**Genetic parameters for methane emissions in UK maternal sheep**

**Application**

Reduction of the amount of greenhouse gas emissions from farm animals can be obtained by the appropriate breeding goals. Breeding for “low-emission” sheep can be the solution to mitigate the amount of methane produced on farms. Having a well phenotyped cohort of animals within a structured breeding program can allow for appropriate selection.

**Introduction**

Greenhouse gases (GHG) have become a major concern for society. Mitigation of GHG is the goal for many countries to combat climate change. The livestock sector contributes significantly to GHG emissions, particularly through methane production from enteric fermentation and nitrous oxide emissions from manure management. Mitigating these emissions is crucial for achieving climate change goals and ensuring the sustainability of livestock production systems. Thus, reducing methane production in farm animals (especially ruminants) has become one of the most important goals in animal production. If methane (CH4) and carbon dioxide (CO2) emissions are heritable, this could enable the development of breeding programs to reduce these emissions.

**Materials and Methods**

Portable Accumulation Chambers (PACs) provide a valuable tool for phenotyping individual animals (sheep) for methane and carbon dioxide emissions, as described by Jonker et al. (2018) and Jonker et al. (2020). A mobile trailer can travel from farm to farm, allowing for relatively easy measurement from grazing sheep. A dataset collected in PACs contained 3,150 records measured on 27 farms on 1,584 male and female lambs of maternal breeds, including Exlana, Lleyn, Dorset, Cheviot and composite lines, during two repeated rounds of measurements, approximately two weeks apart. All sheep were grazed on grass or forage with a minimum availability of 1500 kg DM for at least three weeks prior to measurement and for the two weeks between measurements. Lamb age ranged from 110 to 507 days (mean 2019) and live weight from 18 to 69.5 kg (mean 40.4 kg) at time of measurement. Age of dam (range 1 to 7), birth type (born in litter size of 1 to 4), rearing type (ranging from 1 to 4) and management group on the farm were also recorded. Animals were allocated the chambers randomly in a “lot” of 12 animals (one in each chamber). Sheep were weighed and kept off the pasture for at least one hour (maximum 4 hours) before the measurements were taken. Sheep stayed in the PAC for a period of 50 minutes, with the concentrations of methane, carbon dioxide and oxygen (O2) taken at time 0, 25 and 50 minutes by the ENVCO Eagle 2 hand-held gas meter. All the data went through quality control, ensuring collected emissions of CH4 and CO2 increased with time, while the measure of O2 decreased. Recorded (raw) CH4 and CO2 emissions were transformed to standardized units: grams per day (g/day). Transformation considered the pressure, temperature and average of gases produced by the “lot” of animals that were measured in PACs at the same time. Linear regression was used for repeatability estimation of the CH4 phenotypes collected during round one and round two. Several models with different fixed effects were tested for significance in order to find the best model to estimate variance components for CH4, CO2 and gas ratio (molar proportion of methane to the sum of CH4 and CO2 emissions) – suggested proxy for methane emission relative to feed intake (Johanson et al., 2022). Genetic correlation between CH4 and CO2 emissions was also investigated.

**Results**

Quality control performed on transformed methane and carbon dioxide measurements indicated normality of data distribution (p-value <2.2e-16). Repeatability of CH4 between measurement rounds was estimated at 0.41 (SE 0.02). A model incorporating fixed effects of animal sex, age of dam, time off feed, live weight, birth type, breed and management group was identified as optimal for both CH4 and CO2, with the majority effects being highly significant (p-value <0.001). Heritability estimates were 0.08 (0.02) for CH4, 0.22 (0.04) for CO2, and 0.23 (0.04) for the gas ratio. Fitting live weight was found to negatively impact (reduce) heritability of methane emission. No significant differences in heritability were observed between the two measurement rounds across all three traits. No significant difference from zero was found for the genetic correlation between CH4 and CO2 (0.01, SE 0.06), however a moderate phenotypic correlation of 0.27 (SE 0.01) was found.

**Conclusions**

This study conducts a comprehensive analysis into variance components of methane and carbon dioxide emissions for UK maternal sheep breeds. Moderate repeatability obtained between round one and round two measurements indicates that an altered phenotyping strategy, collecting one measurement only on more animals per sire, should provide sufficiently accurate data. Results obtained in this study were in line with the results from other research undertaken in New Zealand (Johnson et al., 2022) and Ireland (McHugh et al. 2022), proving that there is genetic variation for the examined traits and that levels of GHG produced could be successfully reduced in a breeding program with a goal to mitigate emissions from sheep. All the animals for which PAC phenotypes are collected are being genotyped and further research will focus on genomic selection for these traits. Furthermore, the next stage of this research will examine the correlations of PAC measurements with other important traits for which phenotypes are collected routinely (such as lamb and ewe production traits, health traits etc.).

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**Acknowledgements**

The authors wish to thank the technicians who measured animals and breeders who supplied animals. This work was supported by the DEFRA’s farming Innovation Programme (10055702: Breeding Low Methane Sheep).