How kangaroo burgers could save the planet

* 25 December 2008 by Bijal Trivedi
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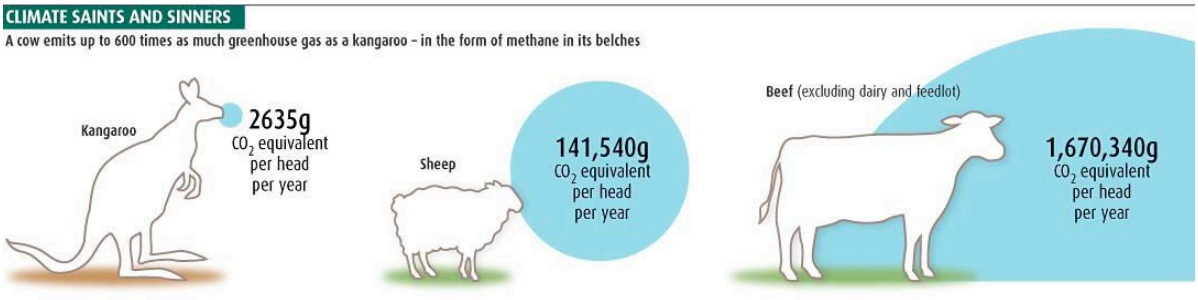
COWS, sheep and goats may seem like innocent victims of humanity's appetite for meat, but when it comes to climate change they have a dark secret. Forget cars, planes or even power stations, some of the world's worst greenhouse gas emitters wander idly across rolling pastures chewing the cud, oblivious to the fact that their continuous belching (and to a lesser degree, farting) is warming the planet.

Take New Zealand, where 34.2 million sheep, 9.7 million cattle, 1.4 million deer and 155,000 goats emit 48 per cent of the country's greenhouse gases in the form of methane and nitrous oxide. Worldwide, livestock burps are responsible for 18 per cent of greenhouse gas emissions - more than produced from all forms of transport combined. Methane accounts for the bulk of ruminant green house gas emissions, one tonne of the gas has 25 times the global warming potential of the equivalent amount of carbon dioxide.

Livestock are responsible for more greenhouse gas emissions than all forms of transport combined



Rising populations and incomes are expected to double the global demand for meat and milk from 229 to 465 million tonnes and 580 to 1043 million tonnes, respectively, by 2050. This will almost double the amount of greenhouse gases produced by livestock, dwarfing attempts to cut emissions elsewhere. Apart from all of us turning to a vegetarian diet, can anything be done to reduce greenhouse gas emissions from livestock?

Several ideas have been proposed to raise animals that are kinder to the environment. In New Zealand, researchers are testing different diets, food additives, vaccines and drug therapies, as well as breeding low-methane animals. One Australian team has even suggested we wean ourselves from cattle and sheep altogether and eat kangaroo instead - they do not emit methane.

Concern for the climate isn't the only factor driving the research. Eight per cent of the energy expended by a ruminant's metabolism goes on producing methane. If livestock stopped making this gas, the energy saved could be diverted into making more meat.

So why do ruminants give off so much methane? It's all down to their stomachs. Sheep and cattle have a pregastric stomach, or rumen, where microbes digest plant matter and produce hydrogen, carbon dioxide and fatty acids. The fatty acids are a useful source of energy to aid animal growth, but the hydrogen and carbon dioxide are not. This is where microorganisms called methanogens come in: they have co-evolved with the animal to consume the carbon dioxide and hydrogen, producing methane. In return, the methanogens gain a home and a food source.

This cosy relationship is now in the cross hairs. In June, researchers from the Pastoral Greenhouse Gas Research Consortium in New Zealand - a group dedicated to reducing methane emissions from livestock - announced they had decoded the genetic sequence of Methanobrevibacter ruminantium, one of 20 or so species of methane-producing microbes in sheep and cow stomachs. They are hoping to discover a genetic hallmark for all methanogens, says Graeme Attwood, a microbiologist at the New Zealand based AgResearch and leader of the consortium's genome-sequencing project. Such methanogen-specific genes might provide a targeted way to knock out these microbes without harming the hundreds of other beneficial species in the rumen. The researchers think the hydrogen and carbon dioxide left behind that would have been digested by methanogens would then be consumed by other microbes, such as acetogens which dominate marsupial guts and are present in smaller numbers in ruminant guts, to produce the nutrient acetate, making the animals healthier too.

Going live

While analysing the genes, Attwood and his colleagues discovered the recipe for an enzyme that they believe breaks open chemical bonds unique to the methanogen cell wall. The enzyme originally belonged to a virus that infected the methanogen long ago, becoming incorporated into the microbes' genome as it evolved. Attwood's team has manufactured the enzyme and shown that it kills methanogens in vitro. "It's very exciting," says Attwood. Within the next six months, Attwood and his colleagues plan to test the enzyme in live animals.

The genome sequence is also being used to identify proteins that sit on the outer surface of M. ruminantium - the immune system can easily identify these proteins, making them ideal candidates for vaccines. Vaccinating animals against M. ruminantium has many benefits, not least that it is cheap to produce and could be given several times a year to livestock grazing in pastures.

This is not the first time an anti-methanogen vaccine has been tried. Four years ago, scientists in Australia developed an anti-methanogen vaccine that lowered methane production in sheep by almost 8 per cent compared with those that did not receive it. But the vaccine did not work in sheep from New Zealand, says Bryce Buddle, who leads the methanogen vaccine project at AgResearch. He says that this is probably because the methanogen strains in sheep from New Zealand and Australia are different.

Still, it was proof that a vaccine could work. Buddle is now testing a more sophisticated vaccine made from a mix of surface and intracellular M. ruminantium proteins. Though the mechanism of action is unclear, early lab tests have shown that the antibodies triggered in response to the vaccine can decrease methane production. He expects to test the vaccine in live animals within three years. Ultimately, he hopes that vaccinating cattle and sheep will decrease methane emissions by 20 to 30 per cent.

For animals that are kept mainly in sheds and not allowed to graze, methane emissions could be further reduced by changing their diet. Ermias Kebreab and his colleagues at the University of Manitoba in Winnipeg, Canada, have shown that grass-fed cattle typically produce 20 per cent more methane than those fed a mixture of grass and corn. Kebreab says that the addition of unsaturated fats like coconut and sunflower oil to their food could curb methane emissions by a further 20 per cent. The unsaturated oils serve as a sink for the hydrogen in the animal's gut - absorbing it before the methanogens can consume it - and produce hydrogenated fats which the animal can then store or digest for energy. Sunflower oil, for example, can lower methane by 21 per cent in cattle fed a high corn diet. The caveat to this approach, says Kebreab, is that the oils cannot exceed more than 5 per cent of the animal's total diet or it will stop eating the enriched food.

Legumes such as clover can also help to reduce methane levels in burps. The key seems to be the high level of tannins in the clover, says Jamie Newbold, an animal scientist at Aberystwyth University in the UK. Tannins, which give red wine its colour, are thought to slow the growth of methanogens, thus curbing methane production.

Legumes such as clover can help reduce methane levels in cow burps

Earlier this year, Newbold reported that a plant extract from garlic, called allicin, could dramatically lower methane output by between 25 and 50 per cent. While this would benefit the climate, nobody has yet tested whether it would affect the flavour of the milk and meat from these animals.

Athol Klieve, a microbiologist at the Department of Primary Industries and Fisheries in Brisbane, Australia, thinks it might be possible to cut cows and sheep methane emissions completely. He has just completed a census of microbes inhabiting the gut of the eastern grey and red kangaroos and has identified three distinct species of acetogens in the forestomach of kangaroos. Acetogens are also present in cattle and sheep, so he is now exploring whether the acetogens in ruminants can out-compete the methanogens and become the dominant species in the gut, as they are in the kangaroo.

All of these approaches will take a long time to develop, though, and when it comes to climate change, time is not on our side. "If livestock populations rise as projected then high-tech solutions [such as vaccines and feed additives] are just fiddling around at the edges," says Peter Smith, who studies how climate change impacts soil and agriculture at University of Aberdeen, UK. "If people ate less meat, there would be fewer animals, and less methane would be emitted." Tom Wirth, at the US Environmental Protection Agency, thinks chemicals added to the feed could cause problems with the animal's digestion, and he wonders whether consumers would want to eat an animal that had been injected with a methanogen vaccine.

There is a simpler alternative. Two Australian biologists say there is a sure-fire way to reduce methane emissions without resorting to complex biotechnology: cut the number of cattle and sheep being reared and meet the demand for meat with marsupials. Kangaroos produce barely any methane (see diagram) as their dominant gut flora are acetogens, not methanogens. These convert the hydrogen into acetate, a fatty acid that can also be used by cattle as an energy source. George Wilson and Melanie Edwards, based at Australian Wildlife Services in Canberra, have calculated that replacing a third of Australia's sheep and cattle with kangaroos would slash cattle emissions and reduce the nation's entire greenhouse gas output by 3 per cent. "It's not a completely wacky idea," says Wilson. "All [Australian] supermarkets already carry kangaroo meat on the shelf. It is a AU$250 million industry." Kangaroo burger anyone?