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## **Towards guidelines to validate genetic evaluations for enteric methane emissions**

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Enteric methane is a major contributor to agricultural greenhouse gas emissions and has become a major trait of interest for animal breeding in ruminants. Genetic selection offers a permanent, cumulative, and cost-effective mitigation pathway for reducing enteric methane emissions in ruminants. Therefore, genetic evaluations for enteric methane emissions are implemented, or will be soon, by organizations worldwide in dairy cattle, beef cattle and small ruminants. However, it is at an early stage, and approaches vary across breeds, species, regions, and production systems. Genetic progress depends on understanding associations between the phenotypic measurements, the genome and environmental factors. Therefore, harmonized protocols are needed to implement and validate genetic evaluations for methane emissions, maximizing the global impact of genetic selection for reducing enteric methane emissions.

Under the umbrella of the Global Methane Genetics (GMG) Initiative, this study aimed to map the current international status of genetic evaluations for enteric methane emissions across the three species. We surveyed five pillars: methane recording methodologies, SNP genotype data, genetic evaluation frameworks, publication rules of estimated breeding values, and statistical validation methods. Additionally, we reviewed state-of-the-art validation techniques applied to methane-related genetic evaluations, highlighting their limitations and proposing tailored adaptations for methane-specific contexts. Finally, we proposed a quantile-based validation approach to demonstrate the impact of genomic selection for reduced methane emissions, offering a clear statistical pathway to prove that the selection of animals with favorable breeding values results in measurably lower enteric methane emissions.

The findings from this GMG Initiative survey and the validation approaches will provide practical guidelines and validation protocols to support organizations in developing and validating genetic evaluations, ensuring genetic gain for reduced enteric methane emissions.