Narrative 6: Methane emission in herbivores

Whereas pilot investigations in methane emissions by herbivores were initially part of the studies on the effect of body size on digestive processes in the framework of work on dinosaur gigantism (see narrative 2 'Digestive adaptations and ecological niches'), during which time I already collaborated with Michael Kreuzer, we subsequently investigated methane emissions in a large number of vertebrate species,

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developing new hypotheses on associated mechanisms in the process, e.g.

Dittmann, ..., **Clauss** (**2014**) Methane emission by camelids. ***PLoS One*** 9: e94363

Vendl, **Clauss**, ..., Munn (**2015**) Decreasing methane yield with increasing food intake keeps daily methane emissions constant in two foregut fermenting marsupials, the western grey kangaroo and red kangaroo. ***J Exp Biol*** 218:3425-3434,

Frei, ..., **Clauss** (**2015**) Comparative methane emission by ratites: differences in food intake and digesta retention level out methane production. ***Comp Biochem Physiol A*** 188:70-75.

For her publications on metabolism and methane in camelids (the J. Arid Environm. and the PLoS One paper), Marie Dittmann was awarded the Young Scientist Award of Vetsuisse Faculty of the University of Zurich, 2014.

These studies also expanded to domestic animals, linking methane emission and digesta retention

Grandl, ..., **Clauss** (**2018**) Kinetics of solutes and particles of different size in the digestive tract of cattle of 0.5 to 10 years of age, and relationships with methane production. ***J Anim Physiol Anim Nutr*** 102:639-651,

and testing the effect of methane (manipulated via insufflation or suppression) on digestive physiology

Dittmann, ..., **Clauss** (**2016**) Influence of ruminal methane on digesta retention and digestive physiology in non-lactating dairy cattle. ***Br J Nutr*** 116:763-773

with results suggesting for the first time a feedback mechanism that increases motility in the presence of methane, possibly to prevent further increases in methane losses.

This work led to the invitation as plenary speaker at the 8th International Symposium on Ruminant Physiology, Leipzig, Germany, 2019

and the review publication associated with that invitation that represents the largest synthesis on comparative methane emissions so far,

Clauss et al. (**2020**) Comparative methane production in mammalian herbivores. ***Animal*** 14:s113-s123,

demonstrating that simple dichotomic rules (such as 'ruminants vs. nonruminants', or 'foregut vs. hindgut fermenters') or simple physiological rules (such as 'it depends on the digesta retention time of the species') do not have empirical support, but that species-specific reasons probably linked to the microbiome have to be investigated to explain interspecific variation in methane emissions.

More recent developments also include the new hypothesis that methane production in poultry differs systematically from that in mammals due to a different substrate for fermentation (uric acid)

Clauss et al. (**2020**) Methane emissions of geese (*Anser anser*) and turkeys (*Meleagris gallopavo*) fed pelleted lucerne. ***Comp Biochem Physiol A*** 242:110651,

and the observation that in domestic ruminants, phenotypes that achieve a higher fibre digestibility apparantly do this at lower methane production per unit digested fibre

Terranova M, Kreuzer M, Li Y, Schwarm A, **Clauss M** (**2023**) Indications for a lower methane yield from digested fibre in ruminants digesting fibre more efficiently. ***Animal Feed Science and Technology*** 307: 115834

The link we postulated between 'digesta washing' and methane production

Clauss, Hummel (**2017**) Physiological adaptations of ruminants and their potential relevance for production systems. ***Rev Bras Zootec*** 46: 606-613

and that we demonstrated *in vitro*

Pfau, ..., **Clauss**, Hummel (**2021**) Effects of dilution rate on fermentation characteristics of feeds with different carbohydrate composition incubated in the rumen simulation technique. ***Front Anim Sci (Anim Nutr)*** 2: 715142

did not show as clear a relationship when trying to trigger salivation pharmacologically *in vivo*

Zhang, ..., **Clauss** (**2023**) Effect of induced saliva flow on fluid retention time, ruminal microbial yield and methane emission in cattle. ***J Anim Physiol Anim Nutr*** 107:769-782

Further in vitro work on the interplay of microbial growth and methane production is in progress with collaborators. After demonstrating, in a pilot study, that chicken on typical diets emit measurable amounts of enteric methane, we hope to expand methane work more to poultry in exploring the function of avian caeca.