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THE EFFECT OF PRP GENOTYPE ON GROWTH OF RAMS ON TEST STATION

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Invited paper

Abstract: The frequencies of alleles on PrP locus and its effect on growth of rams were studied in Jezersko solčavska and improved Jezersko solčavska breed. Genetic resistance against scrapie depends on genotype on PrP allele. Animals were housed in quarantine at age of approximately 120 days. They were moved to test station where stated with test at the age of 184 days. The procedure was finished at the age of 257 days. During the test the animals were genotypized on the PrP locus. The frequency of the most susceptible allele VRQ was only 3.11 % and of the most resistant allele ARR it was 18.56 %. Daily gains between ages of 120 and 257 days and between 184 and 257 days were not influenced by PrP genotype. The PrP genotype influenced only daily gain between birth and age of 257 days. ARR allele as heterozygote in combination with other alleles showed good growth performances. The ARR homozygotes grew slower in comparison with other genetic combinations, but the differences in comparison to the other genotypes were not significant with exception of live period daily gain.

Key words: sheep, Jezersko solčavska sheep, PrP locus, scrapie resistance, growth

Introduction

Scrapie is well known prion disease of sheep. *Belt et al. (1995)* and *Hunter et al. (1996)* found, that the PrP locus is controlling resistance on scrapie. Five important mutations were found on that locus. The VRQ allele is the most susceptible and the ARR allele the most resistant on scrapie. The resistance against infection with scrapie of three other alleles is intermediate according to VRQ and ARR alleles. The high proportion or homozygosity of ARR on PrP locus was found as an appropriate method for controlling of scrapie. European Commission adopted a *Commission Decision 2003/100/EC* which obligates breeding organizations to implement programs which increase the frequency of ARR allele and decrease the frequencies of other, more susceptible alleles. The demands from that directive were also included in Slovenian breeding program. That program is important not only because of legal obligations, but also because the first infection with scrapie was found in Slovenia in year 2004. Infected were only flocks which originated from imported animals. Scrapie was fortunately never found in Slovenian autochthonous breeds.

The frequencies of PrP alleles differ between the breeds. The frequencies of the most frequent ARQ allele in continental breeds were found in interval between 50.4 % in Sardinian *(Salaris et al., 2007)* and 75.9 % in Churra sheep *(Alvarez et al., 2006)*. The most resistant ARR allele is less frequent: between 18.2 % in Churra *(Alvarez et al., 2006)* and 42.5 % in Sardinian sheep *(Salaris et al., 2007)*. The frequencies of VRQ allele are fortunately much lower: between 0.1 % in Sardinian sheep *(Salaris et al., 2007)* and 8.0 % in experimental Texel breed *(Brandsma et al., 2005)*. The ARR allele is much more frequent in British populations - between 31.1 and 76.5 % *(Roden et al., 2006)*.

Previously published results show some contradictories. The ARH allele showed favourable results of growth traits compared to ARR and ARQ alleles *(Casellas et al., 2007)*. Texel ARR/ARR homozygotes grew slower than animals with VRQ alele *(Brandsma et al., 2004)*. Meat traits in three French breeds *(Vitezica et al, 2005)* were not influenced by PrP genotype.

The aim of this study was to find out if the PrP genotype is affecting growth traits of rams of Jezersko – solčavska (JS) and improved Jezersko-solčavska breed (JSR).

Materials and Methods

Jezersko solčavska breed originates from west-northern part of Slovenia. The breed is known because of its all year fertility. The Improved Jezersko solčavska breed (JSR) originates from crosses of JS and Romanovska breed which were bred as closed population. The JSR breed is still fertile during the whole year with an increased litter size. JS and JSR are the most numerous breeds in Slovenia.

The rams of meat breeds are according to Slovenian breeding program tested on central test station. They entered quarantine facility at the average age of 120 days. The test of rams started at the age of 184 days and was finished at the age of 257 days. Animals were fed with hay ad libitum and one kg of concentrate with 15% crude proteins and 10.29 MJ ME per day. They were weighed at housing in quarantine facility, at housing in the test facility and at the end of the test. The samples for PrP analyses were collected during the test.

The growth of animals was studied during the test period (T), during the quarantine and test period (QT) and during the whole live period between birth and the end of the test period (LP).

The frequencies of genotypes and alleles were calculated with SAS/STAT procedure FREQ. The growth data were analyzed with SAS/STAT procedure GLM with the following two statistical models:

$$Y_{ijklmn} = \mu + B_i + G_j + J_k + M_l + L_m + b\left(W_{ijklmn} - \overline{W}\right) + e_{ijklmn} \quad \text{<1>}$$

$$Y_{ijklmn} = \mu + B_i + G_j + J_k + M_l + L_m + e_{ijklmn} \quad \text{<2>}$$

The independent variable Y_{ijklm} is representing the daily gain of animal, μ is an average of the model, B_i is the effect of the breed, G_j the effect of the PrP genotype, J_k the effect of the year of birth, M_l the month of the birth (season), and L_m is the effect of litter size. The $b\left(W_{ijklmn} - \overline{W}\right)$ is representing regression of the weight of animal n at the beginning of the period (at the housing in the test station, period T, and at the housing in quarantine, period QT). The e_{ijklm} is representing the residual of observation ijklm. Less frequent genotypes and animals from litters with three or more born animals were excluded from analysis of variance.

With the model <1> daily gain during growth periods T and QT was studied. The daily gain during the live period was studied with the model <2>.

Results and Discussion

During the last five years 1.288 rams were tested and genotypized. The frequency of alleles and PrP genotypes are presented in Figure 1. The most frequent allele was ARQ (65.53%). The value is in the middle of interval of ARQ frequencies, found in continental breeds - between 50.4 % in Sardinian *(Salaris et al., 2007)* and 75.9 % in Churra sheep *(Alvarez et al., 2006)*. The frequency of the most resistant allele ARR is 18.56 %. The frequency is low even for continental breeds, where frequency of 42.5 % was found on Sardinian sheep *(Salaris et al., 2007)*. Fortunately the frequency of VRQ allele is low (3.11%). Only 2.64 % of animals are ARR/ARR homozygotes and protected against scrapie. Only a little more than five percent of animals or every twentieth animal is a carrier of VRQ allele. On the other hand nearly one third of animals are carriers of ARR allele and partially resistant against scrapie. The breed is fortunately only moderately endangered by scrapie. The long-lasting selection for genetic resistance against scrapie will be necessary, because intensive selection can cause a decrease of production traits, even if PrP locus has no influence on growth rate.

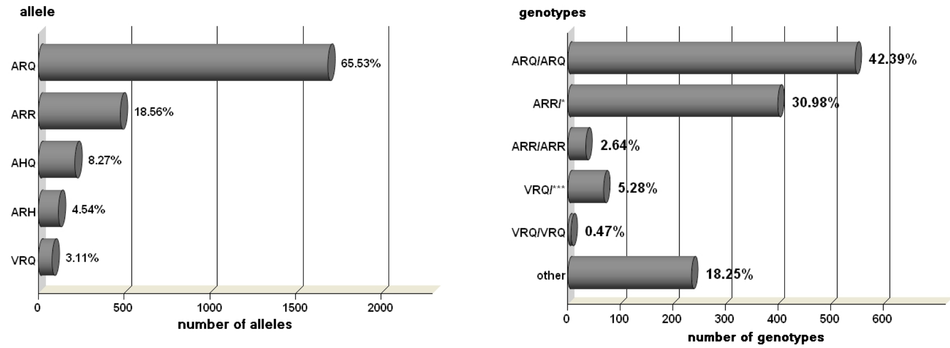

Figure 1. Frequencies of PrP alleles and genotypes in JS and JSR rams, tested in test station. Genotype ARR/VRQ is included in group VRQ/*

Average daily gains during the test period (T), during the quarantine and test period (QT) and between birth and the end of the test for seven selected genotypes are presented in Table 1.

Table 1. Average daily gains during the test period (T), during the quarantine and test period (QT) and between birth and the end of the test for seven selected genotypes

	AHQ/ARQ	ARH/ARQ	ARQ/ARQ	ARR/AHQ	ARR/ARH	ARR/ARQ	ARR/ARR
T	145	145	151	146	148	155	139
QT	127	129	128	127	131	133	124
LP	193	183	189	193	196	195	183

Daily gain during the live period between birth and the end of the test was the largest comparing to the other three periods. The test period is positioned after the period of the fastest growth. The growth of the animals in test period is also influenced by the moving of animals from farm to quarantine and from quarantine to test station. This is the reason why the daily gain between the birth and the end of the test is also included in selection index. Unfortunately, the most desired homozygote ARR/ARR was less productive genotype in all three growth periods.

The analysis of variance according to models <1> and <2> is presented in Table 2. The genotypes HQ/AHQ, ARH/ARH, AHQ/VRQ, ARH/ARH, ARH/VRQ, VRQ/VRQ, ARQ/VRQ and ARR/VRQ were excluded from statistical evaluation because of low frequency. LSMEANS and SE according to the both models are presented in Figure 2.

Table 2. Analysis of variance for daily gain during the test, during the quarantine and test (model <1>) and between the birth of animal and end of the test (live period) - model <2>

		T		QT		LP	
	df	F	P	F	P	F	P
model	29	7.33	<0.0001	7.95	<0.0001	6.12	<0.0001
breed	1	5.96	0.0148	4.90	0.0271	15.09	0.0001
PrP genotype	6	0.92	0.4780	0.67	0.6717	2.28	0.0339
year of birth	9	8.62	<0.0001	9.82	<0.0001	9.00	<0.0001
month of birth	11	4.20	<0.0001	3.78	<0.0001	5.71	<0.0001
litter size	2	0.42	0.5148	0.82	0.3661	3.51	0.0611
weight	1/0	42.42	<0.0001	62.22	<0.0001		/

The breed, the year and the month of birth influenced daily gain in each of the studied periods (P<0.05). The daily gain during test and during quarantine and test period was influenced by the start body weight. Litter size did not influence daily gain in all three periods. That effect was almost exception in case where daily gain in live period (LP) was studied.

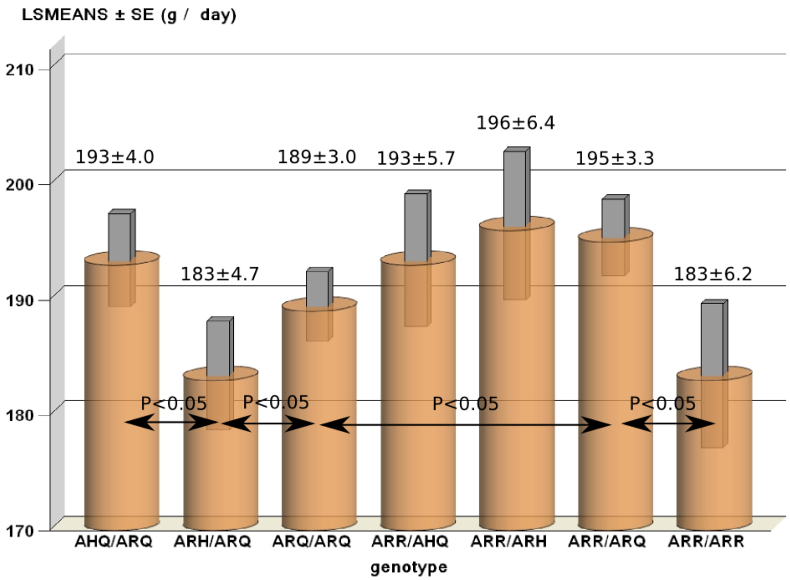

Figure 2. LSMEANS ± SE for daily gain between birth and the end of the test (LP). The arrows show statistical significant differences (P<0.05) between estimated LSMEANS for separate genotypes

The probability that litter size effected daily gain during whole live period was 0.0614. Birth weight was unknown and was not included in the model <2> and litter size. The litter size is correlated with birth weight which was not included in model <2>. Animals from larger litters have lower birth weight. Relatively high probability for the effect of litter size was probably the consequence of previously described relations between birth weight and litter size. The PrP genotype influenced only daily gain in live period (LP) but not in periods T and QT.

Genotype ARR/ARH (196±6.4 g/day) grew faster comparing to all other PrP genotypes, but the difference in comparison to other genotypes was not significant. The genotype ARQ/ARQ (189±3.0 g/day) grew significantly faster than genotypes ARR/ARQ (195±3.3 g/day) and ARH/ARQ (183±4.7 g/day). The ARR heterozygous animals grew much faster (ARR/AHQ 193 ± 5.7 g/day, ARR/ARH 196 ± 6.4 g/day, ARR/ARQ 195 ± 3.3 g/day) than ARR/ARR homozygous animals (183±6.2 g/day), but the difference was statistically significant (P<0.05) only comparing to genotype ARR/ARQ. The reason is an extremely large standard error of LSMEAN for ARR/ARR heterozygotes which can be a consequence of extremely low frequency (2.64 % in total) of ARR/ARR homozygotes. The result is not in contradiction with results on Texel population *(Brandsma et al., 2004)*, where the ARR/ARR genotype showed inferiority comparing to other genotypes. The effect of ARH allele on growth of rams was not possible to study because of low frequency. That allele showed favourable results in study of *Casellas et al. (2007)*. How the ARR homozygosity on PrP locus will influence the growth traits of JS and JSR breed is difficult to predict. Although the ARR homozygotes showed less acceptable growth performances during the LP period, the number of ARR homozygous animals was very low and consequently the standard error of estimated LSMEAN was large. The moving of animals and permanent adaptation of animals on changing environment is influencing the growth of animals and makes the picture unclear. Because of indicated negative effect of PrP genotype on daily gain in LP period and because of small number of ARR homozygotes, selection on increased frequency of ARR allele must be at least careful. The frequency of sensitive VRQ allele is fortunately low. Low frequency of VRQ allele indicates poor growth of animals with that allele and makes its elimination possible.

Conclusion

Scrapie is well known infective disease of sheep. The ARR alele on PrP locus causes genetic resistance against scrapie. Selection programs for sheep in EU are obligated to increase the genetic resistance on scrapie. Under some conditions selection on genetic resistance against scrapie can influence the production traits of some breeds. In the study it was found that in Slovenian populations of JS and JSR breeds:

- the frequency of the most susceptible allele VRQ is relatively low comparing to frequencies on other breeds,
- the frequency of the most resistant allele ARR comparing to frequencies at that allele on other breeds is also relatively low, but high enough to increase in relatively short time period.
- the PrP genotype did not influence daily gain of rams during the quarantine and test period between ages of 120 and 257 days as between ages of 184 and 257 days.
- the PrP genotype influenced life daily gain between birth and age of 257 days. Unfortunately the daily gain of ARR/ARR genotype was the lowest among the studied genotypes, but the difference in comparison to other genotypes was significant ($P<0.05$) only comparing to ARR/ARQ genotype.

The most sensitive VRQ allele for scrapie can be easily eliminated. The increase of frequency of the ARR allele must be done carefully because of low frequency of that allele and because some indications of negative influence on growth performance of rams of JS and JSR breeds.

Uticaj PrP genotipa na porast ovnova u testnim stanicama

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Rezime

Skrapi je poznata prionska bolest ovaca. PrP lokus određuje genetsku otpornost na skrepi. Jezersko solčavska (JS) i oplemenjena jezersko solčavska (JSR) su najzastupljenije rase ovaca u Sloveniji. Uključene su u slovenački odgajivački program. Zbog propisa Evropske Unije kao i zbog nekoliko registrovanih slučajeva ove bolesti u Sloveniji je iniciran program povećanja genetske otpornosti na skrepi. Cilj ovog istraživanja je bio da se utvrdi da li PrP genotip utiče na osobine porasta JS i JSR ovnova, testiranih u testnim stanicama. Test je uključivao period karantina i test period. Životinje su smeštene u karantin u uzrastu od oko 184 dana. Postupak je završen u uzrastu od 257 dana. Učestalost najpodložnijeg alela VRQ je bila samo 3.11 % i najotpornijeg alela ARR - 18.56 %. Dnevni prirasti u uzrastu između 120 i 257 dana nisu bili pod uticajem PrP genotipa. PrP genotip je uticao na dnevni prirast između rođenja i uzrasta od 257 dana. ARR alel kao heterozigot u kombinaciji sa drugim alelima je pokazao

dobre performanse kod porasta. ARR homozigoti su rasli sporije u poređenju sa ostalim kombinacijama, ali razlike prema ostalim genotipovima nisu bile signifikantne sa izuzetkom životnog dnevnog prirasta. Eliminacija VRQ alela se može uraditi bez ikakvih poteškoća. Povećanje ARR alela ili čak postojanje isključivo ovog alela se mora uraditi mnogo pažljivije kako bi se izbegao negativni uticaj ARR homozigotnosti na osobine porasta.

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