The beauty of the grazing beast

Ruminants are grazing herbivores that acquire the nutrients for their sustenance from plant-based food. They do so by, among others, fermenting their feedstock in a specialised stomach prior to digestion. This fermentation process is mainly done by microbes. Because of their unique digestive track, the digestive process of ruminants differs vastly from that of humans or omnivores like dogs. Table 1 provides a brief illustration of these differences. Due to this fermentation-based digestive system, ruminants orally release large quantities of methane (CH_4), and CH_4 is a greenhouse gas associated with global warming. This release of CH_4, also called enteric fermentation, is responsible for between 80% and 90% of all greenhouse gas emissions associated with ruminants.

Table 1: Differences in the digestive tracks of humans, dogs and ruminants[1]

	Humans	Dogs	Ruminants/sheep
Empty time of stomach	3 hours	3 hours	Never empties
Inter-digestive rest	Yes	Yes	Never
Bacteria present	Not in stomach, but in gut	Not in stomach, but in gut	Yes, vital, in the rumen (the first stomach)
Digestive efficiency	100%	100%	60% or less
Size of colon	Short & small	Short & small	Long & capacious
Digestive activity of the colon	None	None	Vital function
Bacterial flora in colon	Putrefactive	Putrefactive	Fermentative
Gross food in faeces	Rare	Rare	Large amounts
Feeding habit	Intermittent	Intermittent	Continuous
Survival without stomach	Possible	Possible	Impossible
Length of digestive track to body length	1:5	1:7	1:27

It is enteric fermentation that drives the narrative that domesticated ruminants, notably sheep and cattle, are detrimental for the climate and the environment in general. It is thus suggested that an environmentally conscious person, and society, should therefore reduce the number of sheep and cattle and rely increasingly more on alternative plant-based foods, for example. In the same breath it is often ironically argued for the rewilding of the world. Such rewilding includes non-domesticated ruminants like deer and antelope. While one cannot argue against the grace and beauty of the non-domesticated ruminants, they have the same digestive system than that of cattle and sheep. Thus, are ruminants truly bad for the environment? Are they the curse of nature? A design error of some kind?

> Note: On a pure body-mass basis there are fewer mammals (including ruminants) today than ever before in recorded or imputed history, and enteric fermentation is directly linked to body mass[2]. If the global

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[1] Adapted from Keith, L. 2009. *The vegetarian myth*. Cresent City: Flashpoint Press.
https://library.uniteddiversity.coop/Food/The_Vegetarian_Myth.pdf

[2] https://www.science.org/doi/epdf/10.1126/sciadv.abb2313
https://www.science.org/doi/epdf/10.1126/science.aao5987
https://www.pnas.org/doi/epdf/10.1073/pnas.1711842115
https://www.pnas.org/doi/epdf/10.1073/pnas.0801918105
https://phys.org/news/2022-10-wildlife-populations-fallen-years-wwf.html
https://ourworldindata.org/wild-mammal-decline
https://www.worldwildlife.org/press-releases/catastrophic-73-decline-in-the-average-size-of-global-wildlife-populations-in-just-50-years-reveals-a-system-in-peril
https://www.nature.com/articles/s41612-023-00349-8

weight of ruminants is less today than, say, a hundred years ago, why are they so bad for the environment today?

Part of the answer lies with the way conventional carbon accounting is done according to what is called a Life Cycle Analysis (LCA) based on, among others, ISO 14040:2006[3] and 14044:2006[4]. According to the LCA, a farm is akin to the production line in a factory, and the interaction of ruminants with a pasture is like that between a motor car and the asphalt road it travels on. This linear approach is largely focused on emissions while placing little emphasis on mitigation and sequestration options. The more recent standard of carbon accounting (ISO 14067:2018[5]), however, outlines a biogenic approach. A biogenic approach, per definition, is a systems-based approach whereby the enteric fermentation of ruminants is weighed relative to their interaction with the pasture or veld, i.e. the local context within which they graze[6]. The basic accounting identity to capture this interaction is given by the following equation:

The net (sink) or source[7] =

- *Minus* CO_2 embedded in the dry matter of the grazed biomass, *plus*
- (The released emissions inclusive of respiration, all greenhouse gasses, and volatised manure, *less*
- The CO_2 embedded in the litter because of the grazing and fodder sales, *plus*
- The CO_2 embedded in the product, be that milk, wool or livestock sales, *plus*
- The CO_2 embedded in external inputs such as fuel, electricity, pesticides and herbicides).

This identity is derived from the biogenic cycle, which can be described as:

1. As the ruminant grazes and exhales CH_4, it provides the food and energy source for methanotrophs[8], a soil-based bacteria that uses CH_4 as energy and which converts methane into soil-based sugars, thus reducing the CH_4 load that is emitted into the atmosphere.
2. The remaining CH_4 travels to the top of the troposphere (the atmospheric strata in which we live). This journey takes about 90 days and there they encounter the hydroxyl (HO) radicals.
3. The HO radicals are a group of very short-lived molecules that act as nature's scrubbers. They convert CH_4 and carbon monoxide (CO), among others, into carbon dioxide (CO_2) and H_2O (rain/water).
4. HO reacts faster with CO than with CH_4. The more CO is emitted due to industrial processes and fire, the more it outcompetes the CH_4 – that leaves more CH_4 to be released from the troposphere into the stratosphere, the next atmospheric strata. It is in the stratosphere where CH_4 acts as a greenhouse gas. The CH_4 molecule, however, has a very short lifespan, namely between 7 and 12 years[9], before being broken down and returned to the troposphere as CO_2 and H_2O.
5. The returning CO_2 and H_2O, in combinations with sunlight, stimulate plant growth through photosynthesis.
6. It is the plant that is grazed, and notably the carbon within that plant, that is used for herd development, milk production, meat and protein formation, and deposited into the soil in the form of manure and urine. Only a fraction, between 3% and 5%, of the carbon is released back into the troposphere through enteric fermentation, and the cycle starts at #1 again.

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[3] https://www.iso.org/standard/37456.html

[4] https://www.iso.org/standard/38498.html

[5] https://www.iso.org/standard/71206.html

[6] https://www.envirotech-online.com/news/air-monitoring/6/breaking-news/where-do-biogenic-carbons-come-from/56517
https://clear.ucdavis.edu/explainers/biogenic-carbon-cycle-and-cattle

[7] Please note, sinks are reported as negative values and sources as positive values, hence that the equation starts with a minus and then it counts the releases, fluxes and possible offsetting options back. The carbon embedded in the product (e.g. wool, milk and meat) is indicated separately and not considered part of the sink as they tend not to be permanent, and to avoid double counting.

[8] https://en.wikipedia.org/wiki/Methanotroph
https://link.springer.com/referenceworkentry/10.1007/978-3-319-60053-6_10-1
https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2021.678057/full

[9] https://climate.nasa.gov/vital-signs/methane/?intent=121

Not only is it just a portion of the CH_4 released that end in the stratosphere, but its stay is short-lived; that while the returned CO_2 and water are instrumental in plant and animal growth. These insights, among others, led to the development of an alternative global warming potential measure (GWP*) to that of the conventional GWP. According to the convention GWP measure, CH_4 has a radioactive forcing 27 times that of CO_2, but according to GWP* it is much lower and fluctuates at about 8[10]. The Inter-governmental Panel on Climate Change (IPCC), in their 6th Assessment Report (2023), furthermore distinguishes between GWP, which is an energy-based metric, and global temperature change potential (GTP), a temperature-based metric. GTP is much lower as GWP, namely 4.7 for non-fossil fuel CH_4[11].

When considering the carbon sequestration capability of plants and the contribution that responsible herd management can make to accelerate such sequestration, a farm housing ruminants can function as a potential net sink of carbon, cooling the atmosphere. This can be done by applying regenerative practices such as multiple rotations on a single hectare, as is already being practised by forward-looking farmers. For example, a farm of 1000ha with two rotations effectively stimulates plant growth and carbon drawdown on 2000ha. In the case of irrigated systems, up to ten or more rotations are possible. This expands the annual carbon drawdown area significantly. In addition, such management systems can promote improved water infiltration, biodiversity and enhanced nutrient cycling, among others. It should be noted that the use of rumen supplements as well as careful genetic selection can also help to reduce enteric fermentation.

Grass's life cycle follows one of three possible pathways if not grazed by ruminants. First, it can be burned releasing particulate matter and greenhouse gasses into the atmosphere. It also mostly releases CO which reduce the HO's ability to remove the CH_4, while depleting the soil bacteria. Second, it can be mowed using fossil fuels. This, however, is akin to mining the resource since it removes the nutrients contained therein without replacing it. Third, grass can also become moribund and dry – inert – becoming a sterile system. Often the only way to regenerate such as system is by means of burning or mowing. In all cases, grazing avoids the release of emissions and greenhouse gasses, while promoting soil health and biodiversity and not destroying it.

In summary, photosynthesis stimulates the growth of grass and an increase in carbon drawdown and the deposit thereof in either biomass or the soil – and this entire process is stimulated and accelerated through grazing while avoiding the detrimental consequences of fire and mowing. This systemic and mutually beneficial co-existence of ruminants and grass maintains the functioning of grass-dominant ecosystems. It has done so from the beginning of time. The enteric fermentation further stimulates the methanotrophs while the enzymes in the saliva kick-start the re-growth of plants. In addition, the hoof movement loosens the soil and the nitrogen in the urine and manure stimulates plant growth and soil carbon development. This activates sugars that leads to further root and plant development, resulting in a process whereby ruminants not only can, but do, offset their released emissions. They do so while upcycling low-value and inaccessible starch into high-value, nutritious and accessible protein.

Long live the grazing beast, its beauty and its symbiotic relationship with grass.

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[10] https://www.nature.com/articles/s41612-021-00169-8
https://www.frontiersin.org/journals/sustainable-food-systems/articles/10.3389/fsufs.2020.518039/full

[11] https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter07.pdf Table 7.15, page 1017.