Lesson objective:

- In this lesson students investigate the science behind managing methane production in ruminant livestock production.

Students will have the opportunity to:

- recognise the role of knowledge of the environment and ecosystems in a number of occupations
- describe how technologies have been applied to modern farming techniques to improve yields and sustainability
- use information and knowledge from their own investigations and secondary sources to predict the expected results from an investigation
- use digital technologies to construct a range of text types to present science ideas
- select and use appropriate language and representations to communicate science ideas within a specified text type and for a specified audience.

Lesson focus

The focus of this lesson is to encourage students to adapt their knowledge of what they have learned so far about ruminant digestion to address the issue of methane production in livestock industries.

Setting the context

The digestion of ruminant animals produces a waste by-product — methane.

As well as being the most potent greenhouse gas, it is a waste of energy. If the energy used to produce methane can be redirected, animal growth can be improved.

The Australian Government has instituted the Carbon Farming Initiative (CFI) to support farmers who reduce emissions. This initiative aims to deliver financial incentives to farmers who use CFI approved technologies that reduce emissions.

One area of current research is investigating the impacts of different diets on methane emissions from livestock. Initial research results suggest some pastures and forage shrubs result in lower methane emissions than others (e.g. legumes, such as clover and lucerne, produce less methane during ruminant digestions than grasses, such as perennial ryegrass and phalaris)

Introduction

Explain to students that in this lesson they will be investigating the science and technology Australian livestock producers are using to reduce methane emmissions in sheep and cattle systems in Australia.

To begin the lesson ask students a range of questions, reviewing the previous lesson, to establish their current understanding of the link between ruminant digestion and methane production.

Body of lesson

1. Ask students to read the ABC Science article Methane myth gives cattle a bum steer (see Appendix 1) or listen to the audio file online.

2. Ask students to share their ideas about how livestock producers might manage the level of methane emissions from their livestock. Record students' ideas on the board or in a class science journal. Explain to students that scientists are working with livestock producers to investigate ways to manage methane emissions from livestock. Allow students to read the article: *FARM300 Increasing productivity to lower emissions intensity* from page 48 Beyond the Bale magazine March 2015 (see Appendix 2).

3. Review students' ideas in light of the management options outlined in the table at the end of this article.

Explain to students they are going to investigate some case studies of Australian livestock producers who are adapting their management practices to maintain or improve productivity while reducing the overall methane emissions from their livestock enterprises. Separate students into small project groups. Visit the MLA Farm300 website and ask each group to select a farmer case study to investigate. Some of the case studies are listed below:

- SA cattle producer Sandy Nott — Investigating grape marc as a supplementary feed source
- NSW sheep producer Tom McGuiness focused on matching stocking rate with feed availability and the changing climate.
- Victorian mixed farmer Simon Ross measured the efficiency, emissions and profitability of the farm's sheep feedlot.
- SA cattle and sheep producer Janet Furler — alternative pasture species and feed to fill feed gaps, increase efficiencies and reduce methane emissions.

4. Ask students to review these case studies and using a digital format (such as PowerPoint® or Slideshare®) develop a presentation that outlines:
    - the relevant production system (e.g. location and livestock type — sheep or cattle
    - feedbase — pasture, novel feed, grain
    - the innovation or management change employed (e.g. change in grazing management, change in feedbase)
    - the results.
5. Encourage students to include information on the 'science behind the story' in their presentations.
6. Ask students to be prepared to explain why and how the "innovation" is reducing emissions or increasing productivity in each case.

Conclusion

Ask students to share their presentations with the class.

Ask the students questions such as:

- What are the challenges for livestock producers in Australia in terms of balancing production and sustainability?
- How do livestock producers use science to produce food and fibre sustainably?

Note: Additional information about current research projects investigating ways to reduce methane emissions in livestock production can be found on the MLA National Livestock Methane Program webpage.

Links to the Australian curriculum:

- People use science understanding and skills in their occupations and these have influenced the development of practices in areas of human activity (ACSHE136)
- Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge (ACSIS139)
- Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions based on evidence (ACSIS145)
- Communicate ideas, findings and evidence based solutions to problems using scientific language, and representations, using digital technologies as appropriate (ACSIS148)

Methane myth gives cattle a bum steer

The atmospheric scientists tell us that we humans have affected our planet's atmosphere in two major ways.

We have punched a hole in the ozone layer; and we have, quite separately, set off global warming by dumping so-called greenhouse gases into the atmosphere.

Most of us know that the most villainous of these gases is carbon dioxide. Many of us probably know that methane from cattle and sheep is another significant greenhouse gas.

But practically all of us wrongly believe that this methane gas comes from the back end of the animals. And very few of us know that methane is 22-or-so times nastier than carbon dioxide.

Once again, let me start by saying 'everything is made from atoms'.

Carbon dioxide is made from one atom of carbon and two atoms of oxygen. Methane is a bigger molecule. It's made from one atom of carbon and four atoms of hydrogen.

Livestock, of which cattle are a significant proportion, produce about 20 per cent of the world's methane output. The rest comes from rice paddies, coal mining, landfill sites and so on.

There are about 1.3–1.5 billion cattle on Earth today. India has about 30 per cent, Brazil about 20 per cent, the USA about 10 per cent and Australia just three per cent.

The methane that comes from cows is not made directly by the cows. No, it's made by tiny bacteria-like critters that live in the gut of the cattle.

These critters have a happy symbiotic relationship with the cattle. The cattle give the critters a safe home and the critters turn grass into food for the cattle.

More specifically, these critters eat cellulose. Cellulose is a big molecule that makes grasses stiff and tough enough to stand upright. We humans would starve to death if we tried to eat grass.

But cattle can eat grass and grow big and healthy because the critters in their gut can digest the cellulose.

Animals that can do this are called ruminants. Cattle are ruminant animals, as are sheep, goats, deer, giraffes and moose.

They're not called ruminants because there is lots of room in it. No, the word rumen comes from the Latin for gullet, or throat.

Ruminants will partially digest the food in the rumen, and then vomit it back up into the mouth to chew it some more. A more polite word for vomit is regurgitate.

(By the way, another meaning for the word ruminant is a person who ruminates: they think deeply on matters, they contemplate and they meditate. They 'chew over' ideas and concepts, in the same way that cattle 'chew over' their food. The word ruminant comes from the Latin word ruminat, meaning chewed over, and it's closely related to the word rumen.)

So cattle can eat grass because they have not one but four digestive chambers at the top end of their gut. The first of these chambers is called the rumen. The average rumen can hold around 160 litres, which is two to four times the volume of your car's petrol tank. Tiny creatures (bacteria, fungi, protists and viruses, and bacteria-like critters called archaea) live in the rumen, and help digest the cellulose.

Some of these archaea can actually eat the cellulose, as well as the by-products of the other microbes living in the rumen.

The next chamber, the reticulum, is the smallest. This is where metal objects (barbed wire fragments, etc.) usually end up.

The third compartment is the omasum, which absorbs nutrients and water.

The fourth chamber, the abomasum, is similar to our human stomach, which is why it's called the 'true stomach'.

Getting back to the first chamber, the rumen is loaded with tiny critters, including archaea. These archaea are messy eaters and 'waste' about six to 10 per cent of what they eat. The waste comes out as methane.

If this potential source of energy were not wasted, it could be used to bulk up the cow.

But on the other hand, the strange combination of cow-and-archaea does have a marvellous, very special and very rare skill, so surely we can forgive their slight inefficiency?

Their special skill is to turn non-protein into protein, or grass into cattle. I have always been amazed that a cow can get so huge and meaty, while eating such a low-energy food as grass. It is all because of the archaea in their gut.

We humans do not have critters in our gut that can do that for us, so we have to eat protein.

But there is the unfortunate side-effect of the archaea-making methane, which the cattle then release. And I'll talk more about that, next time.

Source: http://www.abc.net.au/science/articles/2010/09/28/3023670.htm Accessed 10 August 2016

FARM300

INCREASING PRODUCTIVITY TO LOWER EMISSIONS INTENSITY

Farm300 producers at a field day near Springfield in Western Australia in October last year.

More than 300 beef and sheep producers across Australia are participating in the Farm300 project which aims to reduce greenhouse gas (GHG) emissions of cattle and sheep businesses by up to 30 per cent while boosting both profitability and productivity by 10 per cent.

The project is funded by the Australian Government, managed by Meat and Livestock Australia (MLA) and delivered in partnership with the Australian Farm Institute (AFI), Australian Wool Innovation (AWI) and Dairy Australia, and concludes in May 2015.

The Farm300 project aims to boost the productivity of livestock enterprises by improving producers' ability to manage greenhouse gas emissions.

Currently the main opportunities for livestock producers to manage their GHG emissions are to reduce the intensity of livestock emissions (the GHG emissions per kg of red meat or wool produced). As a result, on-farm practice changes which improve productivity, including by reducing wastage, can significantly reduce the estimated level of emissions intensity. As an example, increasing lambing percentage by reducing mortality may reduce emissions intensity by 30 per cent.

While the carbon policy environment has changed rapidly in recent years, and the specifics for farmer engagement in the Government's Emissions Reduction Fund are still being resolved, the Farm300 project seeks to assist farmers take a proactive approach to minimising their emissions intensity, while improving productivity and profitability.

128 specialist farm advisors have been trained to build their practical knowledge and skills in managing on-farm GHG emissions as well as options on how to participate in the Government's Emissions Reductions Fund. These advisors use the knowledge to support producers to adopt new management techniques that will increase productivity and profitability, whilst reducing emissions. Of these advisors, 23 were selected to work around the country with one or more producer groups and run workshops, discussion forums and one on one coaching sessions.

The 337 producers participating in the program will become skilled in the best management practices and principles that can reduce on-farm emissions and boost farm productivity. They will also learn about relevant opportunities under the Australian Government's Emissions Reduction Fund (as they become available) to mitigate greenhouse gases and earn carbon credits.

Each coach uses a GHG calculator with their group to help benchmark the baseline emissions of their farm businesses, and then to test the impact of different on-farm strategies that look to improve those baseline emissions. These calculators are freely available online – see the links right – and while they are relatively easy to use, you may require assistance, which can be arranged through the Farm300 National Coordinator.

Using the calculators, a number of management changes have been identified which increase productivity and simultaneously reduce emissions intensity - see table below.

By evaluating the application of management practice changes, Farm300 aims to support and underpin producers' business objectives, encouraging them to make small and robust adjustments to their enterprise now, rather than wait and be forced to make large, more radical and often more costly decisions under stress.

While Farm300 is a two year program, due to finish in May 2015, it aims to leave a lasting legacy by equipping producers and advisors with the skills to manage emissions on farm, understand and respond to challenges from climate variability and potentially benefit from trading carbon credits while minimising their environmental footprint.

RESOURCES

- Tracking of producers participating in Farm300: www.mla.com.au/Farm300
- Why Sustainability Matters – a short video which outlines why industry should act now to reduce emissions: http://youtu.be/8SiR3nVlEV4
- A video tutorial which outlines three key steps to managing climate variability in livestock enterprises: www.mla.com.au/News-and-resources/Industry-news/Steps-to-managing-climate-variability
- The 'Sustainable Grazing' producer manual explains how grazing management techniques can be used to achieve productivity and emissions benefits: www.mla.com.au/Livestock-production/Environmental-management/Sustainable-grazing-a-producer-resource

GREENHOUSE GAS CALCULATORS

- FarmGAS calculator (an online calculator: users must register with AFI): www.farminstitute.org.au/calculators/farm-gas-calculator
- SheepGAF and BeefGAF (Excel files downloaded from the University of Melbourne website): www.greenhouse.unimelb.edu.au/Tools.htm

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MORE INFORMATION
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WAYS PRODUCERS ARE INCREASING PRODUCTIVITY AND REDUCING EMISSIONS

ON-FARM MANAGEMENT CHANGE	PRODUCTIVITY/PROFITABILITY INCREASE	EMISSIONS REDUCTION
Rotationally grazing to increase native grasses	May enable additional lambs to be weaned and sent to market earlier	Stock are turned off faster
Establishing higher quality pastures	May make livestock production systems more efficient	Potentially reduced methane emissions
Improving soil health	May improve pasture utilisation, and retention of moisture and nutrients	May improve soil carbon sequestration
Genetic selection for faster lamb growth rates	May enable growth targets to be achieved sooner	Stock could be turned off faster
Change of stock enterprise, from breeding to finishing or vice versa	Might result in increased income or better cash flow	Animals could be turned off earlier and have reduced maintenance requirements.
Improve weaning rates through scanning etc	Increase production per ewe joined, and reduces wastage	Potentially increased weaner turnoff per ewe joined
Revegetation of less productive land	Potentially increases grazing capacity	Possible productivity and carbon sequestration increase