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BREEDING OBJECTIVES TO REDUCE ENTERIC METHANE PRODUCTION FROM BEEF CATTLE: A REVIEW

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INTRODUCTION

Since 1980 scientific evidence on human interference on the climate placed the question of climatic change and its environmental consequences on the world's political agenda. After various discussions, the Kyoto Protocol, adopted in December 1997 in Japan, officially established goals for emission of greenhouse gas (GHG) for industrialized nations (UNFCCC, 2007). Up to November 2009 a total of 187 states had signed and ratified the protocol. In December 2009, the United Nations Climate Change Conference, commonly known as the Copenhagen Summit, took place where a framework for climate change mitigation beyond 2012 was to be agreed. At this conference, the Copenhagen Accord was drafted by the US, China, India, Brazil and South Africa, but was not passed unanimously.

The document recognized that climate change is one of the greatest challenges of the present day and that actions should be taken to keep temperature increases to below 2°C. The document is not legally binding and does not contain any legally binding commitments for reducing CO_2 emissions.

From all methane emissions sources, agriculture is by far the most important source in South Africa. Enteric fermentation in ruminants accounts for 90% of the agricultural sectors methane emissions in South Africa (Blignaut et al., 2005).

The overall increase in CO_2-equivalent concentration is approximately 0.6% per year in South Africa. The Department of Environmental Affairs and Tourism of South Africa (DEAT) (2007) predicted a quadruple increase in CO_2-equivalent emissions by 2050 form 440 Mt to 1600 Mt. According to the DEAT (2007), the South African government has set a reduction target of between 30 and 40% from the 2003 levels by 2050. This is in line with the requirements of the Koyto protocol of which South Africa is a signatory.

Ruminants are important to mankind since most of the world's vegetation biomass is rich in fibre (Moss et al., 2000). Only ruminants can convert this rich in fibre vegetation into high quality protein sources (i.e. meat and milk) for human consumption and this will need to be balanced against the concomitant production of methane.

In spite of this important role of livestock, it is being specifically targeted and singled out as producing large quantities of Green House Gasses that contribute to climate change. This may result in many consumers deciding to reduce their consumption of red meat. The popular press is fueling these sentiments with slogans telling consumers to eat less meat. This may result in many of the developed consumers deciding to reduce their consumption of red meat.

Thorpe (2008) reviewed current levels of CH_4 discharges by both animal type and country, and shows how the growth or decline in national herds over the last 20 years has significantly altered the global composition of enteric emissions. Developing countries are responsible for over three-quarters (76.3%) of such emissions (Brazil and India leading the total emissions, mainly due to cattle production). It is therefore clear that livestock do contribute to climate change. This has important implications in terms of mitigation strategies, as most of these countries are presently outside the remit of the Kyoto Protocol.

DISCUSSION

Methane makes up 16% of total world gas emissions and is therefore the second most important GHG (US-EPA, 2006). Despite the highest concentration being carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) have a heating potential 23 and 296 times higher than CO_2, respectively, due to the higher atmospheric warming activity of these compounds (Clark et al., 2001).

Human-related activities producing methane include fossil fuel production, animal husbandry (enteric fermentation in livestock and manure management), rice cultivation, biomass burning, and waste management. Natural sources of methane include wetlands, gas hydrates, permafrost, termites, oceans, freshwater bodies, non-wetland soils, wild ruminants (game) and other sources such as wild fires. It is estimated that more than 60 percent of global methane emissions are related to human activities (IPCC, 2007).

Enteric fermentation (animal digestive tract) is the main source of methane and is responsible for 28% of global CH_4 emissions, followed by natural gas (15%), waste management (13%) and rice cultivation (11%) (US-EPA, 2006). Factors that influence enteric methane production in livestock are level of feed intake, diet composition, digestibility and quality of roughage, forage species, C3 versus C4 grasses, cultivar and variation between animals.

Green House Gas (GHG) emission from livestock is measured either in terms of kg CO_2 equivalent per kg of meat or milk available for consumption, or per area of land used. In the case of ruminants extensive systems are usually found to have a lower *per-area* footprint than intensive grain-fed systems but a higher footprint if expressed in terms of *kg/product* (Garnett, 2010).

In ruminants, CH_4 is produced by a specific group of bacteria called methanogenics, (Moss, 1993), whereas CH_4 may also be produced by protozoa's, which may account for up to 20% of methanogenic microorganisms. Lin et al. (1997) observed that although the Archae group represent a significant portion of functional rumen microbiota, they are few in number (0.5 to 3% of total microorganisms). The most important are *Methanobrevibacterium ruminantium* and *Methanosarcina barkeri* (Mackie et al., 2002). *M. ruminantium* uses H_2 and CO_2 as substract, while *M. barkeri* also uses metanol (CH_3OH), metylamines (formed in the rumen by degradation of coline) and acetate (Moss, 1993).

As CH_4 cannot be metabolized by the animal or microorganisms, it is partly absorbed by the ruminal wall and enters in the blood stream where it is eliminated in respiration. Most however, is eliminated by eructation with CO_2 (Kozloski, 2002). From a nutritional point of view, methane represents a loss of energy by the animal of between 6 and 10% which is not converted to a product (meat, milk, wool, etc). This increases production costs and reduces profit.

Some studies have shown that the use of tanninferous legumes in exclusive or in combination with grasses in pastures for ruminant feeds may reduce enteric methane emissions per unit of dry matter consumed (g CH_4/Kg DMC) without affecting production performance (Pinares-Patino et al., 2003). However, most research has focused on manipulating animal diet in an effort to inhibit a rumen environment favorable for methane production..

Other options to combat enteric fermentation such as genetic engineering and the use of additives may be options (Beauchemin et al., 2008), but further research and development is needed before such options can be employed. The use of the antibiotic monensin was examined by McGinn et al. (2004) but its use did not significantly reduce methane emissions, and questions remain about the permanence of these reductions. Studies have also been conducted examining the potential for genetic engineering aimed at increasing the efficiency of feed conversion, which would also reduce enteric fermentation in animals. An example is the research of Ellis et al. (2009) who looked at breeding cattle that would have 25 percent less methane emissions and require less feed.

Nkrumah et al. (2006) reported that beef cattle with low residual feed intake produced up to 28% less methane than those with high residual feed intake. Residual feed intake is calculated as the difference between actual feed intake and the expected feed requirements for maintenance of body weight at a certain level of production (Hegarty et al., 2007). The lower methane production was attributed to differences in ruminal microbial population and Nkrumah et al. (2006) stated that the differences could be heritable.

Goopy and Hegarty (2004) found large variations in methane emissions between animals (Friesian Jersey crossbreds) at the same level of production and fed the same diet. “High” and “low” methane emitters were identified on identical feed and feed intakes. The reason for the reported differences is unclear, but they assumed that factors such as the rate of passage, microbial activity, fermentation conditions and grazing behaviour could play a role.

CONCLUSION

The atmospheric lifetime of CH_4 is 12 years compared to the 20 - 200 years of CO_2 and 114 years of N_2O. Furthermore, the heating potential of CH_4 is 23 and times higher than that of CO_2. Reduction in CH_4 levels livestock will thus have a significant effect on the targets set by the South African government since its impact will be faster due to the shorter lifetime and bigger due to the higher heating potential, compared to CO_2.

Breeding objectives to reduce enteric methane production from beef cattle under extensive production systems can therefore play a significant role in addressing climate change. Wall et al. (2009) reported variations between animals, between breeds, and across time, providing the potential for improvement through selection.

Genetic change is easy to achieve. It results when animals that depart from the average are selected as parents. Genetic improvement is much more difficult to achieve than is genetic change. It requires that the aggregate value of all favourable changes exceeds loss caused by unfavourable changes.

Genetic improvement in livestock results in permanent and cumulative changes in animal performance. This is a very important aspect in reducing enteric methane production from livestock. Selection for productivity and efficiency will mitigate greenhouse gases in two ways namely:

1. Higher productivity leads to higher gross efficiency as a result of diluting the maintenance cost of animals
2. A given level of production can be achieved with fewer higher yielding animals.

Since feed intake is already measured in the Phase C of the National Beef Recording and Improvement Scheme, it will be possible to calculate residual feed intake from the existing information. Genetic variance components for residual feed intake and correlations with other traits can thus be estimated with the aim to estimate breeding values for residual feed intake. This can assist in breeding cattle with lower Green House Gas emissions, since it has been reported that beef cattle with low residual feed intake produced up to 28% less methane than those with high residual feed intake.

Until now most measurements for beef improvement in South Africa is per individual (weaning weight, calving interval, growth rate, etc.). Although breeding values are estimated for a trait such as feedlot profit and the ARC-Animal Production Institute is in the process of developing the estimation of a breeding value for a trait such as cow efficiency for the Bonsmara, breeding values are only estimated once or twice a year. Farmers therefore need a measurement that can be available immediately (as is the case with weaning weight) after weaning that can be used in the first line of selection. A measurement is thus needed that expresses performance in a per constant unit bases, e. g. kilogramme calf weaned per Large Stock Unit, which can then be translated to kg calf produced per kg CO_2 equivalent.

Whereas the livestock industry should recognize the effect of livestock on climate change, it is also important that mechanisms are to be put in place to mitigate this effect, and genetic improvement may be a cost effective way since it is permanent.

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