Assessing meteorological conditions effects on MIR predicted methane emissions of Holstein cows under a temperate environment

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Introduction Methane (CH_4) emissions produced from enteric fermentation by ruminants represent major losses of energy for dairy cows. These emissions contribute to global warming. Therefore, it appears necessary to develop different approaches to mitigate CH_4 emissions in order to improve the sustainability of dairy farming. CH_4 emissions could be partly influenced by the meteorological conditions as they vary according to the season (Lassey, 2007). Moreover, individual cows under high temperature could be partly responsible for these variations. The aim of this study was to assess the impact of meteorological conditions on CH_4 emissions of Holstein cows under a temperate environment.

Material and methods 257,635 milk mid-infrared (MIR) spectra collected between January 2007 and December 2010 in 983 herds by the Walloon Breeding Association (Ciney, Belgium) from 51,782 primiparous Holstein cows were used. CH_4 emissions values (g/day) were predicted based on the calibration equation developed by Vanlierde *et al.* (2013; R^2 of cross-validation=0.70) and applied to the recorded spectral data. Two traits were derived from these predictions: g CH_4 per day and g CH_4 per kg of fat and protein corrected milk yield (FPCM). Daily meteorological data from 4 public weather stations were available. Daily temperature humidity indices (THI) were computed as followed (NRC, 1971):

$$\mathbf{THI = (1.8 \times T_{db} + 32) - [(0.55 - 0.0055 \times RH) \times (1.8 \times T_{db} - 26)]}$$

where T_{db} was the dry bulb temperature and RH was the relative humidity. The mean daily THI of the previous 3 days before each test-day (TD) MIR CH_4 record was designed as the THI of reference for that TD. The mean distance between the weather reference station and the herd was of 25 km.

The following random regression TD model was developed in order to study the effect of THI on MIR CH_4 emission of cows:

$$\mathbf{y = Xb + Q_1(Wh + Zp + Za) + e}$$

where **y** was the vector of MIR CH_4 emissions (g of CH_4/day or g of CH_4/kg of FPCM), **b** was the vector of fixed effects (*i.e.*, herd x TD, minor lactation stage, gestation stage x major lactation stage, and lactation stage x age at calving x season of calving), **h** was the vector of year of calving x herd (YxH) random regression coefficients, **p** was the vector of permanent environmental (PE) random regression coefficients, **a** was the vector of additive genetic random regression coefficients, and **e** was the vector of residuals, **X**, **W**, and **Z** were the incidence matrix, and $\mathbf{Q_1}$ was the covariate matrix for first-order Legendre polynomials related to THI. The model estimated the variance components using REML. The phenotypic expression of the different MIR CH_4 predictors was the consequence of general (intercept) and specific reaction to THI (slope) correlated values of YxH, PE, and genetic effects.

Results The mean THI was 50.83 (±10.31), mean MIR CH_4 (g/day) was 558.05 (±89.89) and mean MIR CH_4 (g/kg of FPCM) was 25.64 (±7.76). Table 1 shows the part of the variances associated to THI compared to variances not associated with (intercept effects).

Table 1 Variances associated to THI relative to the variances associated to the intercept effects.

Traits (N=257,635)	YxH	PE	Genetic
MIR CH_4 (g/day)	3.71	1.23	0.21
MIR CH_4 (g/kg of FPCM)	0.65	0.50	0.37

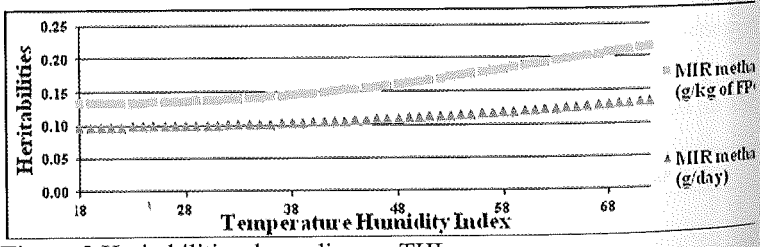

Figure 2 Heritabilities depending on THI.

The association between daily CH_4 emissions and THI scale was marked by changes of variances for the two traits with higher values of THI. As shown in Table 1, more important variations of PE and YxH variances were explained by a larger proportion of variances that was associated with THI. Moreover, heritabilities of the two CH_4 emissions predictors increased with THI, higher heritabilities being observed for MIR CH_4 (g/kg of FPCM; Figure 1).

Conclusions Results from this study showed that THI affects CH_4 emissions of dairy cows under a temperate environment. Large parts of environmental (PE and YxH) and, to a lesser extent, genetic variations were associated with THI.

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