STUDIES ON POSSIBLE ASSOCIATIONS BETWEEN THE MAJOR HISTOCOMPATIBILITY COMPLEX AND REPRODUCTION TRAITS IN SWINE

C. GAUTSCHI[1], C. GAILLARD[1], B. SCHWANDER[2] and S. LAZARY[1]

1) Institute of Animal Breeding, University of Berne, Switzerland
2) Herdbook of Small Livestock, Berne, Switzerland

Summary

The effect of swine lymphocyte antigens (SLA) on different reproductive traits were investigated. 609 sows and 133 boars from two breeds were involved in the evaluation. Reproductive performances were measured by litter size and average piglet weight at birth and at weaning as well as the still-birth rate. Some SLA-haplotypes had significant positive effects on reproductive performances where as others had negative ones. In many cases an increased homozygosity in the litter affected prolificacy as well as average piglet weight at birth. SLA-haplotypes can be used to improve female fertility in a selection program as long as no close antagonistic correlation exist with important production traits.

Introduction

The major histocompatibility complex (MHC) plays a central role in the immune system, but there are also many non-immune functions connected with it (Edidin, 1983). Of special interest are the MHC-linked genes associated with certain reproduction traits. Experiments have shown MHC involvement in mating preference (Yamazaki et al., 1976), fetal loss and fetal weight (Melnick et al., 1981) and in the control of early embryonic development in mice (Warner et al., 1984), fertility in the rat (Kunz et al., 1980) and higher egg production in the chicken (Simonsen et al., 1982). In humans, sharing of MHC-antigens might lead to recurrent abortion (Beer et al., 1981), although these results have been disputed (Caudle et al., 1983).

The MHC of the pig is called SLA (Swine Leucocyte Antigen) and is quite well analysed (Vaiman et al., 1979). The complex is situated on chromosome 7 together with the blood group systems C and J. It consists of three class I and two class II loci, which are closely linked. The five corresponding alleles generally segregate together. Their association is named haplotype. The class I antigens are identified using serological methods. As in other species, the system is highly polymorphic and therefore a good genetic marker.

There is evidence that the SLA complex is involved in production parameters (Capy et al., 1981) and reproduction. In France, where most studies have been done, a decrease in the number of piglets was observed when the boar and sow shared one SLA haplotype (Vaiman et al., 1980; Renard et al., 1985). Some haplotypes seemed to have an influence on birth and weaning weights (Rothschild et al., in press), difference in ovulation rate (Rothschild et al., 1984) and piglet mortality (Kristensen et al., 1980; Renard et al. 1982). Segregation distortion associated with the SLA complex has been reported (Philipsen and Kristensen, 1985). The purpose of our study was to further investigate the relationship between SLA complex and reproduction in the pig.

Material and Methods

SLA-typing was performed on 743 pigs from 10 different breeding units. The animals consisted of 357 sows and 72 boars in 5 Large White (LW) herds and 252 sows and 61 boars in 5 Swiss Landrace (LR) herds. The SLA-antigens were detected by a standard microlymphocytotoxicity test (Vaiman et al., 1978). The antisera had been produced in France, Switzerland and Denmark. The agreement between antigen assignment and reaction pattern of the SLA reagents has been described by Kristensen et al. (1985). In 12.4 percent of the LR sows and 15.8 percent in LW, the haplotype could not be determined. These blanks are either homozygotes or have one undefined haplotype.

Reproduction traits were measured by breeders and reported to the central herdbook from where the data were taken, together with the identity of the parents. For statistical evaluations the following traits were considered: litter size at birth (live piglets only) = LSB, still-birth rate = SBR, average corrected piglet weight at birth = PWB, litter size after 28 days = LSW and average corrected piglet weight at 28 days of age = PWW. The average piglet weight were standardized for litter size (LSW = 9) and interval birth-test day (standard 28 days). The estimated (partial) regressions are:

		LW	LR
PWB	kg/piglet	-0.042	-0.037
PWW	kg/piglet	-0.185	-0.248
	kg/day	-0.169	-0.138

Before LSW and PWW were analysed, all sows were eliminated where LSW were greater than LSB in order to discard foster-mothers. Overall averages of the reproduction traits are given in table 1. Means of litter sizes are slightly lower than the corresponding breed averages and the fertility is generally better in LW than LR.
In order to eliminate herd effects as much as possible from our figures, each individual performance was compared with the corresponding herd-year-parity average. Included in this average were all sows, also those which were not SLA typed. Deviations were further weighted for the number of observations in the herd-year-parity subclass. Statistical evaluations were carried out with the weighted deviations. Least-squares analysis were performed either with SAS or LSML76 programs (Harvey, 1977; SAS, 1982).

Results and Discussions

Only the significant estimated mean differences between sows with a given haplotype and those without it are given in table 2. The means were estimated by LSQ-methods with a model including effect of the haplotype (fixed) and effect of the sows within haplotype (random). In LW the offspring of HBe2 sows has a lower birth weight but at weaning this difference is no longer present. The litter size at weaning is 0.23 piglet less for sows with HBe3 and the average piglet weight at that time is significantly better than the other groups, although the piglet weights were corrected for litter size. HBe6 sows show the opposite. Animals with HBe9 farrow smaller litters. Sows of the LR breed with HBe1 weaned on average heavier piglets. HBe19 sows are apparently poor mothers. Their piglets were lighter at birth and did not catch up at weaning. Schwörer et al.(1984) found similar results for the same breeds in sows with SLA HBe1, HBe2 and HBe3; the other haplotypes were either not tested or with too few animals.

In an additional LSQ analysis, the reproductive performances of homozygous HBe9 sows (n=29) were compared with heterozygotes having the same haplotype (n=469). The mean difference between these two groups was 0.76 piglets less at birth ($P < 0.15$) and 0.5 kg lighter at weaning ($P < 0.05$) for the homozygotes. Similar comparisons with other haplotypes were not calculated because of the very small number of homozygous sows in those groups.

Further, some mating studies were performed to investigate the effect of homozygosity on reproduction traits. Within haplotypes matings were grouped in three classes according to the expected proportion of homozygous piglets in the litter (1 = 0 percent, 2 = 25 percent, 3 = 50 percent homozygotes). Because the number of homozygous sows are different from haplotype to haplotype and these sows had significantly lower reproductive performances (e.g. HBe9 sows, see above) only heterozygous dams were considered in the analyses. Only those mating boars have been chosen, where both haplotypes were known. Matings between two identical heterozygotes were discarded, because the effect of homozygosity cannot be attributed to one of the haplotypes. The effects of mating classes on reproduction traits were measured by regression coefficients. Only results of mating classes with more than 30 litters are shown in table 3. LSB is affected seriously in four haplotypes but only for HBe3 is the regression significantly different from zero ($P < 0.1$). In this case, an increase of 25 percent of homozygous piglets by assortive mating with respect to SLA, would result in an average decrease of 0.39 piglet per litter. Among the HBe13 the litter size at birth increases with homozygosity but the still-birth rate increases too ($P < 0.05$). In HBe9 an expected increase of homozygosity of 25 percent lowered the average birth weight significantly by 50g ($P < 0.05$). That part of the variance explained by the regression model is very low for all analyses (R^2 = 0.2% to 4%).

Conclusion

These results suggest that some SLA-haplotypes have an influence on different reproduction traits. Worth mentioning is the fact that decreased prolificacy of sows seems more likely to depend on embryonic development than on still-birth rate. Matings avoiding homozygotes in the litters, would benefit breeders with better reproductiv performances. These SLA-haplotypes could be used to improve female fertility by selection and planned matings as long as no close antagonistic association with other performances exists (e.g. growth, carcass).

Acknowledgement

This work was supported by grants from private Swiss breeding organizations and the Federal Swiss Veterinary Office.

References

Beer, A.E., Quebbeman, J.F., Ayers, J.W.T. and Haines, R.F. 1981. Am.J.Obstet.Gynecol. 141, 987-999.

Capy, P., Renard, Ch., Sellier, P. and Vaiman, M. 1981. Ann. Génét.Sél.anim. 13 (4), 441-446.

Caudle, M.R., Rote, N.S., Scott, J.R., De Witt, C., Barney, M.F. 1983. Fertil.Steril. 39, 793-798.

Edidin, M. 1983. Immunology today 4, 269-270.

Harvey, W.R. 1977. Mimeographed paper, Ohio State University.

Kristensen, B., Wäfler, P. and de Weck, A.L. 1980. Animal Blood Groups and Biochemical Genetics II(Suppl. I), 58-59.

Kristensen, B., Philipsen, M., Lazary, S., Renard, Ch. and de Weck, A.L. 1985. Animal Blood Groups and Biochemical Genetics 16, 109-124.

Kunz, H.W., Gill, T.J.III, Dixon, B.D., Taylor, F.H. and Greiner, D.L. 1980. J.Exp.Med. 152, 1506-1518.

Melnick, M., Jaskoll T. and Slavkin H. 1981. Immunogenetics 14, 303-308.

Philipsen, M. and Kristensen, B. 1985. Animal Blood Groups and Biochemical Genetics 16, 125-133.

Renard, Ch., Vaiman, M., Capy, P. and Sellier, P. 1982. Congress Proceedings. 2nd World Congress on Genetics Applied to Livestock Production (Madrid) VIII, 570-583.

Renard, Ch., Bolet, G., Dando, P. and Vaiman, M. 1985. Journées Recherche Porcine en France 17, 105-112.

Rothschild, M.F., Zimmerman, D.R., Johnson, R.K., Venier, L. and Warner, C.M. 1984. Animal Blood Groups and Biochemical Genetics 15, 155-158.

Rothschild, M.F., Renard, Ch., Bolet, G., Dando, P. and Vaiman, M. (In Press) Animal Blood Groups and Biochemical Genetics (SLA Complex and Weaning Weights).

SAS, 1982. SAS Institute Inc., Cary, North Carolina.

Schwörer, D., Kristensen, B., Blum, J.K. and Schneider A. 1984. Schweiz.Landwirtsch.Monatsh. 62, 268-272.

Simonsen, M., Kolstad, N., Edfors-Lilja, I., Liljedahl, L.-E. and Sorensen, P. 1982. Amer.J.Reprod.Immunol. 2, 148-152.

Vaiman, M., Hauptmann, G. and Mayer, S. 1978. Journal of Immunogenetics 5, 59-65.

Vaiman, M., Chardon, P. and Renard, Ch. 1979. Immunogenetics 9, 353-361.

Vaiman, M. and Renard, Ch. 1980. Animal Blood Groups and Biochemical Genetics II(Suppl. I), 57.

Yamazaki, K., Boyse, E.A., Miké, V., Thaler, H.T., Mathieson, B.J., Abbot, J., Boyse, J., Zayas, Z.A. and Thomas, L. 1976. J.Exp.Med. 144, 1324-1335.

Table 1 Overall means and standard deviation (SD) of reproduction traits

Trait		Number	Mean	SD
			Large White	
Litter size at birth	LSB	1306	9.86	2.63
Still-birth rate	SBR	1306	4.83 %	8.66 %
Av. piglet weight at birth	PWB	1306	1.40 kg	0.21 kg
Litter size at 28 days	LSW	1216	8.94	2.31
Av. piglet weight at 28 days	PWW	1216	6.85 kg	1.13 kg
			Landrace	
Litter size at birth	LSB	872	10.16	2.59
Still-birth rate	SBR	872	7.52 %	10.68 %
Av. piglet weight a birth	PWB	872	1.41 kg	0.20 kg
Litter size at 28 days	LSW	745	9.32	1.90
Av. piglet weight at 28 days	PWW	745	7.56 kg	1.22 kg

Table 2 Estimated mean differences between sows with a given haplotype and those without the haplotype

Haplo- type	Number of litters with the haplotype	LSB	SBR %	Traits PWB kg	LSW	PWW kg
				Large White		
HBe2[1]	269	+.08	+.50	-.03°	-.00	+.05
HBe3	612	+.04	+.19	+.00	-.23°	+.14*
HBe6	123	+.42	-.86	-.02	+.53*	-.22°
HBe9	664	-.29°	-.08	+.02	-.14	+.09
				Landrace		
HBe1	393	-.08	-.00	+.02	-.07	+.13°
HBe19	142	-.07	-.97	-.05**	-.25	-.19°

° P < 0.1
* P < 0.05
** P < 0.01

[1] our nomenclature

Table 3 Regressions of reproduction traits on degree of homozygosity in litters

Haplotype	Number of litters	Regression on mating class[1] LSB	SBR %	PWB kg
		Large White		
HBe2	96	+.07	- .14	+ .14
HBe3	275	-.39°	+ .18	- .02
HBe9	294	-.31	- .33	- .05*
HBe11	91	-.42	+ .34	- .03
		Landrace		
HBe1	92	-.54	+2.89	-0.03
HBe13	117	+.40	+4.37*	-0.05
HBe18	37	-.03	-1.28	+0.03

[1] Definition of mating class see text