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Reducing greenhouse gas emissions through better animal health

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Summary

- This briefing examines the case for reducing green house gas emissions (GHGs) through improvements in animal health.
- Ruminant livestock have been singled out for their particular contribution to GHGs.
- Greater productivity from ruminants will reduce GHGs per kg of product but little attention has been paid to the potential role of animal health in this strategy.
- Preliminary calculations suggest that improvements in animal health will deliver worthwhile reductions in GHGs and increased farm profits in many circumstances but there are barriers to uptake of the necessary actions.
- Locating animal health interventions relative to other GHG mitigation options (i.e. on a marginal abatement cost curve) would be a useful first step towards determining priority interventions and then overcoming barriers to improved animal health.

Introduction

Global greenhouse gas emissions (GHGs) from livestock are controversial, with competing estimates suggesting that they amount to between 10% and 18% of anthropogenic emissions (Steinfeld et al., 2006, Pitesky et al 2009). Ruminants have come under particular scrutiny in this regard because of their high emissions per kg of product, caused primarily by enteric methane production (Gill et al., 2010). This is of particular concern to Scotland, which has a high proportion of sole right rough grazing (3.4m Ha, about 80% of UK total), and associated populations of cattle and sheep (Scottish Government, 2009). But Scottish livestock farms may in some circumstances absorb as much carbon as they emit as plants and trees on the farm absorb carbon dioxide from the atmosphere, transferring the carbon to the soil. This counterbalances carbon release from other processes (Topp and Rees, 2008). Even so, it remains important to reduce emissions from livestock farming and there are indications that targets can be achieved through feasible increases in productivity (EBLEX,

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2009). It therefore seems surprising that limited attention has been paid to the ‘win-win’ potential of cattle and sheep health improvements, which can improve productivity while reducing emissions of GHGs per unit of product. Associated improvements in animal welfare, food safety and possibly biodiversity (interactions with wildlife health) would be added bonuses to offset against any environmental costs of disease prevention and control.

Potential gains from animal health

Taking mastitis in the dairy cow as a prime example of an endemic disease, we find that productivity i.e. milk yield per cow is reduced by about 3.5% over all dairy cows in Great Britain. This ‘medium’ figure is based on a back calculation of the economic impact of this disease estimated by Bennett and Ijpelaar (2005). Their ‘high’ estimate is about 5%. If we assume that 40% of this loss could be recouped by applying the most profitable existing control strategies (Yalcin et al., 1999), better mastitis control could supply a 1.5% to 2% improvement in productivity along with greater profitability from its effect on milk yield alone. FAO (2010) estimate that in Western Europe milk production accounts for about 1.7kg carbon dioxide (CO_2) equivalent per kg of milk produced. Given an average milk yield per cow of 7,000kg from 1.86m cows in the UK (DairyCo, 2010), better mastitis control could deliver about 0.4Mt CO2 equivalent from its milk yield benefits alone, less any emissions arising from the extra mastitis control actions. Associated improvements in milk quality, mortality, fertility and longevity would add to this benefit, at very least outweighing the emissions from extra mastitis control. The mitigation of 0.4MtCO_2e represents a reduction of 8% of the UK dairy emissions (UK dairy emissions arising from enteric fermentation and from wastes were estimated to be 5.4 MtCO_2e in 2007 (Jackson *et al.* 2009).

Garnsworthy (2004) demonstrated a strong link between cow fertility and greenhouse gas emissions in the dairy herd. This is because good fertility reduces the size of the breeding herd required to support each milking cow as well as increasing the productive life of the milking cow herself. He found that restoring UK dairy cow fertility to 1995 levels (about 20% improvement in the then current conception rates) would reduce GHGs (methane and ammonia) by about 10%. Achieving such a restoration could be done by genetic means, but this would require the sacrifice of some genetic gain in productivity (Pryce et al., 2004) and hence some of the environmental benefit. Garnsworthy (2004) advocates a nutritional approach to restore dairy cow fertility but greater investment in the management of fertility may also be profitable (Stott et al., 1999). Another way (not exclusive of alternatives) would be to invest in improved animal health as this can lead to improvements in fertility. For example, Berends et al. (2008) found that Dutch dairy herds engaged in a certification programme for freedom from Bovine Viral Diarrhoea Virus (BVDV) had significantly lower abortion rates than control herds (unknown BVDV status). These herds also experienced a significant reduction in mastitis incidence, demonstrating the potential synergies to be had from a focus on animal health. Such synergies also make it difficult to establish the economic and environmental contribution of any one mitigation strategy. Bio-economic models can help to resolve this difficulty by providing an optimal solution at farm or higher systems level that can be used as a benchmark (Santarossa et al., 2005).

Varo Barbudo et al. (2009) estimated that reduced fertility in a typical Scottish beef suckler herd at the peak of a BVDV epidemic could result in the loss of 10 calves per 100 cows and an associated financial loss of £43/cow. This would raise methane production per calf sold by about 8% based on emissions tables in MacCarthy et al. (2010). Across the range of a 10-year BVDV epidemic, infertility losses averaged £33/cow/year, associated with elevated methane emissions per calf of about 5%. Extra GHGs per calf due to loss of productivity caused by BVDV would be additional to this. The economically optimal costs of avoiding BVDV losses through vaccination and higher levels of biosecurity may be around £6/cow/year (Stott and Gunn, 2008) in a disease-free herd, giving a clear ‘win-win’.

However, this level of investment does not eliminate all BVDV losses, suggesting that public benefits remain after all private benefit from BVDV control has been obtained.

If a BVDV eradication programme for Scotland (Scottish Government, 2010a) were to be successfully implemented then the full environmental public good would be realised. An important question is how much might that good be? This could then be compared with the likely farm-level costs and benefits of eradication as set out in Scottish Government (2010b). In this situation, comparing GHG emissions at current and most profitable control strategies as in the above calculations for dairy cow mastitis is inappropriate. However, Stott et al. (2003) took a different approach to the economic evaluation of BVDV, which is more useful in this context. They established risk minimising farm plans for a typical Scottish beef suckler herd either free of BVDV or of unknown BVDV status. At the same farm income (£7500 pa), the BVDV-free herd required one less heifer (1%) and 15 fewer sheep (3%) because of costs saved by less disease, despite greater expenditure on biosecurity to maintain the disease-free status. Table 1 shows how this benefit might relate to GHG emissions.

Table 1: Estimated emissions savings from BVDV eradication from beef cattle in Scotland

	Holdings[1]	Animals/ holding[1]	Holdings of unknown BVDV status[2]	Extra animals due to BVDV	kg CO2e/ animal[3]	Emissions saved (T CO2e)	Total Emissions (T CO2e)	Emissions saved (%)
Beef Cows	9485	49	3130	1535	1593	2445	740810	0.3
Ewes	13158	211	3130	19367	235	4556	653704	0.7

[1] Holdings and animals/holding in Scotland, Scottish Government (2009).
[2] 0.33 of beef cow holdings not BVDV free based on Brulisauer et al. (2010).
[3] MacCarthy et al. (2010).

The estimates in Table 1 are very crude for a variety of reasons. For example, they assume that every beef cow holding also has an average sized sheep flock to benefit from the BVDV cost savings. No specific account is taken of the fertility benefits from BVDV freedom outlined in the last paragraph. Also the average fixed income assumption of Stott et al. (2003) is applied. A higher fixed income assumption would realise a greater benefit than this as greater investment in BVDV prevention could then be afforded. On the positive side, this preliminary analysis accounts for changing risks and thus includes the costs of extra biosecurity measures to maintain freedom from BVDV once eradication has been achieved. If BVDV remains endemic in England, this will be an important consideration for Scotland. The analysis also recognises that the benefits of freedom from BVDV are not confined to the beef sector and may alter the structure of the industry more widely. This will have GHG implications not accounted for here. This example therefore again emphasises the need for a bio-economic systems modelling approach.

Stott et al. (2005) asked focus groups of sheep farmers to assess the impact on productivity of 2 alternative levels of disease control on a hypothetical 900-ewe extensive sheep farm where the default strategy was to routinely treat all common ailments. The alternatives were either to routinely treat a limited number of common ailments or to only treat individuals when they were sick. Based on these estimates and the UKNIR emissions tables (McCarthy et al. 2010), the first alternative would raise methane emissions per lamb sold by about 6% compared to the default scenario. Treating animals only when sick would raise methane emissions by about 28% (see Table 2). However, at the time this work was undertaken default average gross margins per shepherd were about 11% and 18% lower than the first and second alternative disease control strategies respectively, i.e. the higher levels of disease prevention expenditure were not financially justified. The default high level of disease prevention measures was thought important for animal welfare.

Table 2: Farmer estimated performances for an extensive sheep flock under alternative health management strategies with associated methane emissions

	Animal health strategy*:		
	Default	Alternatives:	
		1	2
Outcomes:	Treat all common ailments	Treat some common ailments	Treat when sick
Number of ewes	900	900	900
Lambs produced	1080	990	810
Lambs sold for meat	873	805	625
Methane emissions (kg):			
Ewes at 8.2kg/head	7380	7380	7380
Lambs at 3.3kg/head	3564	3267	2673
Total methane production	10944	10647	10053
Methane per lamb sold for meat:	12	13	16

*From Stott et al. (2005)

The default sheep health management strategy outlined in Table 2 has a net cost, i.e. the financial benefits arising from improved health are smaller than the costs of achieving the improved health. However, this does not take into account the value of the GHG emissions reduction achieved in the default strategy. The preliminary analysis in Table 3 suggests that two of the options - moving from Option 2 to Option 1 and moving from Option 2 to the Default management strategy - are potentially cost-effective GHG mitigation strategies, when compared to the non-traded price of carbon. The central estimate of the price of carbon for the non-traded sector was £52/tCO_2e in 2010, rising to £60tCO_2e by 2020 (DECC, 2009).

Table 3: Estimated cost-effectiveness (CE) of sheep health management strategies

	Mitigation (tCO2e)	Effect on gross margin	Cost* (£)	CE (£/tCO2e)
Default v option 1	18.3	-11%	£2,475	135
Default v option 2	73.3	-18%	£4,050	55
Option 1v option 2	50.7	-7%	£1,575	31
**Assuming a gross margin of £2500 per 100 ewes, giving a gross margin per farm of:*			£22,500	

Why the gains may not be fully realised

With the exception of extensive sheep farming, the above examples all suggest a ‘win-win’ for farm profits and environmental impact from investment in better farm animal health. This implies that farmers acting in their own best interests will invest in animal health once they understand the costs and benefits. Public benefits for animal welfare and for the environment will follow. The ‘beneficiary pays’ principle behind this line of argument forms a basis for the Animal Health and Welfare Strategy for Great Britain (Defra, 2004).

There are various reasons for believing that the levels of farmer investment in animal health will fall short of those justified by the public good (Stott et al., 2010). Many of these reasons were summed up by a farmer client of SAC who when presented with the published economic arguments, stated that if the costs of all the diseases on his farm were correct then he would have gone out of business years ago. His statement was justified as many published figures give the average historic total costs of a single disease in isolation. They do not reflect the full potential of future investments in animal health that could be achieved by striving for maximum net benefit within a specific whole farm systems context (Stott and Gunn, 2008). Paradoxically, this might reveal even more opportunity than implied by the historic figures as important impacts of many diseases go unattributed as illustrated by the examples of links between disease and bovine infertility given above. However, even if maximum private net benefits of animal health were achieved, some disease and hence some unrealised public good will remain as the economic optimum level of control for the farmer will be lower than minimum levels of disease in many cases (Stott and Gunn, 2008).

It is also important to realise that farmers' decisions are not based solely on maximising expected net benefits. Risk is also an important consideration i.e. farmers need to consider the range of future outcomes likely to emerge from an investment in animal health and these may increase with increasing investment (Stott et al., 2003). Cattle and sheep farmers were found by Heffernan et al. (2008) to be largely dismissive of measures associated with biosecurity. Justification for this stance was framed in relation to blame for the disease threats. Extending the analysis to European countries and applying it specifically to BVDV revealed different attitudes in countries that applied compulsory rather than voluntary approaches to the disease. These differences related to blame for BVDV and the roles ascribed to farmers and other stakeholders in its eradication and control. Such socio-economic considerations will be important as Scotland considers whether or not to engage in a BVDV eradication programme (Scottish Government, 2010a).

When national disease control programmes are considered a different economic analysis is required. It is not appropriate simply to aggregate up farm level analyses (McInerney, 1996). For example, marginal costs of eradication are likely to increase substantially towards the end of a control programme as the few remaining infected farms will become harder to find and may present particular difficulties. Once substantial proportions of farms move from infected to disease-free status and gain an associated boost in productivity, commodity markets will be affected. Fixed price assumptions used to conduct cost benefit of eradication at the individual farm level are then no longer valid. Weldegebriel et al. (2009) examined this problem for a hypothetical programme of BVDV eradication from the Scottish dairy herd. They found that consumers would gain about £11m from the lower milk prices that would ensue from successful eradication. Farmers with BVDV would gain about £39m as lower prices received for milk would be more than offset by the greater volumes of milk they had to sell and the reduced costs of production. However, farmers free of BVDV at the start of the programme stood to lose £2m from lower milk prices with fewer countervailing benefits from disease eradication. The losses were much smaller than the gains, but these results highlight that the 'beneficiary pays' principle does not apply solely and homogenously to all farmers. They also reinforce the paradox noted by Gunn et al. (2005) that the higher the prevalence of BVDV, the lower the incentive for individual farmers to achieve disease-free status because of the costs of maintaining such freedom. These factors may make it more difficult to instigate a national eradication programme and hence gain the associated GHG reductions.

Conclusions

There have been few detailed studies of the potential impact of animal health on GHG emissions. The crude estimates given above suggest that there is potential for worthwhile 'win-win' for farm profits and GHG emissions. However, these may be difficult to achieve in practice without further research and knowledge exchange to overcome the barriers to uptake of existing disease prevention strategies and to develop improved tools and techniques.

A useful way forward in this situation may be to pool existing knowledge of the relationship between alternative farm animal disease prevention and control options and their effects on disease, assess the barriers to uptake and net benefits, comparing these with likely GHG mitigation potential. This has been done for other GHG mitigation strategies using marginal abatement cost curves (MACC) (Moran et al., 2008). With the most promising disease prevention and control options in the MACC it will be possible to properly assess the relative contribution that alternative means to improve animal health could make to national climate change targets and thus prioritise campaigns against barriers to their uptake.

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