Effect of GHR allele variants on milk production traits in a German Holstein dairy cow population

S. A. Rahmatalla, U. Mueller, M. Reissmann, G. A. Brockmann

Department for Crop and Animal Sciences, Humboldt-Universität zu Berlin, Invalidenstrasse 42, D–10115 Berlin, Germany

Introduction

Growth hormone receptor gene (*GHR*):

- encodes a protein that is a transmembrane receptor for growth hormone [**Fig. 1A**]
- plays major role in the regulation of growth hormone action in the mammary gland
- located at a QTL on chromosome 20 (q1.7) in Holstein Friesian [**Fig. 1B**]
- known as strong positional and functional candidate gene affecting milk production traits.
- a Phe→Tyr substitution (*F279Y*) in exon VIII was suggested to show effects on milk yield, protein and fat content in Holstein Friesian

Objectives

1. determine genotype and allele frequencies of the *GHR*-F279Y polymorphism in a German Holstein population
2. estimate the genetic effects of *F279Y* mutation on milk, fat and protein yields, and fat and protein content

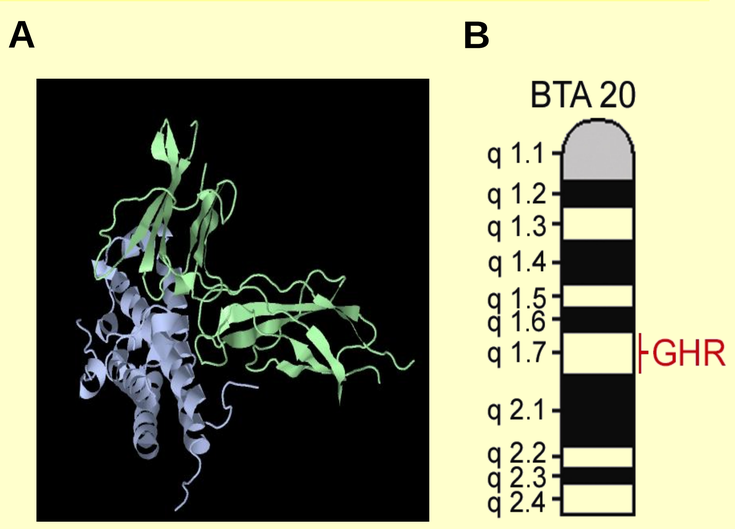

Figure 1: (A) Structure of the GHR protein, (B) location of *GHR* gene on chromosome 20.

Materials and Methods

- 1370 German Holstein cows from three herds, kept at similar feeding and management conditions
- genomic DNA extracted from whole blood
- *GHR*-F279Y polymorphism genotyped by pyrosequencing
- analysed traits: yield deviation for milk, fat and protein yield, and fat and protein content
- allele and genotype frequencies calculated based on genotype counts observed in the population
- genotypes tested for Hardy-Weinberg equilibrium at the *GHR* locus (χ^2 test)
- association analysis with "PROC MIXED" procedure of the SAS software package (release 8.02)

Results

- FF is the most frequent genotype of the *GHR- F279Y* mutation (**Table 1**)
- no significant deviation of the observed genotype from that expected at Hardy-Weinberg equilibrium
- *GHR*-F279Y genotypes show highly significant effects on milk yield, fat and protein content (P < 0.0001)
- effects on fat and protein yield are evident, but less significant
- heterozygous FY carriers show highest milk yield, fat and protein yield
- protein and fat content is highest in homozygous FF cows, and significantly differ from other genotypes [**Figure 2 A and B**]
- the substitution of allele 279F on *GHR*-F279Y has positive effects on protein and fat content, but negative effects on milk, protein and fat yield [**Table 2**]

Table 1: Genotype and allele frequencies of the *GHR*-F279Y polymorphism

Genotype	Freq. (%)	Allele[1]	Freq. (%)
FF	69.1	F	83.5
FY	28.8	Y	16.5
YY	2.1		

[1] F = phenylalanine variant; Y = tyrosine variant

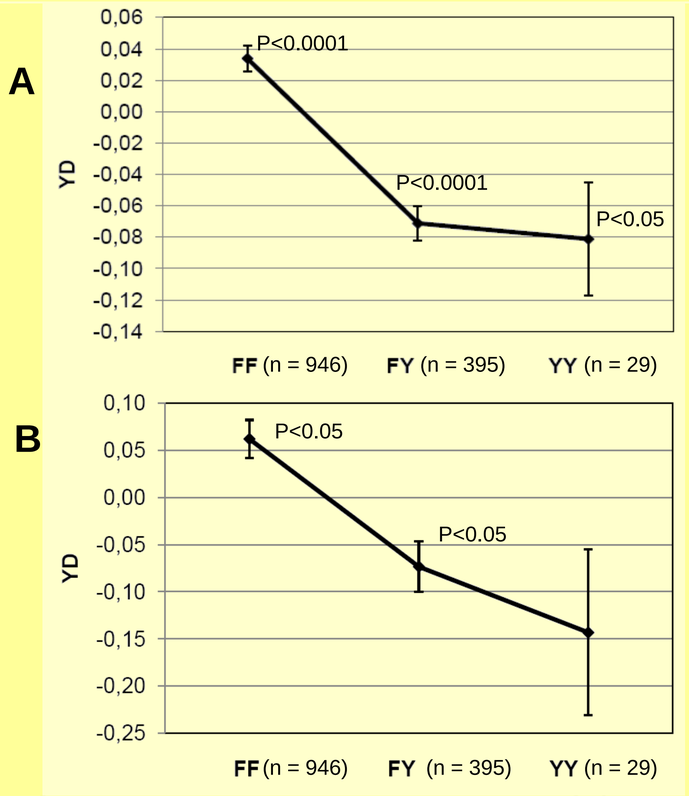

Figure 2: Least square means of the F279Y genotypes for (A) protein and (B) fat content

Table 2: Effect of the *GHR*-F279Y allele (F) on milk production traits

Traits (yield / content)	279 F-allele α	SE	P value
Milk (kg)	-322.22	81.42	<0.0001
Fat (kg)	-2.74	3.02	0.3650
Protein (kg)	-3.29	2.52	0.1925
Fat (%)	0.13	0.03	<0.0001
Protein (%)	0.09	0.01	<0.0001

Conclusion

This study confirms that the F279Y mutation is a strong candidate SNP in the *GHR* gene for milk yield, protein content, and fat content. The 279F allele contributes to an increase of protein and fat content along with a reduction in milk yield.