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THE ROLE OF ANIMAL GENETIC IMPROVEMENT IN REDUCING GREENHOUSE GAS EMISSIONS FROM BEEF CATTLE

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SUMMARY

In Australia emissions from the livestock industries represent 10.9% of the net national greenhouse gas (GHG) emissions in 2006, and most of these were from sheep and cattle. With the government signalling its commitment to reduce emissions, industries need to develop emissions reduction strategies. This paper identifies some of the current genetic improvement practices in beef cattle that reduce GHG emissions and also identifies new areas for further research with potential for GHG reductions. Current GHG emission reduction strategies in beef cattle are reliant on improving productivity of cattle in order to reduce emissions per unit of product. Hence emissions reduction at the national level is largely reliant on there being a cap or reduction in animal numbers. In the long term it is important that strategies that directly reduce GHG emissions per unit of feed intake be developed.

INTRODUCTION

The agricultural sector is a source of greenhouse gas (GHG) emissions worldwide, with the magnitude of its contribution differing from country to country. A recent FAO report estimates that globally livestock are responsible for 18 percent of greenhouse gas emissions (Steinfeld et al. 2006). In Australia, the emission from the livestock industries is estimated at 61.0 Mt CO_2 –e, which represented 11.3% of the net national GHG emissions in 2007 (DCC 2009). Over 90% of the livestock emissions are from ruminants, predominantly sheep and cattle.

In December 2008, the Commonwealth Government of Australia released its White Paper on "Carbon Pollution Reduction Scheme: Australia's Low Pollution Future"**,** and it signalled the government's commitment to reduce greenhouse pollution in Australia in the short and long term. With this comes the need for all industries to examine and develop strategies to reduce their contribution to GHG emissions. The objective of this paper was to identify some of the current genetic improvement practices in beef cattle that reduce GHG emissions and to identify for research new areas with potential for GHG reductions.

GHG EMISSIONS FROM CATTLE

Greenhouse gases generated by cattle production include methane (CH_4) and nitrous oxide (N_2O), which have global warming potentials 21 and 310 times that of CO_2 respectively, making them very potent GHG. Methane primarily arises from enteric fermentation but also small amounts derive from manure stores (Fig 1). Manure emissions are least from extensive grazing enterprises and greatest from manure stockpiles and slurries reflecting the need for a moist anaerobic environment for methanogenesis.

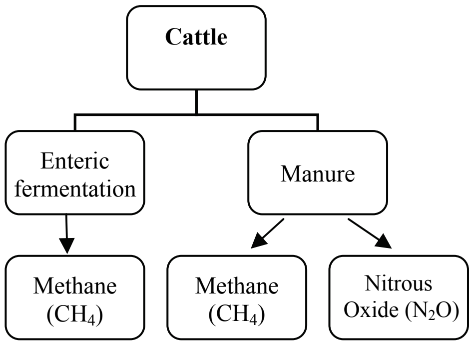

Figure 1. Greenhouse gas emissions from cattle.

BEEF BREEDING PRACTICES THAT REDUCE GREENHOUSE GAS EMISSIONS

A strong positive relationship between feed intake and methane production in ruminants is recognized in most algorithms predicting methane production rate (Blaxter and Clapperton 1965, Pelchen and Peters 1998). On grazing or forage diets, the higher the feed intake the higher the daily methane output by the ruminant, on the same feedstuff. However a strategy of reducing daily feed intake to achieve lower levels of methane production has received little attention because of concerns over reduction in productivity of the ruminant. In beef production such a strategy would mean that slaughter cattle will take longer to reach market weight, young replacement heifers will take longer to reach puberty and weaning rates in cows will reduce. Therefore to achieve the same level of productivity, this will mean that all classes of cattle (steers, heifers, cows etc) have to be kept longer resulting in potentially higher total feed intake. A life cycle analysis approach to consider the broader impacts of such mitigation strategies is important, rather than look only at mitigation effects on individual animals.. Any strategy that reduces feed intake per unit of product would also result in reduction of GHG emission per unit of product, which can be used as an indicator of improved emissions intensity of the production system. Some of the GHG reduction strategies for which genetic improvement can play a major role are discussed below.

Reducing age at slaughter. The endpoint for slaughter cattle is determined by the specification of the target market, usually for weight and fatness. Achieving these slaughter specifications at a younger age will result in a lower total GHG emission per unit of product relative to a higher age at slaughter. Impacts can be substantial, with feedlot finishing of cattle in northern Australia for 2-5 months calculated to reduce lifetime methane production of slaughter cattle by 34–54%, largely through reduced time to slaughter (McCrabb *et al.* 1998).. Similarly, Howden and Reyenga (1999) showed that methane emission per unit liveweight gain reduces as average daily gain (ADG) increases. This is primarily due to the fact that in beef cattle over 50% of feed intake is used for maintenance, hence the faster an animal grows the lower the total feed requirements for maintenance over the growing period, leading to lower methane emission per liveweight gain. In recognition of this, GHG quantification protocols (Beef feeding – reducing days on feed, and, Beef lifecycle) have been developed and approved for the carbon offset trading in Alberta, Canada (Alberta Environment 2009).

Improved ADG can be achieved through improvement in nutrition and the environment, but can also be achieved through genetic improvement either by crossbreeding or selection for growth traits.

Efficiency of feed utilisation. By definition beef cattle that are efficient in feed utilisation will eat less per unit of product. In Australia, residual feed intake is the feed efficiency trait used for genetic improvement of feed efficiency. It has the unique characteristic that low RFI cattle consume less feed than high RFI cattle for the same level of productivity (Arthur *et al.* 2001). Theoretical calculations based on the reduction in feed intake showed that low RFI cattle have 15% - 21% reduction in methane emissions, 15% reduction in methane from manure and 17% reduction in nitrous oxide from manure, relative to high RFI cattle (Okine *et al.* 2001; Herd *et al.* 2002). These results were confirmed by empirical evidence from two studies where actual methane emissions were measured. The results of the two studies indicate that there is a 15% - 30% reduction in methane emissions and 15% - 20% reduction in manure production from low RFI relative high RFI cattle (Nkrumah *et al.* 2006; Hegarty *et al.* 2007). In recognition of this, selection for low RFI is being considered for potential GHG protocol development for the carbon offset trading in Alberta, Canada (Alberta Environment 2009).

Use of adapted, high producing cattle. The main purpose of the breeding herd, in beef cattle, is to produce progeny. Hence a dry cow consumes feed (hence produces GHG) but with no product to show for. A herd with a higher calving rate is therefore desirable, not only in terms of the higher number of weaned calves to be sold, but also in terms of lower feed intake per unit of product, leading to lower GHG emissions per unit of product. It has been shown that female fertility is improved by the use of crossbred females for breeding (Arthur *et al.* 1999). Selection for reduced days to calving in beef cattle also improves reproductive performance in females.

Productivity of most cattle breeds in the tropics is low due to stressors (heat, poor nutrition, disease) imposed on the animal by the harsh environment. Hence most tropical breeds have low productivity. The use of tropically-adapted composites in northern Australia is one of the practical genetic improvement strategies used successfully to improve productivity. Replacement of shorthorn cattle with composite-breed cattle by the North Australia Pastoral Company's "Alexandria" station, was associated with reduction in the methane/kg liveweight weaned from 1.25 to 0.86 t CH_4/t LW weaned. This advantage came largely from increased weaning rate (55 to 80 calves/100cows) but increased slaughter weight may also be expected (Bentley et al. 2008). When planned properly, such tropically-adapted composites offer less GHG per unit of product relative to purebreds due to higher female fertility, progeny achieving lower age at slaughter and higher feed efficiency.

Uniqueness of genetic improvement. It is apparent from the outlined GHG reduction strategies that genetic improvement programs in general will result in a reduction of GHG emissions per unit of product, but not always reduce total emissions. Genetic improvement has been widely adopted in the beef industry to improve production efficiency, with the resulting improvement in enterprise profitability a continuing driver for such change. The fact that some of these breeding decisions also help reduce GHG emissions are unexpected secondary benefits. Further, any change in an animal's characteristics achieved through genetic improvement can be passed on to the next generation, so any reduction in GHG which is associated with such genetic improvement is also permanent. This is in contrast to other strategies to reduce GHG emissions where a particular treatment, such as grain (instead of pasture) feeding, and feeding of edible oils, need to be applied on a regular basis. For some extensively managed cattle, application of such treatment on a regular basis is not practical.

CHALLENGES AND OPPORTUNITIES FOR THE FUTURE

Comprehensive assessment of the contribution of genetic improvement strategies to real or potential reductions in GHG emissions in the Australian context need to be carried out. One such assessment was reported by Alford *et al.* (2006) on potential GHG reductions from selection for low RFI in Australia. Using a modest base scenario of 0.76% rate of genetic improvement and 30% maximum adoption, Alford *et al.* (2006) reported that the cumulative reduction in national emissions was 568,100 t of methane over 25 years, with annual emissions in year 25 being 3.1% lower than in year 1. Any increase in the rate of genetic improvement and/or the maximum adoption level increases the cumulative reduction in methane emission.

The strategies outlined above are important first steps. However, most of the GHG emission reduction strategies are reliant on improving productivity of cattle in order to reduce emissions per unit of product. Achieving greater productivity frequently results in increased feed intake hence greater GHG emissions per head of cattle. Hence GHG emissions reduction for beef cattle at the national level can only be achieved only if there is a cap or reduction in animal numbers. A number of other industries are also faced with this dilemma. The automobile industry, for example, is reducing emissions per vehicle, however any reductions in the national emissions can only be achieved if the number of cars on the road is capped or reduced. Therefore, it is important that in the long term, strategies to directly reduce the GHG emissions per unit of feed intake need to be developed.

One of the long term strategies which need investigating is the genetic improvement in methane emission per unit of feed intake. A review by Herd and Hegarty (2007) gives an indication that there is genetic variation in many of the biological processes inside the animal that contribute to the level of methane production. The challenge now is to develop accurate and repeatable methods of measuring individual animal intake and methane production, which can be applied to large numbers of cattle.

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