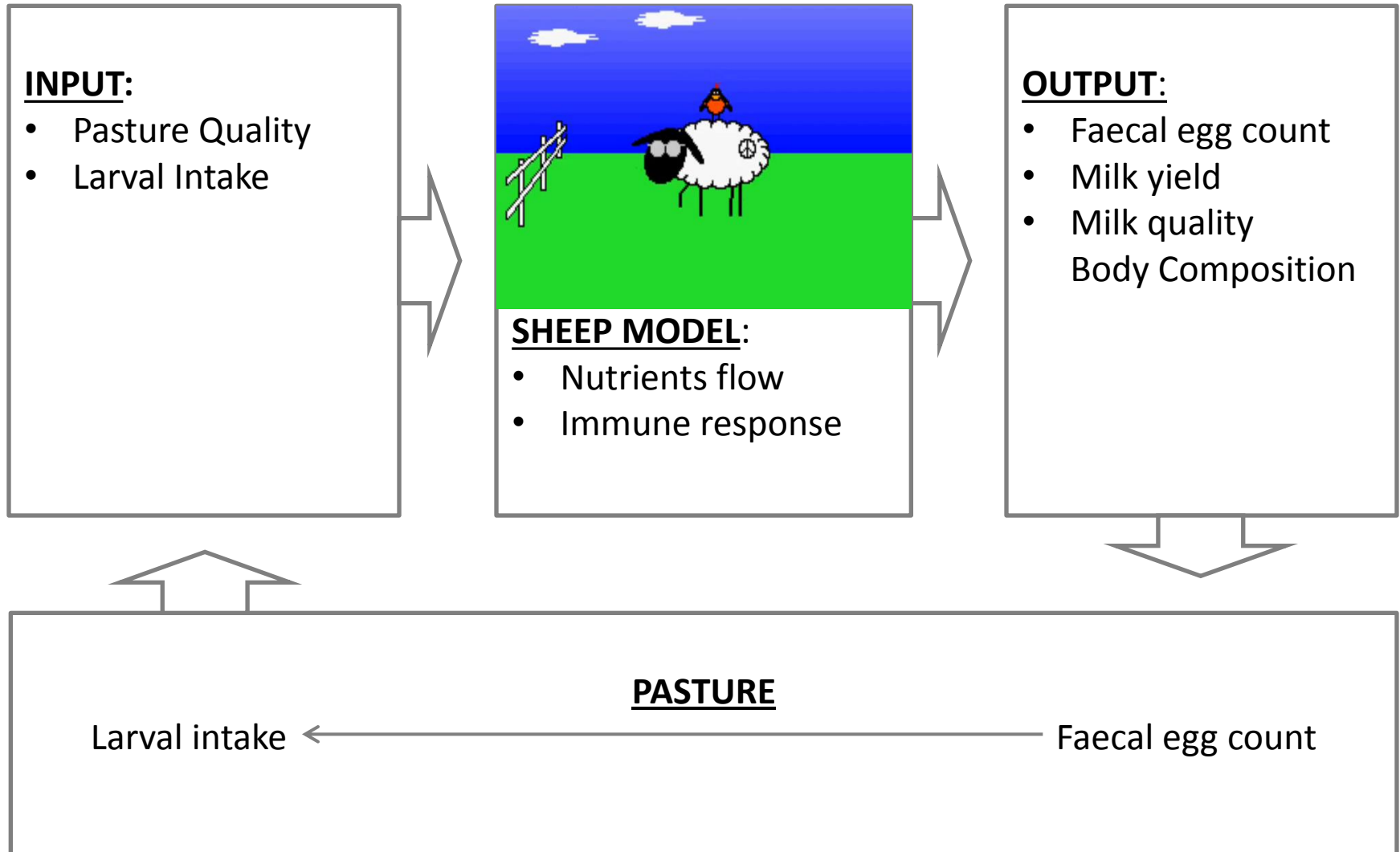
(Modified from Vagenas et Al. 2007)



MODEL: Epidemiology



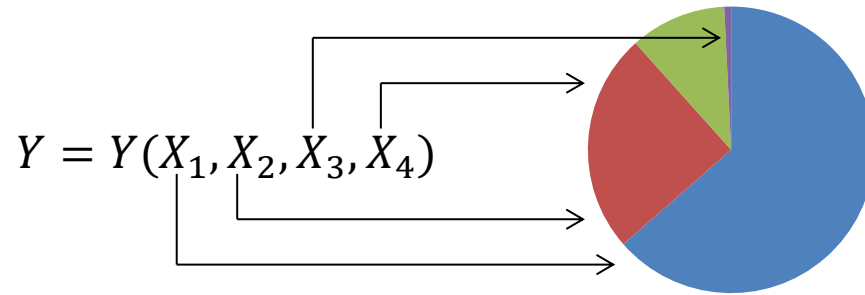
MODEL: Bird's eye view



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SENSITIVITY ANALYSIS



1. OBJECTIVE:

- To rank the model's parameters according to their impact on the model's output
- To test whether each model parameter has a linear or non-linear relation with the model's output

2. APPLICATION:

- Mapping the model behaviour on the parameters space
- Simplification of the model
- Designing informed experiments for the estimation of the model parameters

3. METHOD:

- Computing both the elementary and total sensitivity indices for each model parameter by radial design (Saltelli et Al.2010, Campolongo et Al 2011)

SENSITIVITY ANALYSIS

(Saltelli and Annoni, 2010)

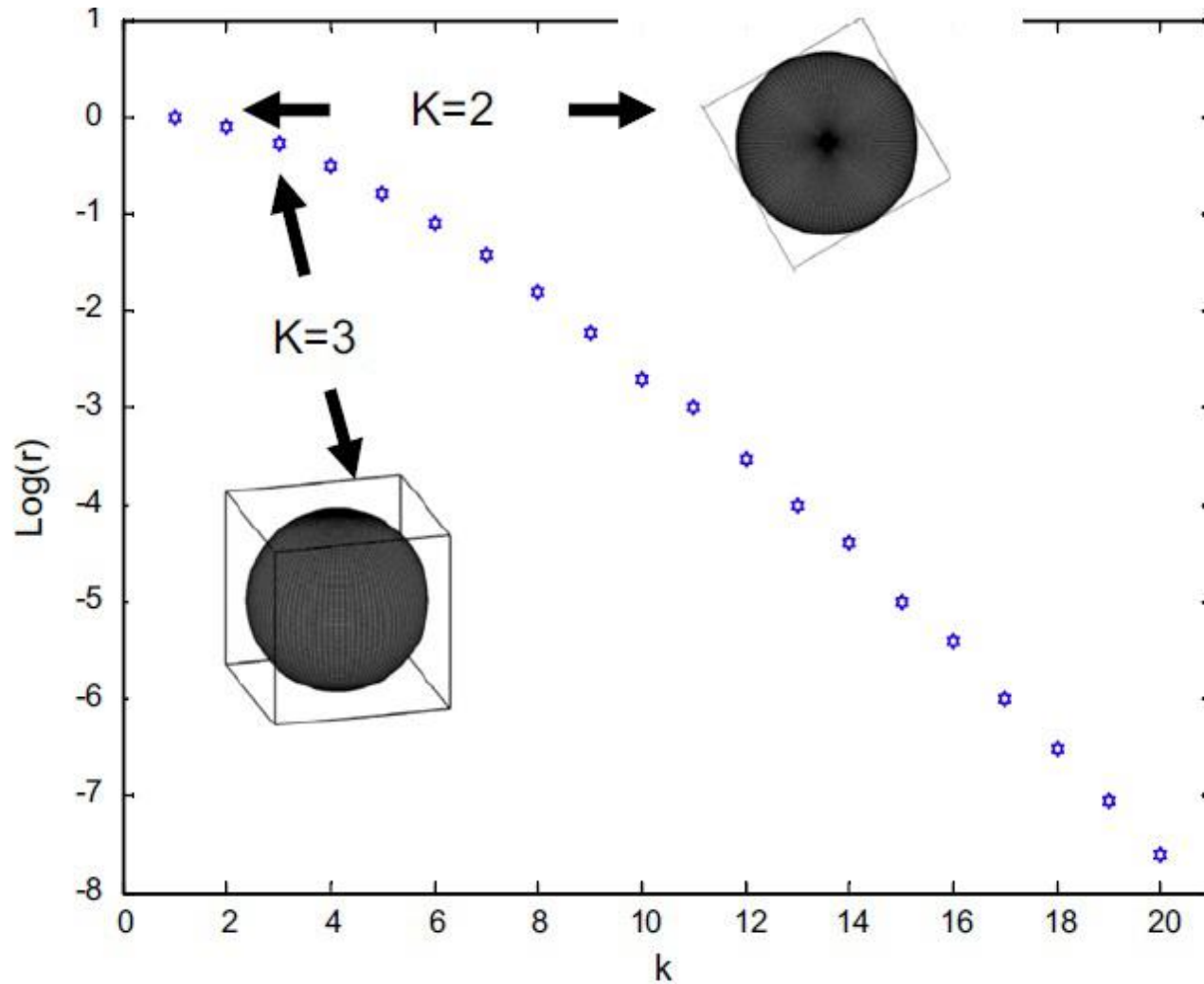


Fig. 1. The curse of dimensionality. In $k = 3$ dimensions the volume of the sphere internal to a cube and tangent to its face is $r \sim 0.5$. r goes rapidly to zero with increasing k .

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NEXT STEPS

DATA COLLECTION:

Phenotypes on faecal egg count and milk production will be collected on a french breed of the Atlantic Pyrenees

MODEL CALIBRATION & VALIDATION:

These Phenotypes will be used for estimating the model parameters and test how close the model's output can get to the real data

Thank you for your attention!



ACKNOWLEDGEMENTS

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