How do parasite infections affect livestock greenhouse gas emissions?

N Lean[1,3,4], N J Fox[1], J Hillier[2], M R Hutchings[1], G Marion[3]

1. SRUC, The Roslin Institute Building, Edinburgh, EH25 9RG, UK
2. Global Academy of Agriculture and Food Sciences, University of Edinburgh, EH25 9RG, UK
3. Biomathematics and Statistics Scotland, JCMB, King's Buildings, Edinburgh, EH9 3FD, UK
4. University of Edinburgh, Old College, South Bridge, Edinburgh EH8 9YL, UK

Background:

Methane from ruminant enteric fermentation represents both an environmental issue and a farm production loss.

- ❑ 12-17% of global methane emissions comes from ruminant's digesting their food [Denman *et.al.* 2007]
- ❑ 2-15% of the total energy from livestock feed is lost to the atmosphere in the form of methane gas [van Nevel 1996].

Currently the impact of parasitism on ruminant methane emissions is estimated by multiplying standard emission by a factor representing the increased time parasitized animals take to reach slaughter weight.

However, a recent study [Fox *et.al*.2018] showed a 33% increase in methane emissions per kilogram of dry matter intake (CH_4/ Kg DMI) near the peak of a *Teladorsagia circumcinta* parasite burden in lambs, compared to the uninfected control groups. This suggests **a more accurate method to quantify the effects of parasitism on livestock methane emissions is required**.

My PhD project will quantify the effects that the gutworm *T. circumcinta* has on sheep methane emissions throughout the duration of infection and explore potential methane mitigation strategies.

Main questions:

- ❑ How does parasitism affect livestock GHG emissions over the course of infection?
- ❑ How does parasitism affect livestock methane emissions as a measurement of CO_2-eq/ kg live weight gain?
- ❑ What is the potential for methane mitigation through parasite control?

Measuring methane emissions from sheep:

Use respiration chambers to measure methane emissions over the course of a parasite infection

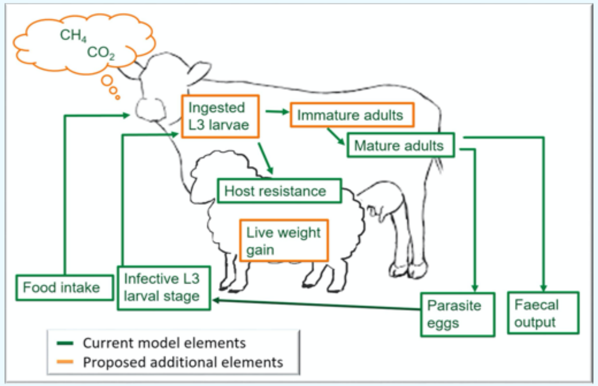
Conduct experiment during Spring/ Summer 2021

Take measurements of the lambs':

- ❑ Methane emissions throughout the parasite infection
- ❑ Food intake
- ❑ Live weight gain
- ❑ Blood TH2 to assess host immune response
- ❑ Blood pepsinogen to assess parasite larval damage
- ❑ Faecal egg counts to monitor parasite infection and confirm non-parasitized status of control groups.

Treat half of each group with anthelmintic drugs after peak parasite burden + peak methane yield to assess impact of parasite treatment.

Mathematical model:



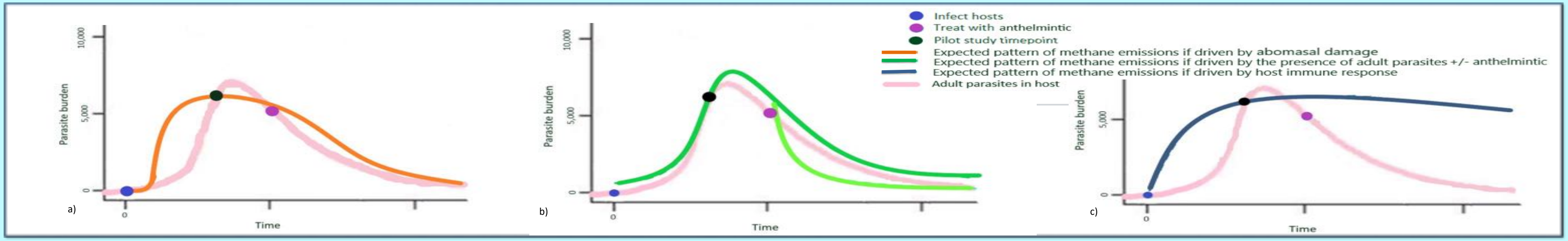
The mechanism behind the increased methane emissions seen in Fox *et al's* [2018] study is currently unknown. A mathematical model, using principles from the models of Roberts and Grenfell [1991] and Fox *et al.* [2015], will be developed to explore potential mechanisms.

Potential mechanisms to be explored:

- ❑ Presence of different parasite lifestages
- ❑ Host anorexia
- ❑ Damage to abomasal wall
- ❑ Host immune response

The model will influence the design and analysis of the experiment.

Predicted methane emission profiles for 3 potential mechanisms:



Potential methane emissions from livestock during a parasite challenge if increased methane emissions are driven by a) abomasal damage, b) presence of adult parasites +/- if anthelmintic treatment is given, c) host immune response.

References:

- Fox NJ, Marion G, Davidson RS, White PCL, Hutchings MR. (2015) *Climate-driven tipping-points could lead to sudden, high-intensity parasite outbreaks*. R. Soc. open sci. 2: 140296. http://dx.doi.org/10.1098/rsos.140296
- Fox N.J., Smith L.A., Houdijk J.G.M., Athanasiadou S., Hutchings M.R. (2018) *'Ubiquitous parasites drive a 33% increase in methane yield from livestock', International Journal for Parasitology*. Pergamon, 48(13), pp. 1017–1021. doi: 10.1016/J.IJPARA.2018.06.001.
- Rogelj, J., *et.al.*, (2018) *Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte *et.al* d (eds.)]. In Press.
- Roberts MG, Grenfell BT. (1991) *The population dynamics of nematode infections of ruminants: periodic perturbations as a model for management*. IMAJ.Math. Appl.Med.Biol. 8,83–93.(doi:10.1093/ imammb/8.2.83)
- Van Nevel CJ, Demeyer DI. (1996) Control of rumen methanogenesis. Environ Monit Assess. Sep;42(1-2):73-97. doi: 10.1007/BF00394043. PMID: 24193494.