

PROTEIN PHENOTYPES AND PRODUCTIVE TRAITS IN LANDRACE, LARGE WHITE AND DUROC SWINE

FENÓTIPOS PROTÉICOS E CARACTERÍSTICAS PRODUTIVAS EM SUÍNOS LANDRACE, LARGE WHITE E DUROC

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SUMMARY

Fourteen protein systems coded by 15 structural loci were typed by horizontal electrophoresis to determine possible associations between the protein phenotypes and productive traits in Landrace (N=109), Large White (N=116) and Duroc (N=57) pigs, reared in Southern Brazil. Significant associations between protein phenotypes and production traits were detected. The most consistent interaction were observed between two protein systems (phosphogluconate dehydrogenase - Pgd and Hemopexin - Hpx) and at least one of the four performance variables considered. In Duroc breed, the Pgd phenotypes were associated with daily weight gain ($P < 0.01$), feed conversion ratio ($P < 0.01$) and selection index ($P < 0.001$), while in Landrace significant associations were observed only with feed conversion ratio ($P < 0.05$). The Hpx phenotypes were associated with daily weight gain ($P < 0.05$) and backfat thickness ($P < 0.05$) in Large White and with this last variable ($P < 0.01$) and selection index

($P < 0.05$) in Duroc pigs. Since these results had not been reported previously, further studies are need to confirm these associations.

Key words: pigs, protein phenotypes, production traits, associations.

RESUMO

Quatorze sistemas proteicos, codificados por 15 locos estruturais, foram tipados através de eletroforese horizontal para investigar possíveis associações entre os diferentes fenótipos proteicos e parâmetros de produção em suínos das raças Landrace (N=109), Large White (N=116) e Duroc (N=57), criadas no sul do Brasil. As associações mais consistentes foram detectadas entre dois sistemas enzimáticos (Fosfogliconato desidrogenase - Pgd e Hemopexina - Hpx) e, pelo menos, um dos quatro parâmetros produtivos considerados. Na raça Duroc foram verifica-

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das associações dos fenótipos de Pgd com o ganho de peso diário ($P < 0,01$), com a conversão alimentar ($P < 0,01$) e com o índice de seleção ($P < 0,001$), enquanto que na Landrace foram detectadas interações significantes apenas com relação à conversão alimentar ($P < 0,05$). Quanto ao sistema Hpx, foram verificadas associações significantes dos fenótipos desta proteína com o ganho de peso ($P < 0,05$) e com a espessura do toicinho ($P < 0,05$) entre os porcos Large White e nos Duroc com a espessura do toicinho ($P < 0,01$) e com o índice de desempenho ($P < 0,05$). Uma vez que tais resultados não foram observados em investigações anteriores, outros estudos serão necessários para confirmar estas associações.

Palavras-chave: suínos, características produtivas, fenótipos protéicos, associações.

INTRODUCTION

Studies concerning the inheritance of blood groups and protein types in many domestic animals have shown the occurrence of genetic polymorphisms at several loci (BOUQUET and WILLENS, 1971a and 1971b). In farm animals, the biochemical variability are frequently used as genetic markers to investigate the relationships between genetic phenotypes and productive traits. In this context several studies have been performed in swine (JENSEN et al., 1968; TRIPATHI and HOWELL, 1969; VÖGELI et al., 1984; BARDISA et al., 1986a and 1986b). Considering the economic importance of the hog-raising industry in Brazil and the lack of studies about biochemical polymorphisms in pig herds reared in this country, the objective of the present study was to investigate the possible occurrence of associations between protein phenotypes and productive traits.

MATERIAL AND METHODS

Blood samples and data concerning performance tests were obtained from 282 pigs (109 Landrace, 116 Large White and 57 Duroc) at two localities: the Boar Test Station of Venâncio Aires and Estrela, both in Rio Grande do Sul. At these stations the pigs were tested to select the best animals for the Swine Artificial Insemination Center of Rio Grande do Sul. The pigs that were tested came from several farms and were not directly related. The criteria used to preselect the animals were to choose healthy animals and the biggest pigs from the litters.

The performance tests considered were average feed conversion (FC), average daily weight gain (DG) and

ultrason backfat thickness (BT). The test were started when the animals weighed 30kg and were ended when they reached 90kg. A selection index (I) was calculated for each animal based on the results of all performance test according to the formula described by COSTA et al. (1985): $I = 100 + 0.25 (DG - DG) - 30 (FC - FC) - 40 (BT - BT)$, where DG, FC, BT are the averages of these performance results for each population of the different breeds.

Genetic variation was assayed by horizontal starch gel or by agarose gel electrophoresis at 15 structural loci: *malate dehydrogenase (Mdh)*, *isocitrate dehydrogenase (Idh)*, *phosphogluconate dehydrogenase (Pgd)*, *superoxide dismutase (Sod)*, *esterase D (EsD)*, *acid phosphatase (Acp)*, *amylase 1 (Amy1)*, *amylase 2 (Amy2)*, *glyoxalase I (Glo1)*, *phosphohexose isomerase (Phi)*, *albumin (Al)*, *ceruloplasmin (Cp)*, *Hemoglobin (Hb)*, *hemopexin (Hpx)* and *transferrin (Tf)*. The techniques of electrophoresis and proteins staining were those employed by TAGLIARO et al. (1993).

To investigate possible significant associations between performance data and specific protein phenotypes, the following statistical methods were used: the one-way analysis of variance (ANOVA) for data with homogeneous variances by the Bartlett test (ROSNER, 1982), and the Kruskal-Wallis one-way analysis of variances for data with heterogeneous variances (SIEGEL, 1956). The analyses were performed using Epi Info program (DEAN et al., 1990). When significant differences were detected among three distinct phenotype classes, the data were submitted to the Student-Newman-Keuls test (ZAR, 1974), using the SPSS/PC+ statistical program for micro computers (NORUSIS, 1986), to verify which classes are statistically different. The phenotype classes with less than five animals were excluded from these analyses.

RESULTS AND DISCUSSION

Among 15 loci investigated in the three breeds, eight were monomorphic (*Mdh*, *Idh*, *Sod*, *Acp*, *Amy2*, *Glo1*, *Al* and *Hb*) and one was polymorphic (*Cp*) but had an insufficient number of animals to be considered in this study.

Table I shows the number of animals with the different phenotypes detected for the systems that were polymorphic in at least one of the samples under consideration.

The significant associations found between average performance and specific protein phenotypes in Landrace, Large White and Duroc can be seen in Table II, III and IV, respectively.

Landrace pigs (Table II) presented associations between the phenotypes of three enzymatic systems (*Phi*,

Table I - Protein phenotypes at polymorphic loci observed in Landrace, Large White and Duroc breeds.

Loci	Phenotypes	Landrace (N=109)	Large White (N=116)	Duroc (n=57)
Pgd	Pgd AA	42	43	2
	Pgd AB	53	58	22
	Pgd BB	14	15	33
EsD	EsD AA	94	116	40
	EsD AB	14	0	17
	EsD BB	1	0	0
Amyl	Amy AA	4	0	0
	Amy AB	21	21	0
	Amy BB	83	95	57
	Amy BC	1	0	0
Phi	Phi AA	4	28	2
	Phi AB	26	47	17
	Phi BB	79	41	38
Hpx	Hpx 0-0	1	0	0
	Hpx 0-1	6	1	0
	Hpx 0-2	3	0	0
	Hpx 0-3	3	0	0
	Hpx 1-1	44	62	0
	Hpx 1-2	5	0	2
	Hpx 1-3	37	48	6
	Hpx 2-3	2	0	14
	Hpx 3-3	8	5	35
Tf	Tf AA	0	7	1
	Tf AB	8	25	9
	Tf BB	101	84	47

Pgd and Amyl) and two productive parameters (daily weight gain and feed conversion). According to these results Phi BB pigs were, on average, 6% superior to Phi AB pigs in relation to daily weight gain. Differences in average feed conversion were only detected between Pgd AA and Pgd AB phenotypes (Student-Newman-Keuls test). However, the average feed conversion of Pgd AB and BB animals on the role was significantly lower ($P < 0.01$) than that obtained for Pgd AA pigs. Thus, pigs which are carriers of **Pgd*B** allele may need a smaller amount of food to reach the same weight as the pigs that are not carriers of this allele. Differences between feed conversion and Amyl phenotypes were also detected; in this case Amyl BB animals are better than AB pigs.

Significant effects were observed in Large White breed (Table III) for Hpx system on two productive traits. Pigs with Hpx 3-3 phenotypes presented, on average, a daily weight 15% greater than those with the Hpx 1-3.

Table II - Significant associations detected between mean performance of productive trait tests and protein phenotypes in Landrace pigs.

Productive traits	Loci	Phenotype	N	Average	SD	P	SNK
Daily weight gain (g)	Phi	Phi AB	26	932.846	81.785	<0.05 (3)	
		Phi BB	79	990.038	128.703		
Feed conversion (kg)	Pgd	Pgd AA	42	2.903	0.240	<0.05 (2)	a
		Pgd AB	53	2.759	0.301		b
		Pgd BB	14	2.738	0.273		ab
	Amyl	Amy AB	21	2.972	0.191	<0.01 (3)	
		Amy BB	83	2.780	0.290		

SD standard deviation; P significance level;

SNK Student-Newman-Keuls test ($P < 0.05$); means followed by different letters differ significantly;

(2) One-way analysis of variance (ANOVA);

(3) Kruskal-Wallis one-way analysis of variance.

Table III - Significant associations detected between mean performance of productive trait tests and protein phenotypes in Large White pigs.

Productive traits	Loci	Phenotype	N	Average	SD	P	SNK
Daily weight gain (g)	Hpx	Hpx 1-1	62	996.661	120.706	<0.05 (2)	ab
		Hpx 1-3	48	953.792	104.257		a
		Hpx 3-3	5	1094.200	139.313		b
Backfat thickness (cm)	Hpx	Hpx 1-1	62	1.665	0.365	<0.05 (2)	a
		Hpx 1-3	48	1.518	0.335		b
		Hpx 3-3	5	1.392	0.291		ab
Selection index	Tf	Tf AA	7	63.121	36.776	<0.01 (2)	a
		Tf AB	25	89.740	43.651		ab
		Tf BB	84	106.132	38.695		b

SD standard deviation; P significance level;

SNK Student-Newman-Keuls test ($P < 0.05$); means followed by different letters differ significantly;

(2) One-way analysis of variance (ANOVA).

Differences were also detected between this system and backfat thickness, that is, Hpx 1-1 pigs had thicker backfat than those Hpx 1-3. There were no detectable differences between these two phenotypes and Hpx 3-3, however, when the Hpx 1-3 and 3-3 animals were grouped into one class, average backfat thickness were lower than the average estimated for Hpx 1-1 pigs ($P < 0.05$). This suggests that the **Hpx*3** allele may have an advantageous effect concerning this trait. Another significant results obtained in Large White involved the Tf system and the selection index, which was 68% higher in pigs with Tf BB type than in Tf AA animals. Tf AB heterozygous presented an intermediated value and the differences between this phenotype and the other two are not significant.

Table IV - Significant associations detected between mean performance of productive trait tests and protein phenotypes in Duroc pigs.

Productive traits	Loci	Phenotype	N	Average	SD	P	SNK
Daily weight gain (g)	Pgd	Pgd AB	22	1050.364	67.765	<0.01 (2)	
		Pgd BB	33	991.606	66.848		
Feed conversion (kg)	Pgd	Pgd AB	22	2.476	0.273	<0.01 (2)	
		Pgd BB	33	2.707	0.332		
Backfat thickness (cm)	Hpx	Hpx 1-3	6	1.900	0.261	<0.01 (2)	a
		Hpx 2-3	14	1.421	0.264		b
		Hpx 3-3	35	1.489	0.271		b
Selection index	Pgd	Pgd AB	22	116.086	24.162	<0.001 (2)	
		Pgd BB	33	88.017	26.516		
	Hpx	Hpx 1-3	6	73.892	15.946	<0.05 (2)	a
		Hpx 2-3	14	112.707	25.041		b
		Hpx 3-3	35	97.580	28.882		ab

SD standards deviation, P significance level;

SNK Student-Newman-Keuls test ($P < 0.05$); means followed by different letters differ significantly; (2) one-way analysis of variance (ANOVA).

In Duroc breed (Table IV), significant effects were detected for Pgd phenotypes on productive traits. Pgd AB carriers had a higher daily weight gain and a lower feed conversion than Pgd BB homozygous. Furthermore, the selection index of Pgd AB pigs was, on average, 32% higher than that of Pgd BB pigs. Considering the Hpx system, Hpx 2-3 and 3-3 animals presented a smaller backfat thickness than Hpx 1-3 pigs. The selection index of Hpx 1-3 carriers was lower than that of Hpx 2-3.

Many attempts have been made to correlate biochemical polymorphisms to quantitative traits of economic importance in farm animals. In present study, the most consistent effects were observed for two protein loci (**Pgd** and **Hpx**) on at least one of the four productive parameters.

In Duroc breed the Pgd phenotypes were associated with daily weight gain, feed conversion ratio and selection index, while in Landrace a significant association was only detected between this system and feed conversion. VÖGELLI et al. (1984) investigating the effects of several protein loci, including Pgd system, on production traits did not verify, in Swiss Landrace pigs, an association between feed conversion and this system. They also did not verify significant differences in the gene frequencies of Pgd between two line of Landrace pigs (one superior and another inferior) selected for several generations with relation to daily weight gain, feed conversion and backfat thickness.

In this study associations were also detected between Hpx phenotypes and daily weight gain and backfat thickness in Large White and between this system and selection index in Duroc. RIPATHI and HOWELL (1969) studying Yorkshire pigs, which in Brazil is considered the same breed as Large White, and JENSEN et al. (1968) studying Duroc animals did not find any of these associations.

There are great variations among the results obtained in several studies and some of them are inconsistent with no clear patterns of associations (RASMUSEN, 1981). Some of the conflicting results may occur due to problems inherent to the statistical analyses. Furthermore, the interpretation of these data is complicated by the fact that the mechanism responsible for a specific association is frequently not identified, since there are several factors (pleiotropy, linkage disequilibrium, heterozygote advantage, epistatic effects) which might involved in the interactions between biochemical phenotypes and quantitative traits. It is clear, therefore, that further studies, on a large number of animals, are required to confirm, or not, the results obtained in this investigation.

ACKNOWLEDGMENTS

The authors are grateful to the ACSURS (Associação dos Criadores de Suínos do Rio Grande do Sul) for providing the material for this study. They also wish to thank Sídia Callegari-Jacques for the useful suggestions concerning the statistic analyses.

This study was supported by CNPq, FAPERGS, FINEP and PROPESP/UFRGS.

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