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Editorial: Mitigating the impact of animal production on the environment: the ecosystem integration

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Editorial on the Research Topic
Mitigating the impact of animal production on the environment: the ecosystem integration

Climate change, mainly caused by human activities, is one of the biggest challenges modern civilization is facing (Malhi et al., 2021). Worldwide, there is a multiplication of extreme weather events causing economic and societal pressure. This greatly affects agriculture by impacting crop yields and animal productivity (Rosenzweig et al., 2001). Moreover, the global food demand is continuously increasing as the world population and the urban lifestyle grow. World population is expected to increase 1.3 fold by 2050 (United Nations, 2017), hence increasing the global food demand by 1.5-2 fold (Valin et al., 2014). Transformative and innovative solutions are needed to ensure a resilient and sustainable agriculture for future generations. In the last few years, novel initiatives have been brought forward by different funding agencies, such as promoting living laboratories or the One Health approach. These strategies are intended to respond to emerging problems in an integrated manner with transdisciplinary teams. As such, it is important to consider that a type of management could benefit one part of the ecosystem and be detrimental to the other. This Research Topic aimed to offer a broad overview of research conducted to mitigate the impact of livestock production on the ecosystem. A total of 7 papers have been published from authors all around the globe to address different issues related to ruminant rearing with a same common objective to achieve agriculture sustainability.

Thanks to their ruminal indwelling bacteria, ruminants are able to transform human inedible foods such as forage and high-fiber feeds to high-quality human-edible foods, strengthening the crucial role of ruminants in ecosystem sustainability (Oltjen and Beckett, 1996). Indeed, ruminant products such as milk and meat possess high nutritional value for humans considering their excellent amino acid profile and rich content of vitamin B_{12}, amongst others (Pereira and Vicente, 2013; Pereira, 2014). In return, enteric methane, a gas with powerful global warming potential, is produced as a by-product of ruminal fiber and carbohydrate digestion. On dairy farms, enteric fermentation contributes an average of 46% of greenhouse gas emissions (Jayasundara and Wagner-Riddle, 2014). Over the last few decade, research has been conducted to reduce enteric methane production and increase ruminant feed efficiency. For instance, different feed additives and strategies have shown promising results (Hristov et al., 2022). The effect of palm kernel cake, an agro-industry co-product of palm oil extraction, on enteric methane of buffaloes has been assessed by Amaral Júnior et al. The high content of residual fat of this feed additive modifies ruminal methanogenic bacteria populations. With a dietary inclusion rate of 1% of palm kernel cake, methane emission per kg of meat produced was reduced but further studies should be conducted to evaluate the impact of this co-product on animal performance and feed efficiency. The use of this feed additive also promotes a circular economy, although the oil palm industry has been shown to contribute to negative environmental impacts (Meijaard et al., 2020). Another contribution in the Research Topic by Parra et al. evaluated the addition of 9 feed additives on methane emission under *in vitro* conditions. In some countries, such as Australia, the beef cattle industry targets to be carbon neutral by 2030, although other countries such as Canada set the target by 2050. It is therefore important to evaluate promising feed additives which can reduce enteric methane emission without altering ruminal fermentation and digestion. The 9 feed additives studied were: garlic powder, biochar + nitrates, biochar + *Asparagopsis*, commercial essential oil blend, citral extract, pure Sandalwood essential oil extract, *Bacillus* probiotic additive, and sugar cane extract as powder or liquid compared to a Rhodes grass to replicate Australian beef grazing systems. Of the studied additives, only biochar + nitrates and biochar + *Asparagopsis* successfully decreased methane production without impacting ruminal fermentation characteristics and digestion. Although *in vitro* data should be verified by *in vivo* studies, they are essential to stimulate discussions and new *in vivo* project ideas. Different species of algae has also been reported to decrease enteric methane when given as a dietary supplement (Abbott et al., 2020). Although feed additives or by-products have been shown to reduce enteric methane by ruminants, the work from Lind et al. highlighted that several considerations should be observed before offering them to the ruminants. Indeed, brown macroalgae such as *Laminaria hyperborea* or its by-product after alginate production contain high amount of iodine which can be harmful for animal and human health and increase manure iodine concentration.

Even if the major contributor of methane on a dairy farm is enteric fermentation by cows, manure management accounts for 18% of the total greenhouse gas emissions (Jayasundara and Wagner-Riddle, 2014). Strategies to mitigate methane emission from manure storage is then worth investigating as reported by Feng et al. They evaluated the impact of anaerobic digestion, solid-liquid separation and nutrient recovery of manure on methane emission and other greenhouse gases such as nitrous oxide. The combination of the 3 processing systems decreased methane emissions of liquid manure storage by 87% compared with anaerobic digestion alone. Manure also contains valuable nutrients for crops such as phosphorus and nitrogen coming from a normal inefficiency of their absorption by ruminants. Moreover, excessive dietary phosphorus and crude protein contents increase phosphorus and nitrogen excretion in manure, respectively. This in turn increases phosphorus runoff and ammoniac emissions that could respectively impact water and air quality. Then, the concept of precision feeding has emerged to decrease phosphorus and nitrogen excretion in the environment by insuring an adequacy between dietary supply and animal requirements. In the case of nitrogen, evaluating nitrogen partitioning requires an evaluation of nitrogen balance with total feces and urine collection which is labour intensive and only measurable in research setting. Khanaki et al. proposed plasma and urine biomarkers to easily estimate nitrogen balance and excretion in small ruminants. Other nutrients such as trace minerals are found in varying concentrations in manure as outlined by Duplessis and Royer. In intensive dairy production, it is common to feed trace minerals above the requirements as an insurance to fulfil cow requirements to offset low absorption and ruminal interactions. Nevertheless, this can have long-term negative impacts on ecosystem as excess trace minerals are excreted in the manure and can accumulate in the environment.

In conclusion, Wattiaux offered a broad perspective of dairy sustainability and stressed on the importance of transdisciplinary research with natural scientists, social scientists, and non-academic partners to tackle issues for a systemic assessment of sustainability. Hence, an integrated approach studying dairy farm sustainability based on economic, environmental, and social impacts is needed and relevant.

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MD: Conceptualization, Writing – original draft, Writing – review & editing. ST: Writing – review & editing. LP: Writing – review & editing. AL: Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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