Controlling tick borne diseases through domestic animal management: a theoretical approach

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Talk Outline

• Background of tick biology

• Management strategy

• Model Results

• Future plans
Louping Ill Virus (LIV)

• Tick borne disease

• Affects sheep and grouse

• Sheep vaccinated and ‘dipped’

• 80% mortality in infected grouse
Tick Life Cycle

Thousands of eggs are laid.
Approx. 1000 eggs hatch
Tick Life Cycle

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Eggs hatch into larvae
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Eggs hatch into larvae.

Larvae quest for blood meal on small/medium size hosts.
Tick Life Cycle

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Larvae leave host after meal to moult into nymph.

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Larvae leave host after meal to moult into nymph

Larvae quest for blood meal on small/medium size hosts

Nymphs quest for blood meal on any size host

Tick Life Cycle
Tick Life Cycle

Thousands of eggs are laid. Approx. 1000 eggs hatch.

Eggs hatch into larvae.

Larvae leave host after meal to moult into nymphs.

Nymphs quest for blood meal on any size host.

Nymphs leave host after meal to moult into adults.

Larvae leave host after meal to moult into nymphs.

Larvae quest for blood meal on small/medium size hosts.

Tick Life Cycle
Tick Life Cycle

Thousands of eggs are laid. Approx. 1000 eggs hatch

Eggs hatch into larvae

Adults quest for meal on large hosts

Larvae leave host after meal to moult into nymphs

Nymphs quest for blood meal on any size host

Nymphs leave host after meal to moult into adults

Larvae leave host after meal to moult into nymph

Larvae quest for blood meal on small/medium size hosts
Tick Life Cycle

Thousands of eggs are laid. Approx. 1000 eggs hatch.

Mating occurs.

Eggs hatch into larvae.

Larvae leave host after meal to moult into nymphs.

Nymphs leave host after meal to moult into adults.

Nymphs quest for blood meal on any size host.

Larvae quest for blood meal on small/medium size hosts.

Adults quest for meal on large hosts.
Control strategies

- No ticks = no disease

- Treat/remove wild animal hosts
  - Ethical/legality issues

- Treat domestic hosts
  - Sheep tick mops
Sheep ‘tick mops’

• Actively use sheep treated with acaracide to ‘mop up’ ticks.
Sheep Model Results

- Model run in Mathematica
- What effect do sheep tick mops have with different deer densities?
- What effect does varying the efficacy have?
Model predictions with deer

- As deer numbers increase tick numbers increase and grouse numbers decline.
- Increased deer numbers reduces effect of sheep tick mops.
Different efficacy levels

- High efficacy speeds recovery
- Low efficacy prevents recovery, worse than no sheep?
Conclusions

• Using sheep tick mops can be effective if:
  – very few deer
  – high level of efficacy
Empirical evidence

• Game and Wildlife Conservation Trust Key Findings:

  – The use of sheep as ‘tick-mops’ may reduce tick biting rates on grouse chicks where deer densities are lower than five per 100 hectares.

  – Red deer densities of 10 per 100 hectares appear to be too high for ‘tick-mops’ to be effective.

  (Are sheep tick-mops effective in Scotland?
   http://www.gct.org.uk/text03.asp?PageId=339)
Future work

• Seasonality

• Deer tick mops

• Fieldwork/collaboration for validation data
Thanks to: R Norman, L Gilbert
landowners/shepherds for data
NERC
Macaulay Development Fund
The model

Grouse equations

\[
\frac{dG_s}{dt} = (a_g - s_g G)G - b_g G_s - (\beta_1 + P\beta_3)T_i G_s
\]

\[
\frac{dG_i}{dt} = (\beta_1 + P\beta_3)T_i G_s - \Gamma G_i \quad \text{where } \Gamma = \alpha + b_g + \gamma
\]

\[
\frac{dG_z}{dt} = \gamma G_i - b_g G_z
\]

Tick equations

\[
\frac{dT_s}{dt} = (a_t - s_t T)T(\beta_5 D + (1-d)\beta_6 S) - \beta_2 T_s G_i - b_t T_s - \beta_3 T_s G - \beta_5 T_s D - \beta_6 T_s S - d\beta_7 T_s S
\]

\[
\frac{dT_i}{dt} = \beta_2 T_s G_i - b_t T_i - \beta_3 T_i G - \beta_5 T_i D - \beta_6 T_i S - d\beta_7 T_i S
\]