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# A DIFFERENCE IN ALLELE AND GENOTYPE FREQUENCIES OF MILKPROTEIN KAPPA-CASEIN IN BULLS OFFERED FOR ARTIFICIAL INSEMINATION AND THEIR REAL PROPORTION IN A POPULATION OF COWS

J. Bezdíček

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## Abstract

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The aim of this study was an evaluation of allele and genotype frequencies of Milkprotein kappa casein (CSN3) in bulls offred by breeding companies (n = 287) and of a real proportion of these fathers (genotypes) in a population of Czech Fleckvieh cows (n = 27 970) born between 1994 and 2004. An average frequencies of genotypes of the offered fathers and their real proportion in a population of cows was in 1994–2004: AA = 0.3902; 0.4572; AB = 0.4774; 0.3993; AE = 0.007; 0.0004; BB = 0.115; 0.1394 and BE = 0.0105; 0.0036. EE genotype was not found. An average frequency of allele was A = 0.6324; 0.6571; B = 0.3589; 0.3409 and E = 0.0087; 0.002.

The set of observed cows (27 970 head) shows a significant predominance of using fathers with AA and AB genotypes of milkprotein kappa-casein. A frequencies of these two genotypes varied between 0.7885 and 0.9836 in the observed years. A difference between genotype frequencies of CSN3 (AA, AB and BB) in offered bulls and their real proportion in the population of cows was not significant only in years 1995, 1996, 1998, 2002 and 2003. In the rest of the years (1994, 1997, 1999, 2000, 2001, 2004) and also in average of all years the difference was significant or highly significant.

In none of the observed years (1994–2004) were the absolute frequencies of genotypes of the cows' fathers in genetic equilibrium. Genotype frequencies of milkprotein kappa-casein of the offered bulls and their real proportion in the population of cows show, in most of the years, significant or highly significant differences. A variability of heterozygosity in 1994 – 2004 was very high, between 14.03 % and 85.68 %. Gene diversity varied between 34.9 %–49.59 %.

PIC value varied between 0.2882–0.3767 in 1994–2004 and its average in all the observed years was 0.3516.

When counting allele and genotype frequencies in a population with a different intensity of use of several bulls it is important not only to analyze a particular genotype of the father but also his share of influence in the population of cows.

kappa-casein, allele frequencies, genotype frequencies, Czech Fleckvieh

Milk production (kg of milk, milk components) plays a crucial role in breeding of Czech Fleckvieh cattle. Determination of kappa-casein milk protein genotype (CSN3) in offered bulls is important information because of a relation of this genotype and quantity, structure and quality of milk.

Mostly, when a bull is chosen into a herd, the genotype of CSN3 is not in focus. Breeders put the accent more on breeding value of milk production (kg of milk, milk components), or on reproduction and exterior. What happens is more an indirect selection by way of milk production. Due to artificial insemination some bulls and their genotypes are used unevenly. In 2006, for example, the most often used bull of Czech Fleckvieh breed was ZEL 78 (14 037 first inseminations), the second was RAD 64 (11 954 first inseminations), the third was UF 67 (9 653 first inseminations) and the tenth was BO 842 (3 757 first inseminations). It clearly shows a difference in using particular bulls (genotypes) in a population of cows. (http://www.cestr.cz/index.php?file=www/cz/home/journal.html&catID=2&journalID=383).

A relation of kappa casein milk protein and milk production of cows has been proven in many scientific works. Allele B tends to increase of higher content milk percentage protein and fat and milk quality (Boettcher, P. J. et al., 2004; Caroli, A. et al., 2004; Kučerová, J. et al., 2004). Eenennaam, van A. and Medrano, J. F. (1991) obtained the highest milk yields for the BB genotype from 1 454 first lactation heifers of the California dairy cattle population.

Kučerová, J. et al. (2006) detected increased protein and fat content in milk in population of Czech Fleckvieh breed of BB genotype. In the observed population frequencies of CSN3 allele B (0.38) and BB genotype (13 %) were detected. The effect of AA CSN3 genotype on milk, protein and fat yield and effect of AA genotype on protein and fat percentage was found by the author also in her former study (Kučerová, J. et al., 2004). A significantly higher difference in protein production ($p < 0.05$) was determined between AB and BB CSN3 genotypes in the first lactation of dairy cows of the Slovak Fleckvieh breed (Žitný, J. et al., 1996). Dairy cows with AB genotype produced on average by 17 kg of proteins more than the group of cows with BB CSN3 genotype. Negative effects of E allele on milk production parameters and protein quality were found by Ikonen, T. et al. (1999). BB CSN3 genotype is also connected with higher cheese yield and better coagulation qualities (Hanuš, O. and Beber, K., 1995).

Kučerová, J. et al. (2006) established frequencies for CSN3 locus alleles A, B and E in Czech Fleckvieh cattle as 0.598 0.378 and 0.024. Frequencies of AA, AB, AE, BB and BE CSN3 genotypes were 35.4 46.8 2.3 13.0 2.5. The EE genotype was not found in Czech Fleckvieh cows. Bulls of the Czech Fleckvieh breed (n = 37) showed three CSN3 genotypes AA, AB and BB 38 % 48 % and 14 % with frequencies of alleles A = 0.61 and B = 0.39 (Kučerová, J. et al., 2004). Bezdíček, J. (2007) reported in Czech Fleckvieh bulls genotype frequencies AA = 0.391 AB = 0.4887 AE = 0.0075 BB = 0.0902 BE = 0.0226 and EE = 0 and allele frequencies A = 0.6391 B = 0.3459 E = 0.015. Genotype frequencies established in Holstein bulls were AA = 0.5517 AB = 0.2759 AE = 0.1207 BB = 0 BE = 0.0345 and EE = 0.0172 and allele frequencies A = 0.75 B = 0.1552 and E = 0.0948. Čítek, J. and Antes, R. (1996) detected frequencies of the A and B alleles of CSN3 in 25 individuals of Bohemian Red breed. This old breed belongs to endangered gene reserves. Relative frequency of A allele was 0.52 and B allele 0.48. Relative frequency of the AA genotype was 0.24; AB 0.56 and BB 0.2. In the population of the Slovak Fleckvieh cows (Žitný, J. et al., 1996) three genotypes were found – AA (28 %), AB (59.7 %) a BB (12.3 %). In this study 717 cows were observed. Higher occurrence of AA genotypes (57 %) was found in Polish Black-and-White cattle (Strzalkowska, N. et al., 2002). Lower occurrence of genotypes AB (39 %) and markedly low proportion of the BB genotypes (4 %) were determined in this population. Genotypes of kappa-casein were analysed in three breeds of Bulls in Austria. Frequencies of alleles were A = 0.73 and B = 0.27 in Fleckvieh, 0.36 and 0.64 in Braunvieh and 0.54 and 0.46 in Grauvieh. Frequencies of AA, AB and BB genotypes in analysed breeds were following: Fleckvieh 51.9 % 42.8 % 5.3 % Braunvieh 14.2 % 42.9 % 42.9 % and Grauvieh 26.1 % 56.5 % 17.4 % (Schellander, von K. et al., 1992). In Canadian artifical insemination bulls (Holstein, Ayshire and Jersey) Sabour, M., et al. (1993) reported frequencies of alleles A and B. Frequencies of B allele in these breeds were 0.14 0.22 and 0.92. AA, AB and BB genotype frequencies were 0.75 0.23 and 0.02 in Holstein breed, 0.58 0.39 and 0.03 in Ayshire breed and 0 0.15 and 0.85 in Jersey breed.

Čítek, J. and Antes, R., (1996) compared relative and theoretical CSN3 genotype frequencies in Bohemian Red breed. Calculated $\chi^2$ test value was 1.48 (in 25 individuals of the breed) and table values are P = 0.01 and $\chi^2 = 9.21$. It shows a statistically insignificant difference. A rate of homozygosis was 0.501.

The aim of this work was to evaluate a proportion of the kappa casein milk protein genotypes (AA, AB, AE, BB, BE and EE) and allele (A, B, E) in a population of Czech Fleckvieh cows in the Czech Republic (South Moravia area). And at the same time to evaluate a difference of these frequencies in bulls offered into an artificial insemination and their real proportion in a population of cows born between 1994 and 2004.

## MATERIAL AND METHODS

A database of Czech Fleckvieh cows born between 1994 and 2004 in the Czech Republic (South Moravia area) was used for an evaluation. Evaluation of allele and genotype frequencies was carried out in 133 bulls which had at least 10 daughters born between 1994 and 2004 in the studied population. These bulls were labeled as both top bulls in milk production and testing bulls in the observed population. Some of the bulls were used more than one year so the total number of the fathers included in the study was 287. The kappa casein genotype was determined from insemination doses in an immunogenetics laboratory of Czech Moravian Breeders Corporation Inc. and the information was also published for the breeders. PowerMarker (Liu, K., Muse, S. V.: Integrated analysis environment for genetics marker data, Bioinformatics 21 /9/: 2128–2129, 2005) programe was used for the calculation. The calculation was based on finding allele and genotype frequencies in Czech Fleckvieh bulls and their real proportion in a population of cows. Genetical equilibrium and statistically significance were reached by counting $\chi^2$ test and LRT value (Hardy-Weinberg disequilibrium). Calculation of heterozygosis and PIC values (polymorphism information content) of the bulls of examined breed was a part of the procedure.

A closely related diversity mearure is the polymorphism information content (PIC). It is estimated as: Polymorphism information content:

$$PIC = 1 - \sum_{u=1}^{k} \bar{p}_{lu}^{2} - \sum_{u=1}^{k-1} \sum_{v=u+1}^{k} 2\ \bar{p}_{lu}^{2}\ \bar{p}_{lv}^{2}$$

$$\text{Heterozygosity: } H_l = 1 - \sum_{u=1}^{k} \bar{P}_l$$

$$\text{Gene diversity: } D = (1 - \sum_{u=1}^{k} \bar{p}_{lu}^{2}).$$

## RESULTS AND DISCUSSION

Tab. No. I–II shows the found relative allele and genotype frequencies of CSN3 milk protein in Czech Fleckvieh bulls which were offered by breeding companies and whose daughters were born between 1994 and 2004. Genotype frequencies (AA, AB, AE, BB and BE) of these offered fathers varied between these values: 0.2222–0.625; 0.25–0.6429; 0–0.0303; 0.0714–0.2308 and 0–0.0385. Frequencies of A, B, E allele varied between these values: 0.5278–0.725; 0.25–0.4722 and 0–0.0192. Average frequencies of the genotypes in the studied period of time were AA = 0.3902; AB = 0.4774; AE = 0.007; BB = 0.115 and BE = 0.0105 and the allele frequencies were A = 0.6324; B = 0.3589 and E = 0.0087. These values clearly show considerable variability in constituent years mainly in AA and AB genotypes, that is also shown in variability of A and B allele frequencies. The average values in the whole studied period of time correspond to frequencies claimed in Czech Fleckvieh breed by other authors.

Kučerová, J. et al. (2004) detected in 37 bulls frequencies for CSN3 AA = 0.38; AB = 0.48 a BB = 0.14 and allele frequencies A = 0.61 a B = 0.39. High rate of AB genotype (59.7 %) was also found in population of Slovak Fleckvieh breed (Žitný, J. et al., 1996) together with a lower rate of AA genotypes (28 %) and higher rate of BB genotypes (12.3 %). Austrian population of breeding bulls (Schellander, von K. et al., 1992) showed on the contrary higher rate of BB genotype in Fleckvieh (5.3 %), Braunvieh (42.6 %) and Grauvieh (17.4 %) breed. B allele is not more frequent in Austrian Fleckvieh population (Fleckvieh in Austria 0.27; Fleckvieh in the Czech Republic 0.3459), because AB genotype is more frequent in Czech bulls.

Average allele and genotype frequencies of bulls offered by breeding companies do not show the real proportion of the bulls in a population of cows. It is caused by a difference in intensity of using the bulls in artificial insemination. Tab. No. I–II shows number of daughters born between 1994 and 2004 and total number of cows according to the CSN3 genotypes of their fathers. The AA, AB, AE, BB and BE genotypes rates oscillated in the studied period of time between these values: 0.1268–0.6505; 0.138–0.8568; 0–0.0023; 0.0164–0.2324 and 0–0.0469. The average frequencies of these genotypes were 0.4572; 0.3993; 0.0004; 0.1394 and 0.0036. EE genotype was not found. A, B and E allele frequencies varied between 0.5418–0.7746; 0.2254–0.4557 and 0–0.0235. Average frequencies of these allele were 0.6571; 0.3409 and 0.002. Variability of „A and B“ allele in the group of offered bulls (n = 287) and in the group of their daughters in the population (n = 27 970) is shown in figure No. 1. The figure shows the difference in the frequencies in most of the studied years.

Most breeders do not see a CSN3 genotype as a direct criterion for selection. When choosing a bull, breeders prefer those who have been positively proven not only from the point of view of milk production and milk components but also from the point of view of reproduction, exterior, beef production etc. The milk production, however, plays an important role in intensity of using the bull. Most authors (e.g. Kučerová, J. et al., 2004, Žitný, J. et al., 2000 and others) agreed that there is a positive relation between milk production and presence of A or B allele of CSN3 milk protein. It is in accordance with CSN3 genotype rates between 1994 and 2004 (Tab. No. I–II, figure No. 2). Figure No. 2 show a predominant role of AA and AB genotypes. Their collective proportion varied between 79.79–96.7 % in 1994–2004. It also shows a predominant role of „A“ allele. On the other hand, genotypes of fathers with E allele are represented in the observed group of cows minimally and their frequency is in average lower than one per cent (AE = 0.0004 % BE = 0.0036 % EE = not found, E = 0.002 %) and it does not correspond to a 0.01 % polymorphism criterion. Rate of bulls with E allele is low and so is their usage in a population of cows (Table No. I–II). It corresponds to a negative relation of this allele and milk production (many authors, e.g. Ikonen, T. et al., 1999). Difference between CSN3 genotype frequencies (AA, AB and BB) in offered bulls and their real proportion in a population of cows was not significant only in 1995, 1996, 2002 and 2003. In the rest of the years the difference was significant or highly significant (see table No. I–II).

The group of cows was not in a genetic equilibrium in any of the years, which follows from the calculated value of $\chi^2$ test and from the big difference between heterozygosity and gene diversity (table No. III).

In the last ones of the observed years (2000, 2001, 2003 and 2004) highly significant differences between heterozygosity and gene diversity were found. It gives an evidence of a big difference between the real frequency of heterozygotes and their theoretical frequency in a state of genetic equilibrium according to Hardy – Weinberg. Variability of heterozygosity in 1994–2004 was very high, between the values of 14.03 % and 85.68 %. Gene diversity varied between 34.9 % and 49.59 % (table No. III).

PIC value varied between 0.2882 and 0.3767 in 1994–2004 with an average value in the observed years 0.3516.

I: *Allele and genotype frequencies of Milkprotein kappa-casein in bulls offered for artificial insemination and their real proportion in a population of cows (1994–1999 is the year of born of cows)*

| | Bulls 1994 | | Bulls 1995 | | Bulls 1996 | | Bulls 1997 | | Bulls 1998 | | Bulls 1999 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | In offer | Proportion in population | In offer | Proportion in population | In offer | Proportion in population | In offer | Proportion in population | In offer | Proportion in population | In offer | Proportion in population |
| | Freq. | Freq. | Freq. | Freq. | Freq. | Freq. | Freq. | Freq. | Freq. | Freq. | Freq. | Freq. |
| AA | 0.3846 | 0.5875 | 0.5 | 0.6401 | 0.55 | 0.4685 | 0.625 | 0.444 | 0.5 | 0.496 | 0.3462 | 0.5647 |
| AB | 0.4231 | 0.2816 | 0.4167 | 0.2692 | 0.35 | 0.4745 | 0.25 | 0.523 | 0.4 | 0.3997 | 0.4231 | 0.2332 |
| AE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| BB | 0.1538 | 0.084 | 0.0833 | 0.0908 | 0.1 | 0.0571 | 0.125 | 0.0329 | 0.1 | 0.1042 | 0.2308 | 0.2021 |
| BE | 0.0385 | 0.0469 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| EE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| A | 0.5962 | 0.7283 | 0.7083 | 0.7746 | 0.725 | 0.7057 | 0.75 | 0.7056 | 0.7 | 0.6959 | 0.5577 | 0.6813 |
| B | 0.3846 | 0.2483 | 0.2917 | 0.2254 | 0.275 | 0.2943 | 0.25 | 0.2944 | 0.3 | 0.3041 | 0.4423 | 0.3187 |
| E | 0.0192 | 0.0235 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| n | 26 | 1726 | 24 | 1278 | 20 | 999 | 16 | 2216 | 20 | 3012 | 26 | 2736 |
| Differences (AA, AB, BB) | * | | non significant | | non significant | | * | | non significant | | * | |

* $p < 0.05$ ** $p < 0.01$ genotype – AA, AB, AE, BB, BE, EE allele – A, B, E

II: *Allele and genotype frequencies of Milkprotein kappa-casein in bulls offered for artificial insemination and their real proportion in a population of cows (2000–2004 is the year of born of cows)*

| | Bulls 2000 | | Bulls 2001 | | Bulls 2002 | | Bulls 2003 | | Bulls 2004 | | Bulls total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | In offer | Proportion in population | In offer | Proportion in population | In offer | Proportion in population | In offer | Proportion in population | In offer | Proportion in population | In offer | Proportion in population |
| | Freq. | Freq. | Freq. | Freq. | Freq. | Freq. | Freq. | Freq. | Freq. | Freq. | Freq. | Freq. |
| AA | 0.4091 | 0.6505 | 0.3939 | 0.5349 | 0.25 | 0.2778 | 0.25 | 0.1477 | 0.2222 | 0.1268 | 0.3902 | 0.4572 |
| AB | 0.4773 | 0.138 | 0.4848 | 0.2324 | 0.625 | 0.528 | 0.6429 | 0.8005 | 0.6111 | 0.8568 | 0.4774 | 0.3992 |
| AE | 0.0227 | 0.0023 | 0.0303 | 0.0003 | 0 | 0 | 0 | 0 | 0 | 0 | 0.007 | 0.0004 |
| BB | 0.0909 | 0.2093 | 0.0909 | 0.2324 | 0.0938 | 0.1893 | 0.0714 | 0.0508 | 0.1667 | 0.0164 | 0.115 | 0.1394 |

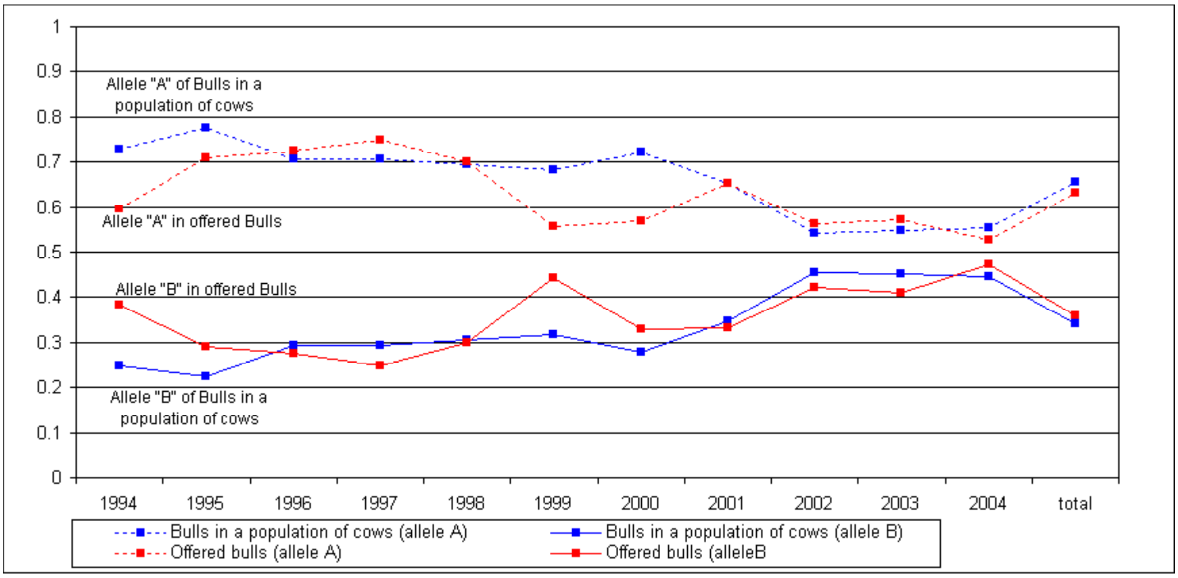
| | Bulls 2000 | | Bulls 2001 | | Bulls 2002 | | Bulls 2003 | | Bulls 2004 | | Bulls total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | In offer | Proportion in population | In offer | Proportion in population | In offer | Proportion in population | In offer | Proportion in population | In offer | Proportion in population | In offer | Proportion in population |
| | Freq. | Freq. | Freq. | Freq. | Freq. | Freq. | Freq. | Freq. | Freq. | Freq. | Freq. | Freq. |
| BE | 0 | 0 | 0 | 0 | 0.0313 | 0.0048 | 0.0357 | 0.001 | 0 | 0 | 0.0105 | 0.0036 |
| EE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0,0000 | 0,0000 |
| A | 0.6591 | 0.7206 | 0.6515 | 0.6513 | 0.5625 | 0.5418 | 0.5714 | 0.5479 | 0.5278 | 0.5552 | 0.6324 | 0.6571 |
| B | 0.3295 | 0.2782 | 0.3333 | 0.3486 | 0.4219 | 0.4557 | 0.4107 | 0.4516 | 0.4722 | 0.4448 | 0.3589 | 0.3409 |
| E | 0.0114 | 0.0012 | 0.0152 | 0.0001 | 0.0156 | 0.0024 | 0.0179 | 0.0005 | 0 | 0 | 0.0087 | 0.002 |
| n | 44 | 4320 | 33 | 3877 | 32 | 3513 | 28 | 2952 | 18 | 1341 | 287 | 27970 |
| Differences (AA, AB, BB) | ** | | ** | | non significant | | non significant | | ** | | * | |

* $p < 0.05$ ** $p < 0.01$ genotype – AA, AB, AE, BB, BE, EE allele – A, B, E

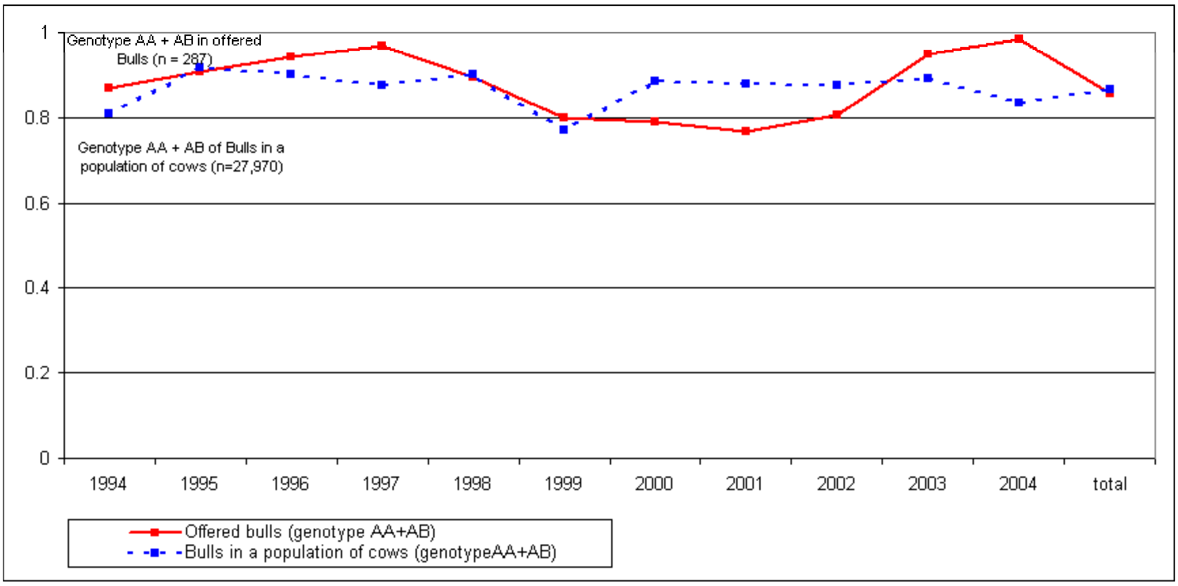
III: *Testing of genetical equilibrium of Milkprotein kappa-casein of bulls in the population of cows (n = 27 970)*

| | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| n | 1726 | 1278 | 999 | 2216 | 3012 | 2736 | 4320 | 3877 | 3513 | 2952 | 1341 | 27970 |
| $\chi2$ test | 299.5 | 67.04 | 20.23 | 148.38 | 9.31 | 586.61 | 1862.39 | 925.67 | 37.28 | 1128.9 | 724 | 476.49 |
| $\chi2$ d.f. | 3 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 1 | 3 |
| $\chi2$ p-value | 0 | 0 | 0 | 0 | 0.0023 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Exact p-value | 0 | 0 | 0 | 0 | 0.0023 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LRT value | 279.75 | 61.29 | 21.28 | 167.26 | 9.19 | 573.37 | 1798.5 | 926.15 | 43.72 | 1242.3 | 854.28 | 471.25 |
| LRT p-value | 0 | 0 | 0 | 0 | 0.0024 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Heterozygosity | 0.3285 | 0.2692 | 0.4745 | 0.523 | 0.3997 | 0.2332 | 0.1403 | 0.2326 | 0.5329 | 0.8015 | 0.8568 | 0.4033 |
| Gene diverzity | 0.4074 | 0.3491 | 0.4154 | 0.4155 | 0.4233 | 0.4343 | 0.4033 | 0.4544 | 0.4987 | 0.4959 | 0.4939 | 0.452 |
| Difference (heterozygosity – gene diverzity) | –7.89 | –7.99 | 5.91 | 10.75 | –2.36 | –20.11 | 26,30 | –22.18 | 3,42 | 30.56 | 36.29 | –4.87 |
| Level of sign. | non sign. | non sign. | non sign. | non sign. | non sign. | * | ** | ** | non sign. | ** | ** | non sign. |
| PIC | 0.3414 | 0.2882 | 0.3291 | 0.3292 | 0.3337 | 0.34 | 0.3229 | 0.3513 | 0.3767 | 0.3734 | 0.3719 | 0.3516 |

* $p < 0.05$ ** $p < 0.01$




1: *Relative frequency of A and B allele in bulls offered for artificial insemination (n = 287) and their real proportion (n = 27 970) in a population of cows*




2: *Relative frequency of AA and AB genotype in bulls offered for artificial insemination (n = 287) and their real proportion (n = 27 970) in a population of cows*

## CONCLUSION

In all the observed years (1994–2004) AA and AB CSN3 genotypes of fathers had a predominant role in the population of cows of Czech Fleckvieh breed (n = 27 970). Proportion of these two genotypes varied between 0.7885 and 0.9836 in the observed years. A predominant role of „A“ allele (0.5418–0.7746) follows from it. On the other hand, fathers‘ genotypes containing a E allele were represented minimally both in the offer and the observed population of cows. Their frequency is in average bellow one per cent.

In none of the observed years were the genotype frequencies in the population of cows (n = 27 970) in a state of genetic equilibrium. CSN3 genotype frequencies of offered bulls and their real proportion in the population of cows showed significant or highly significant differences in most of the observed years.

When counting allele and genotype frequencies in a population with a different intensity of use of several bulls it is important not only to analyze a particular genotype of the father but also his share of influence in the population of cows.

## SOUHRN

### Rozdíl v genových a genotypových četnostech mléčného proteinu kapa-kaseinu u býků nabízených do inseminace a jejich skutečný podíl v populaci krav

Cílem práce bylo vyhodnocení genových a genotypových četností mléčného proteinu kapa-kaseinu (CSN3) u býků nabízených plemenářskými společnostmi (n = 287) a skutečný podíl těchto otců (genotypů) v populaci krav (n = 27 970). Vyhodnocení genových a genotypových frekvencí bylo provedeno v období let 1994–2004 u plemene český strakatý. Průměrná četnost genotypů nabízených otců a jejich skutečné zastoupení v populaci krav bylo v letech 1994–2004: AA = 0,3902; 0,4572; AB = 0,4774; 0,3993; AE = 0,007; 0,0004; BB = 0,115; 0,1394 a BE = 0,0105; 0,0036. Genotyp EE nebyl zjištěn. Průměrná četnost alel byla A = 0,6324; 0,6571; B = 0,3589; 0,3409 a E = 0,0087; 0,002.

Ze souboru sledovaných krav (27 970 kusů) je u CSN3 zřejmá převaha využití otců s genotypem CSN3 AA a AB. Podíl těchto dvou genotypů se pohyboval ve sledovaných letech v rozmezí 0,7885 až 0,9836. Rozdíl mezi genotypovými četnostmi CSN3 (AA, AB a BB) nabízených býků a jejich skutečným podílem v populaci krav byl neprůkazný pouze v letech 1995, 1996, 1998, 2002 a 2003. V ostatních letech (1994, 1997, 1999, 2000, 2001, 2004) a také v průměru všech sledovaných let byl rozdíl průkazný až vysoce průkazný.

V žádném sledovaném roce (1994–2004) nebyly absolutní četnosti genotypů otců krav v genetické rovnováze. Genotypové četnosti u mléčného proteinu kapa-kaseinu nabízených býků a jejich skutečný podíl v populaci krav tak ukazují ve většině let průkazné až vysoce průkazné rozdíly. Kolísání vypočítané heterozygotnosti v letech 1994–2004 bylo velmi vysoké, v rozmezí hodnot od 14,03 % do 85,68 %. Heterozygotnost očekávaná byla v rozmezí 34,9 %– 49,59 %.

Hodnota PIC se pohybovala v letech 1994 až 2004 v rozsahu 0,2882–0,3767 s průměrem za všechny sledované roky 0,3516.

Pro sledování genových a genotypových četností v populaci s intenzivně využívanými otci je proto důležité sledovat jejich skutečný podíl na populaci připařovaných matek.


kapa-kasein, genové frekvence, genotypové frekvence, plemeno české strakaté

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Address

Ing. Jiří Bezdíček, Ph.D., Agrovýzkum Rapotín, s.r.o., Výzkumníků 267, 788 13 Vikýřovice, Česká republika, jiri.bezdicek@vuchs.cz