EFFECTS OF MILK PROTEIN GENOTYPES ON HEIFER AND FIRST LACTATION REPRODUCTION TRAITS IN THE FINNISH AYRSHIRE

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SUMMARY
Effects of composite β-κ-casein genotypes and β-lactoglobulin genotypes on reproduction traits were estimated for 17059 Finnish Ayrshire (FAy) heifers and 17869 FAy first lactation cows using an animal model. No significant effects of composite β-κ-casein genotypes on reproduction traits of Fay heifers were observed. β-lactoglobulin genotypes had statistically significant effect on heifers' age at first insemination, age at conception and age at calving. Heifers with AA genotype were 3 to 6 days younger at first insemination, conception and calving than heifers with β-lactoglobulin BB genotype. Composite β-κ-casein genotypes and β-lactoglobulin genotypes had, in general, no significant effect on reproduction traits of Fay first lactation cows. The effect of composite β-κ-casein genotypes on interval between calving and first service in first lactation was statistically significant, but most of the differences between composite β-κ-casein genotypes were negligible in this trait. It can be concluded, that milk protein genotypes had no effects on reproduction traits of heifers or first lactation cows, or the effects were small in practice. Thus, the possible selection for milk protein genes would hardly have any noticeable impact on reproduction traits in dairy cows.
Keywords: milk protein, genotype, reproduction, dairy heifers and cows

INTRODUCTION
Many studies have revealed favourable effects of κ-casein and β-lactoglobulin B alleles on renneting properties and protein composition of milk (e.g., Schaar *et al.* 1985 and van den Berg *et al.* 1992). Therefore, milk protein genotypes or genes have been considered to be used as an aid for selection, when breeding for good manufacturing properties of milk. Before the milk protein genes are to be used as one selection criterion, their possible effects on all economically and biologically important traits have to be studied. Effects of milk protein genes on milk production traits have been studied intensively until recently (e.g., Bovenhuis *et al.* 1992, Mao *et al.* 1992 and Ojala *et al.* 1997). There are, however, only a few studies about the association between milk protein genotypes and reproduction or health traits in dairy cows (e.g., Lin *et al.* 1987, Lin *et al.* 1992).

The objective of this study was to estimate the effects of the composite β-κ-casein genotypes and β-lactoglobulin genotypes on reproduction traits of heifers and first lactation cows in the Finnish Ayrshire.

MATERIALS AND METHODS

Milk samples of 20928 Finnish Ayrsire cows (Fay) were phenotyped for the major milk proteins by isoelectric focusing (IEF) in polyacrylamide gels according to Erhardt (1989). Records for different measures of heifer and first lactation reproductive performance were calculated based on insemination and calving dates of cows. The heifer reproduction traits studied were age at first insemination (AFI), age at last insemination/conception (ALI), age at calving (AC), days between first and last insemination (service period; SP), number of services per conception (NS) and gestation length (GL). The first lactation reproduction traits were days from calving to first insemination (DFI), service period (SP), days from calving to last insemination/conception (days open; DO), number of services per conception (NS), gestation length (GL) and days between first and second calving (calving interval; CI). The reproduction traits SP (service period) and NS (number of services/conception) had skew distributions; therefore, a logarithmic transformation (ln) was applied on these traits. Records for heifer fertility were available for 17059 cows born in 1985 through 1993, and records for first lactation fertility were available for 17869 cows born in 1984 through 1995. Numbers of herds were 1527 and 1521 in the data sets for heifers and first lactation cows, respectively.

Due to the tight linkage between the casein loci (e.g., Threadgill and Womack 1990), composite casein genotypes were used in estimation of the effects of casein genotypes on reproduction traits. Effects of composite β-κ-casein (β-κ-CN) genotypes and β-lactoglobulin (β-LG) genotypes on reproduction traits of dairy heifers and first lactation cows were estimated using the following model:

$$\mathbf{y} = \mathbf{Xb} + \mathbf{Qg} + \mathbf{Za} + \mathbf{e},$$

where $\mathbf{y}$ = a vector of observations for the reproduction traits on genotyped cows, $\mathbf{b}$ = a vector of unknown fixed effects for herd, birth/service year and birth/service month (heifers) or for herd, calving/service year, calving/service month, age at calving and milk yield (first lactation cows), $\mathbf{g}$ = a vector of unknown fixed effects for 14 β-κ-CN genotypes and 3 β-lactoglobulin genotypes, $\mathbf{a}$ = an unknown vector of random additive genetic effects of animals N~(0, $\mathbf{A}\sigma^2$), $\mathbf{X}$, $\mathbf{Q}$ and $\mathbf{Z}$ are known incidence matrices relating observations in $\mathbf{y}$ to the classes of fixed effects in vectors $\mathbf{b}$ and $\mathbf{g}$ and to the classes in vector $\mathbf{a}$, respectively, and $\mathbf{e}$ = a vector of random residual effects, N~(0, $\mathbf{I}\sigma^2$). When analysing service period (SP) and number of services per conception (NS) of first lactation cows, fixed effects for interval between calving and first insemination (DFI) were included in the model, too.

The pedigree data included identification of parents and grandparents for the cows with records. Numbers of animals included in the statistical analyses were 38785 and 40111 for heifers and first lactation cows, respectively. Variance components for the random effects in the model were estimated using the REML VCE-package (Groeneveld 1995). Variance components used in obtaining solutions for the fixed effects corresponded to the estimates of heritability of 0.10 and 0.11 for gestation length of heifers and cows, respectively; the heritability estimates for the other reproduction traits ranged from 0.02 to 0.05. Statistical significance for differences between the β-κ-CN A_2A_2AA and other β-κ-CN genotypes as well as differences between β-LG BB genotype and other β-LG genotypes were tested using the F-test.

Table 1. Differences between the β-lactoglobulin genotypes and composite β-κ-casein genotypes in reproduction traits for Finnish Ayrshire heifers and first lactation cows

	Heifers			Cows	
	AFI[1]	ALI[1]	AC[1]		DFI[1]
β-LG[2]	$\bar{x}$=481	$\bar{x}$=497	$\bar{x}$=775	β-κ-CN[2]	$\bar{x}$=79
AA (1345)	-3.1*	-5.7**	-5.6**	A_1A_1AA (384)	2.4
AB (7025)	-0.7	-1.1	-0.8	A_1A_1AB (404)	1.2
BB (8689)	0.0	0.0	0.0	A_1A_1AE (1451)	1.7*
				A_1A_1BB (68)	-3.6
				A_1A_1BE (704)	-0.6
				A_1A_1EE (1581)	0.1
				A_1A_2AA (2216)	-0.1
				A_1A_2AB (1239)	-1.6*
				A_1A_2AE (5431)	-0.2
				A_1A_2BB (34)	-12.6**
				A_1A_2BE (104)	4.9*
				A_1A_2EE (24)	8.3
				A_2A_2AA (3994)	0.0
				A_2A_2AB (235)	0.2

[1] The abbreviated traits: AFI=age in days at first insemination, ALI=age in days at last insemination/ conception, AC=age in days at calving, DFI=interval in days between calving and first insemination.
[2] Number of observations in brackets.
The β-LG genotype BB and β-κ-CN genotype A2A2AA were the comparison genotypes in the pairwise contrasts. Statistical significance is given with *=p<0.05 and **=p<0.01.

RESULTS AND DISCUSSION

No significant effects of composite β-κ-casein genotypes on reproduction traits of Fay heifers were detected. β-lactoglobulin genotypes, however, had statistically significant effects on heifers' age at first insemination, age at conception and age at calving (Table 1). Heifers with β-lactoglobulin AA genotype were about 3 days younger at first insemination, and about 6 days younger at conception and at calving as compared to heifers with β-lactoglobulin BB genotype. The differences between genotypes were, however, rather small with regard to the means and variation for these traits. Unlike in this study, heifers with β-lactoglobulin AB genotype were statistically significantly younger at first conception and at freshening, and had a shorter service period than heifers with AA or BB genotypes in a study by Lin *et al.* (1987).

No statistically significant effects of β-lactoglobulin genotypes on service period of Fay heifers were observed in this study.

Composite β-κ-casein genotypes and β-lactoglobulin genotypes had, in general, no significant effect on first lactation reproduction traits in FAy cows. The effect of composite β-κ-casein genotypes on interval between calving and first service in first lactation (DFI) was, however, statistically significant (Table 1). Most of the contrasts between β-κ-CN genotypes were negligible in practice. Out of 13 β-κ-CN genotypes tested, only genotypes A_1A_1AE, A_1A_2AB, A_1A_2BB and A_1A_2BE deviated statistically significantly from the comparison genotype A_2A_2AA. The largest differences between A_2A_2AA genotype and other β-κ-CN genotypes were observed in genotype classes with small number of observations; A_1A_2BB with 34 and A_1A_2BE with 104 observations.

According to the results of this study, milk protein genotypes had no effects on heifer or first lactation reproduction traits in the Finnish Ayrshire, or the effects were small in practice. Also according to Lin *et al.* (1992), the effects of milk protein genotypes on reproduction traits are generally small or absent in different dairy breeds studied. In conclusion, the possible selection for milk protein genes would hardly have any noticeable impact on reproduction traits in dairy cows.

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