



Poznań University of Life Sciences

FACULTY OF VETERINARY MEDICINE
AND ANIMAL SCIENCES
Department of Genetics
and Animal Breeding

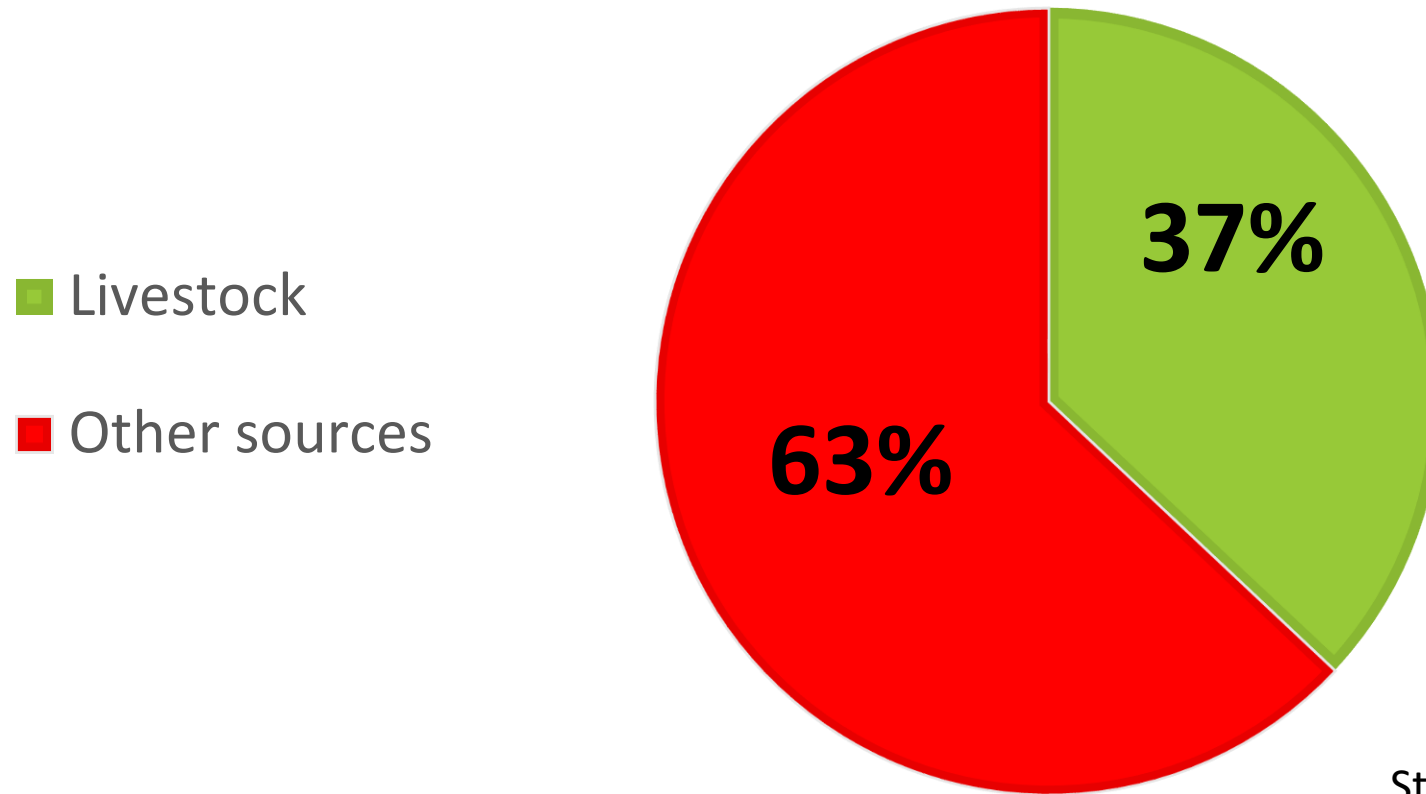
Genome-wide association study for methane concentration emitted by dairy cows

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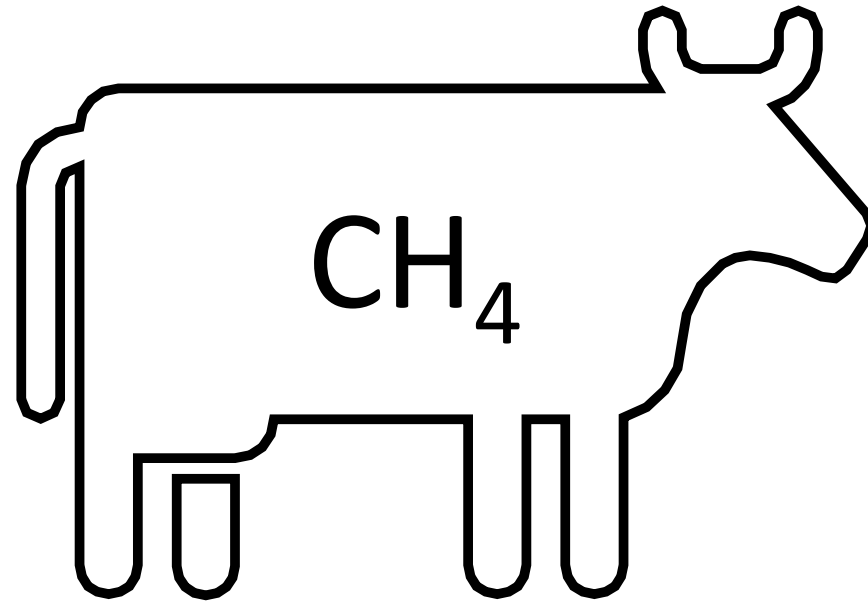
Marcin Pszczoła

Sources of anthropogenic CH₄ emission



Steinfeld et al. (2006)

Economy



Methanogenesis accounts for 2 – 12% feed energy loss
(Johnson and Johnson, 1995)

Options



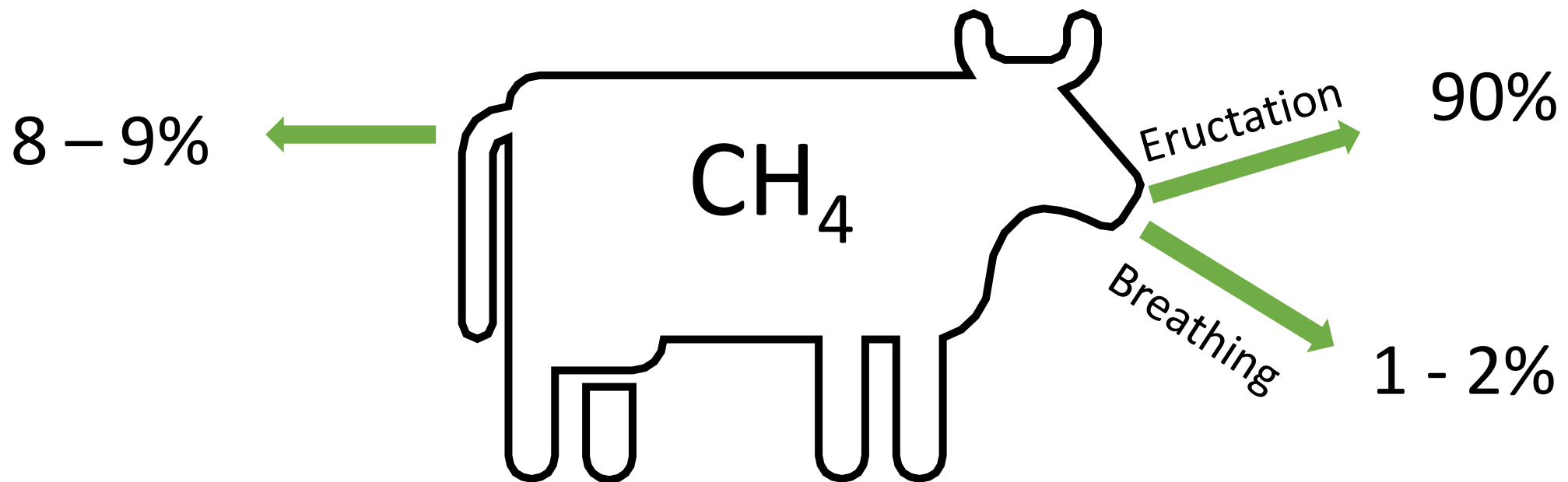
Animal management



Selection for low emitters

Heritability at 0.20 – 0.30

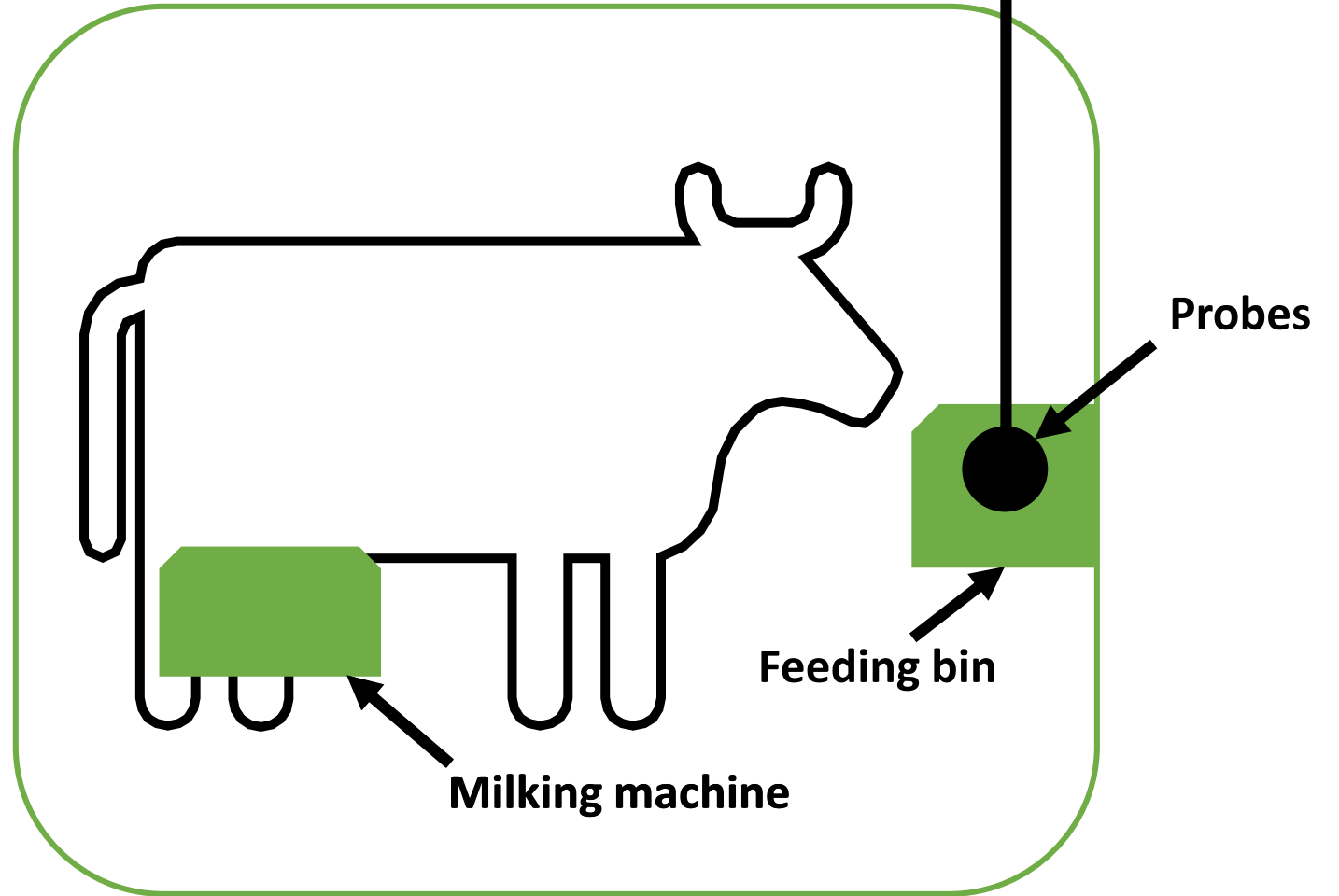
Manzanilla-Pech et al., 2016; Pszczola et al., 2017, 2018; Difford et al., 2018



Murray et al., 1976



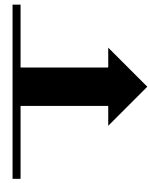
FTIR (Gasmet dx4000)



Direct phenotypes for CH₄ emission

CH₄ L / day

CH₄ g / day



Accounts for
measurements errors

Gives CH₄ production

Influenced by other traits

New phenotype:

CH₄ ppm / day

Objectives



Study of variability in daily concentrations of CH₄ exhaled by dairy cattle



Genome Wide Association Studies of the variability in daily concentrations of exhaled CH₄

Material & Methods

Material



495 Polish Holstein Friesian cows from two herds located in Wielkopolska, Poland



34 359 observations of average daily CH₄ concentrations in the exhaled air



NATIONAL SCIENCE CENTRE
POLAND

GRANT NO: OPUS 2013/09/B/NZ9/03179

Studied phenotype: CH₄ [ppm] / day

	Herd 1	Herd 2
No. of animals	366	129
No. of measurements	31 179	3 180
Measuring period	19 months	1 month
Mean CH ₄ [ppm] / day	505 ± 190	517 ± 166

Animals fed *ad libitum*; partial mixed ration with nutrients covering the 25-kg level of milk yield

Genotyping

		No. of animals
Phenotyped		495
Genotyped	before QC	335
	after QC	332

1 with Call Rate < 0.9
2 with Mendelian conflicts

		No. of SNP
Before QC		49 233
After QC		39 269



50k chip

Statistical model

1 or 2+ lactation

Week of the year of measurement

$$\text{CH}_{4_{ijkl}} = \text{LAC}_j + \underbrace{\sum_{n=1}^4 \beta_n \text{DIM}_{kn}}_{\text{General lactation curve with 3}^{\text{rd}} \text{ order Legendre's polynomial}} + \text{YK}_l + \underbrace{\sum_{n=1}^3 \text{animal}_{in} \text{DIM}_{kn}}_{\text{Random effect with 2}^{\text{nd}} \text{ order Legendre's polynomial}} + \underbrace{\sum_{n=1}^3 pe_{in} \text{DIM}_{kn}}_{\text{PE effect with 2}^{\text{nd}} \text{ order Legendre's polynomial}} + e_{ijkl}$$

Average daily concentration

The diagram shows the equation for CH4 concentration with several annotations. A green arrow points from 'Average daily concentration' to the CH4 term. Another green arrow points from '1 or 2+ lactation' to the LACj term. A third green arrow points from 'Week of the year of measurement' to the YKl term. Three green brackets are placed under the polynomial terms, with corresponding text descriptions below them: 'General lactation curve with 3rd order Legendre's polynomial' under the first polynomial, 'Random effect with 2nd order Legendre's polynomial' under the second polynomial, and 'PE effect with 2nd order Legendre's polynomial' under the third polynomial.

single step GBLUP

Misztal et al., 2009

combining pedigree information **A**
with
genomic information **G**

$$\mathbf{A}^{-1} + \begin{bmatrix} 0 & 0 \\ 0 & \mathbf{G}^{-1} - \mathbf{A}_{22}^{-1} \end{bmatrix}$$

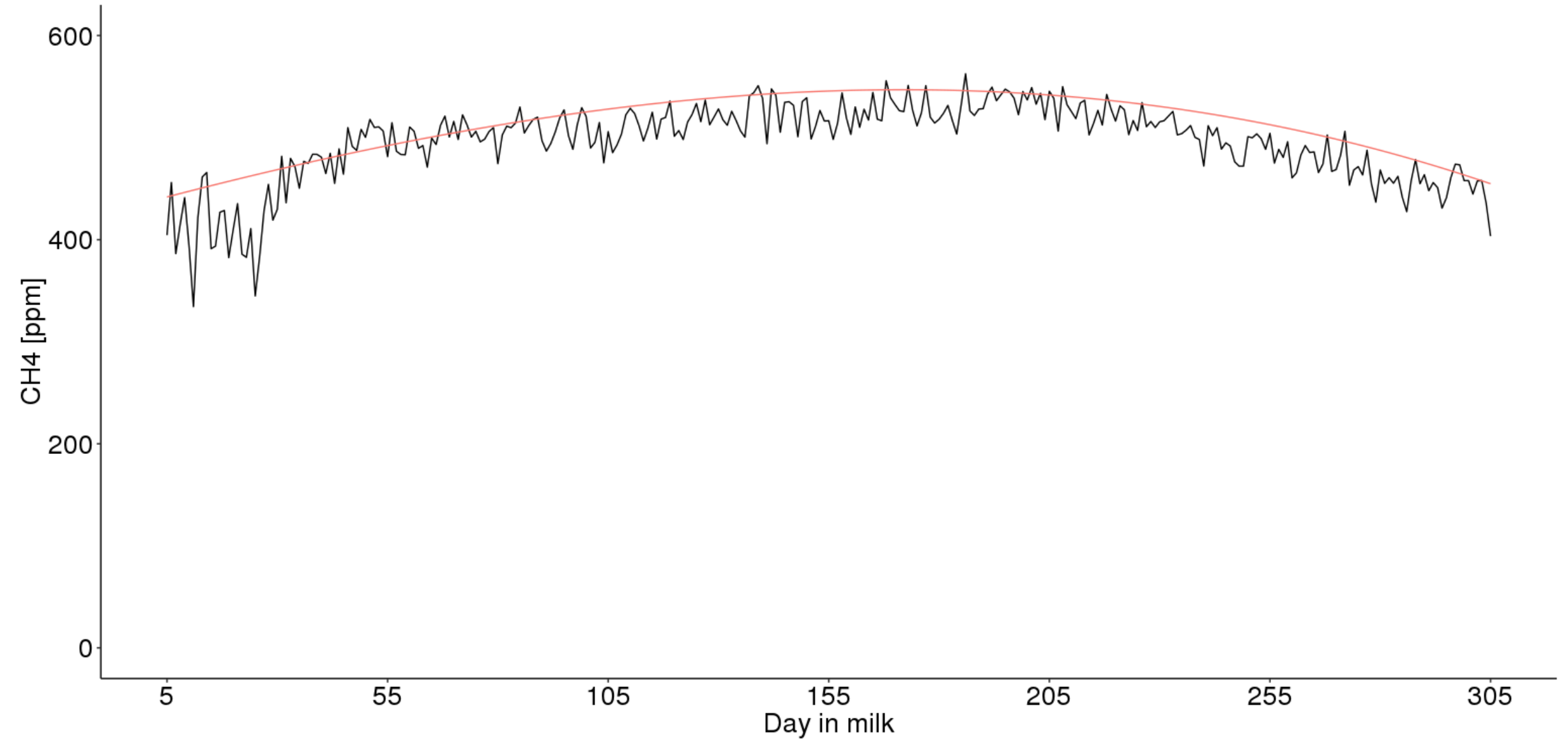
hybrid matrix **H**⁻¹

Results

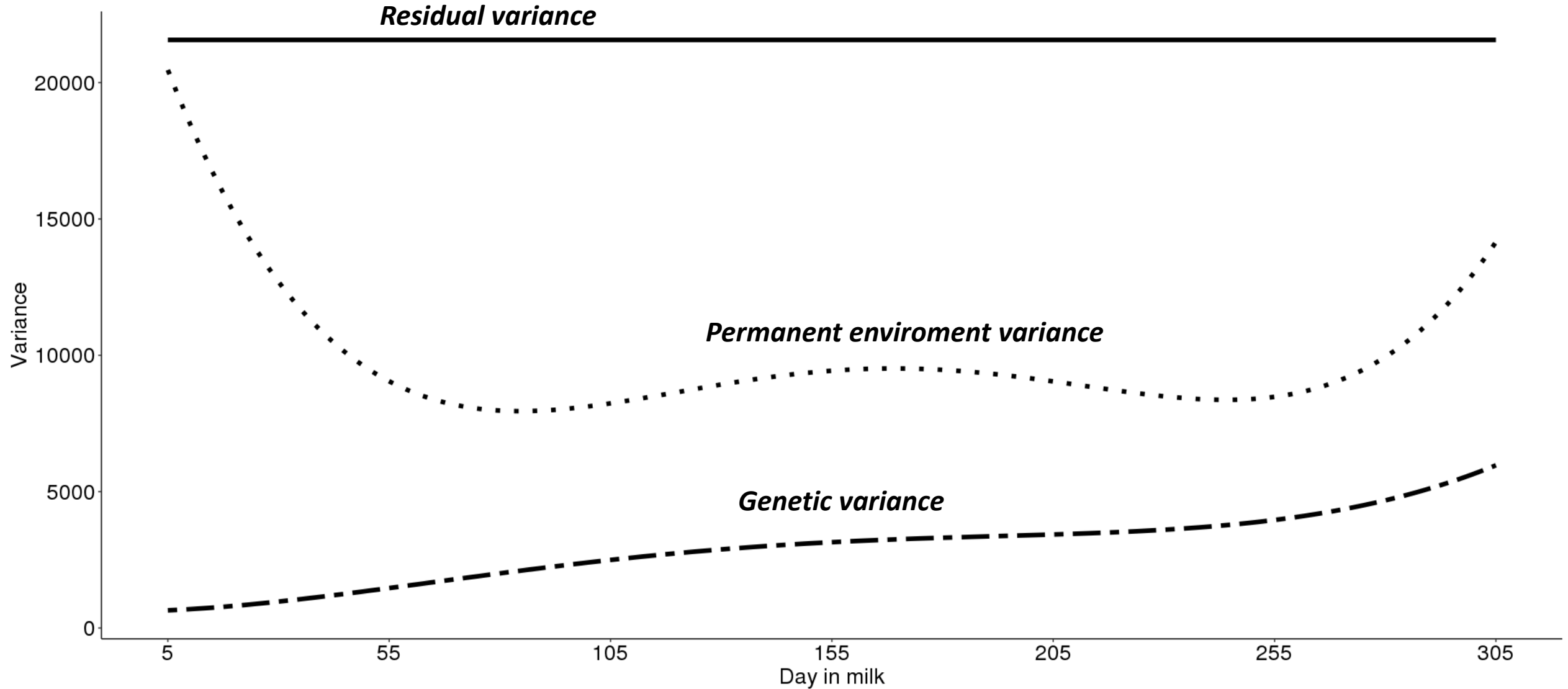


Variability of
CH₄ emission

General lactation curve



Variance components during the lactation

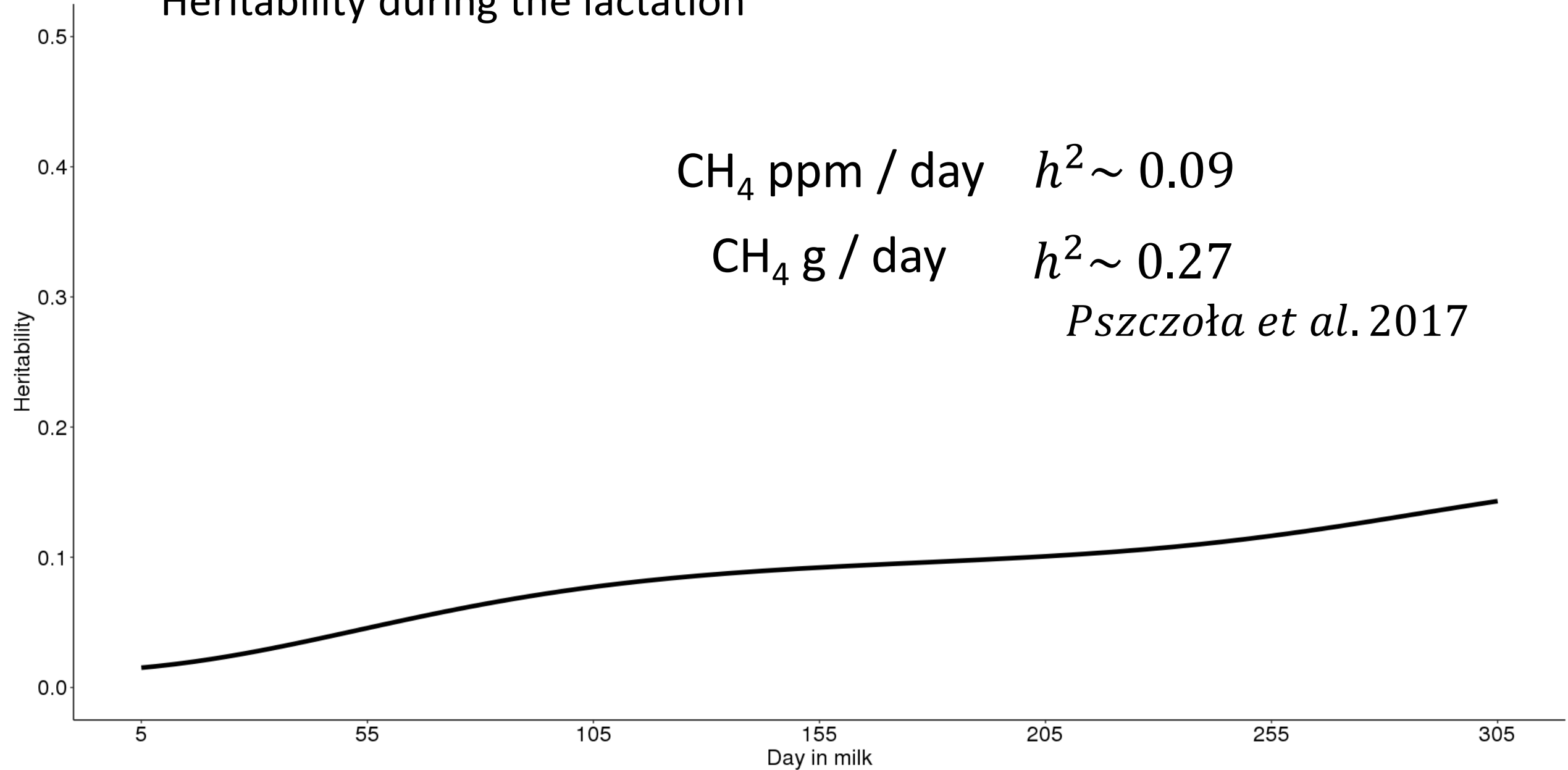


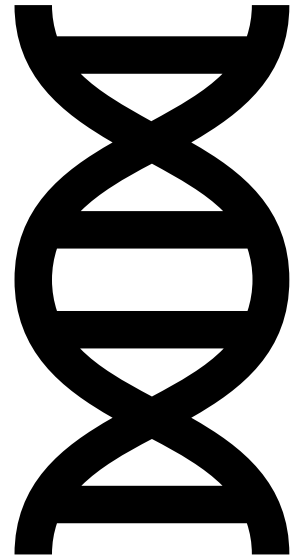
Heritability during the lactation

CH₄ ppm / day $h^2 \sim 0.09$

CH₄ g / day $h^2 \sim 0.27$

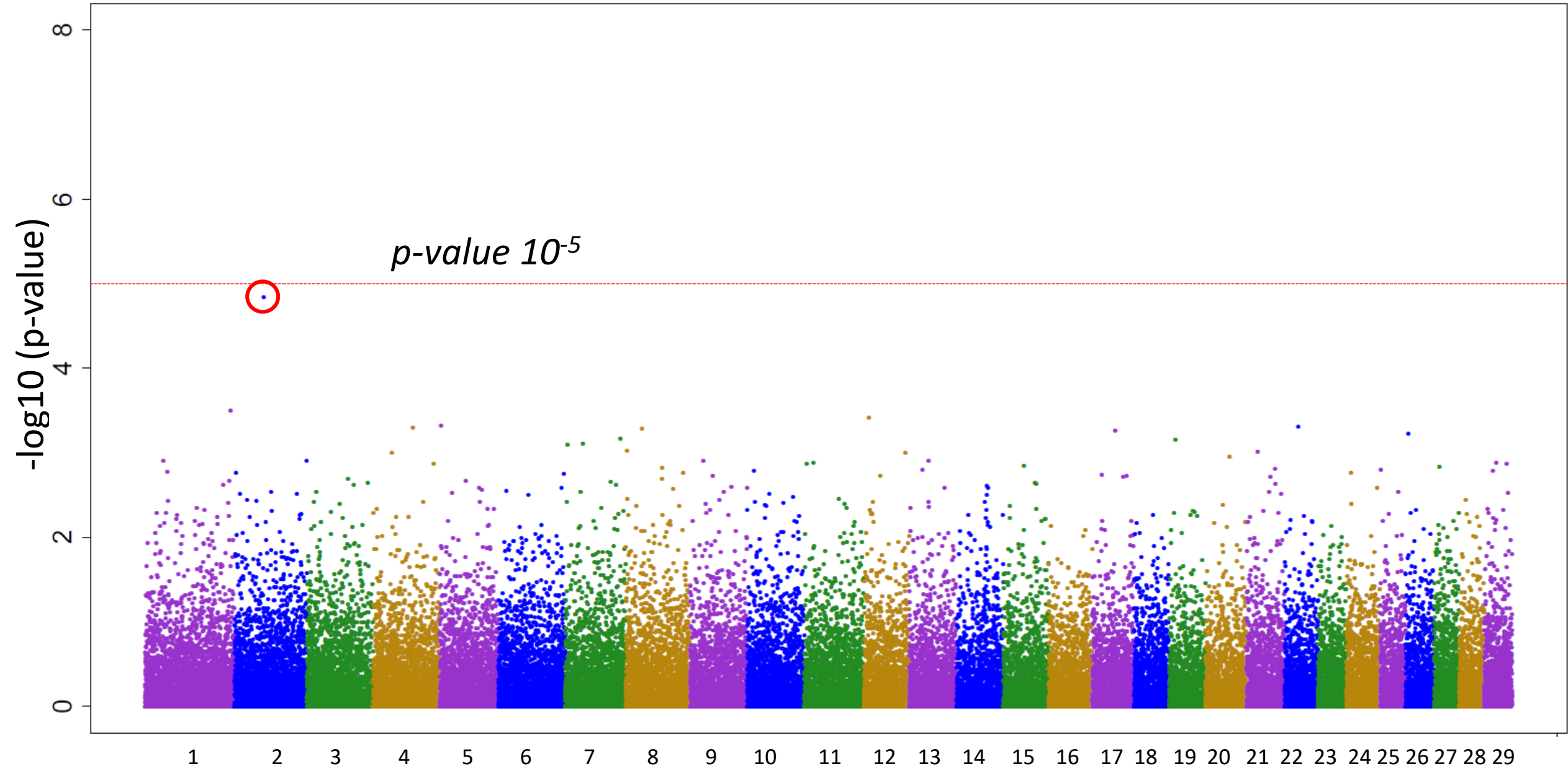
Pszczoła et al. 2017



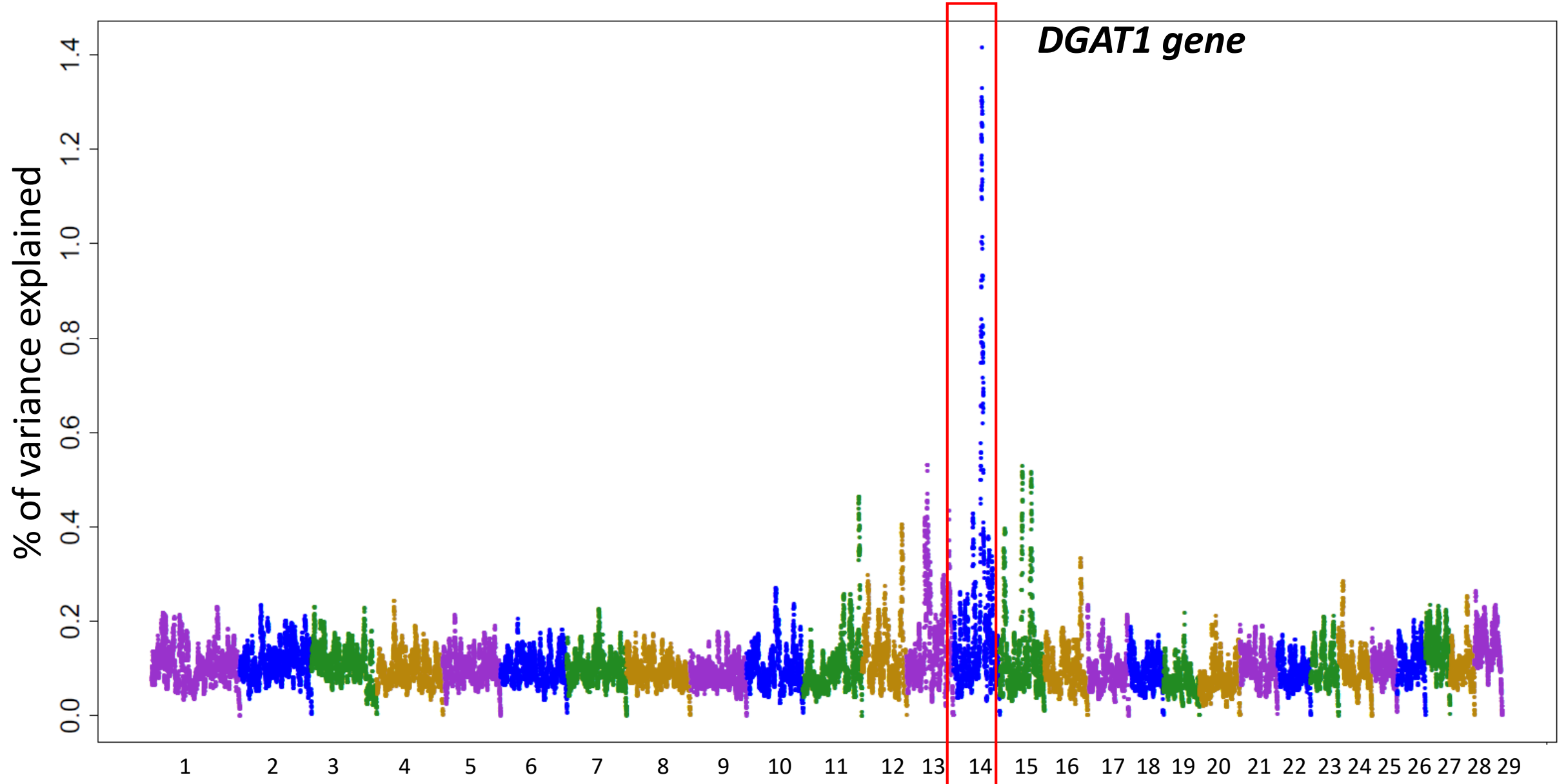


GWAS results

P – values for SNP associated with CH₄ [ppm] / day



Proportion of variance explained in 50 adjacent SNP window



Conclusions

Introduction of new phenotype – CH₄ [ppm]

Confirmed genetic background of new phenotype

Methane concentration is a polygenic trait