

## Approaching a crossroads in selecting for methane production: Trait definition and its consequences for breeding programs

Rutten Marc<sup>[1]</sup>, Gredler-Grandl Birgit<sup>[1]</sup>, van der Werf Julius<sup>[2]</sup>, Aldridge Michael<sup>[3]</sup>, van Breukelen Anouk<sup>[1]</sup>, Veerkamp Roel<sup>[1]</sup>

[1] Wageningen University and Research, Animal Breeding and Genomics, 6700AH Wageningen, the Netherlands, [2] School of Environmental and Rural Science, University of New England, Armidale, NSW 2351, Australia, [3] Animal Genetics Breeding Unit, a joint venture of NSW Department of Primary Industries and Regional Development and University of New England, Armidale, NSW, 2351, Australia

Genetic selection for lower methane emissions in ruminants is among the most promising climate change mitigation strategies in livestock, due to its permanent and cumulative impact. With implementation of large-scale methane recording in cattle and sheep under commercial conditions, robust phenotypic datasets are becoming available, enabling the estimation of breeding values for reduced methane emissions.

Methane production per animal may increase with higher milk or meat yield, because greater production requires higher feed intake. At the same time, methane intensity (e.g. g methane/kg milk or kg meat) typically declines as production increases, indicating improved “methane efficiency” at higher performance levels. These biological relationships create a crossroads for breeding programs: should selection target gross methane production, methane intensity or yield (g methane/kg dry matter intake) (ratio traits), or residual methane (the deviation from expected emissions given production and intake)? Ratio traits such as methane intensity or methane yield are attractive as indicators of environmental efficiency. They are positively perceived by farmers, as emissions are framed relative to productivity or feed use. However, selection on ratio traits is generally less efficient economically than direct selection on their component traits and may lead to unintended responses. Alternatively, selection indices can include linear functions of component traits (e.g. methane production, milk or meat yield, or feed intake) to achieve clearly defined and transparent breeding objectives. Theoretical frameworks exist to predict genetic progress and make adequate choices between these objectives. In this study, conducted within the Global Methane Genetics initiative, we compare alternative methane trait definitions and evaluate their consequences for selection response. Next to the methane trait, milk or meat production and a generalized health trait were included in the breeding goal to reflect producer-oriented efficiency and robustness. We further provide a SWOT analysis of different methane trait definitions, specifically considering their statistical properties, integration into selection indices, MRV readiness, and adoption potential within the sector.