



Novel insight into linkage disequilibrium and additive effect of *GBP1* and *GBP5* SNP haplotypes associated with porcine reproductive and respiratory syndrome virus susceptibility in Korean native pigs

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Accepted for publication 22 August 2021

Brief note

The major quantitative trait loci related to host resistance to porcine reproductive and respiratory syndrome virus (PRRSV) and weight gain have been identified by genome-wide association studies.^{1–3} In addition, the viral load and weight gain traits of PRRSV-infected pigs have strong negative phenotypic and genetic correlations.^{3,4} Several studies have shown that SNPs (rs712180276, WUR10000125, and rs340943904) in the *guanylate binding protein 1* (*GBP1*) and 5 (*GBP5*) genes have significant correlations with the viral load and weight gain of PRRSV-infected pigs.^{2,5–7} In particular, WUR10000125 in *GBP1* and rs340943904 in *GBP5* have complete or strong linkage disequilibrium (LD; $r^2 > 0.70$) in many pig breeds^{8–10} and individual with homozygous recombinant haplotypes have so far not been reported. This precludes an estimation of additive genetic effects of the *GBP1* and *GBP5* SNPs.

This study analyzed, in 113 Korean native pigs (KNPs), associations of the three SNPs (Table S1) with three phenotypes of days to 90 kg, backfat thickness (BF), and average daily gain (ADG; Table S2), considering sex and genotype as fixed effects and slaughter age as a covariate. The degree of LD between *GBP5* (rs340943904) and

GBP1 (WUR10000125) SNPs, D' , and r^2 between the variations were estimated.¹¹

Individuals with rs340943904 genotype GT genotyped pigs grew more slowly than those with GG genotype (Tables S3, S4; TT has not been observed). Two SNPs (rs712180276 and WUR10000125) in *GBP1* were also in complete LD in our KNPs. The WUR10000125 GG genotype had a significant effect on ADG and BF ($P < 0.05$). Unlike in previous studies, the two SNPs *GBP5*: rs340943904 and *GBP1*: WUR10000125 showed very low LD ($r^2 = 0.203$, Tables S5, S6a). The frequencies of haplotype (ht) 1 (-GA-), ht2 (-GG-), and ht3 (-TG-) were 0.814, 0.142, and 0.044, respectively (Table S5b). Ht1 confers a significantly better BF ($P = 0.021$) than ht2, while it had faster growth in days to 90 kg and ADG than ht3 (Table 1). Ht2 showed clearly faster growth than ht3 ($P < 0.001$), suggesting that individuals with the rs340943904 SNP T and WUR10000125 SNP G alleles, which are associated with high resistance to PRRSV, grow more slowly.

Lack of LD in KNP results indicated rs340943904 and WUR10000125 SNPs have independent effects on growth traits, with the allele effect size of *GBP5* is larger than for *GBP1*. Hence, we suggest that the KNP is a suitable population for studies of the mechanism of PRRSV resistance.

Acknowledgements: This work was carried out with the support of the “Cooperative Research Program for Agriculture Science and Technology Development (Project No. PJ015611)” Rural Development Administration, Republic of Korea.

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Table 1 Differences in phenotypes between the *GBP5* (rs340943904) and *GBP1* (WUR10000125) haplotypes in 113 Korean native pigs.

Haplotype estimate	D90 (days) least squares means \pm S.E (p -value)	BF (mm)	ADG (kg)
ht1 (GA) vs. ht2 (GG)	4.54 \pm 2.37 (0.336)	0.15 \pm 0.03 (0.021)	-0.02 \pm 0.01 (0.107)
ht1 (GA) vs. ht3 (TG)	-20.06 \pm 4.02 (0.004)	-0.22 \pm 0.05 (0.012)	0.04 \pm 0.01 (0.010)
ht2 (GG) vs. ht3 (TG)	-24.60 \pm 6.49 (0.002)	-0.36 \pm 0.09 (<0.001)	0.05 \pm 0.01 (<0.001)

D90, days to 90 kg; BF, backfat thickness; ADG, average daily gain (kg); SE, standard error; ht, haplotype structure in *GBP5* (rs340943904) and *GBP1* (WUR10000125) polymorphisms.

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Supporting information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Table S1 The candidate genes and polymorphisms examined in this study.

Table S2 Summary statistics for the four phenotypes in Korean native pigs.

Table S3 Genotype and allele frequency of three polymorphisms in the *GBP5* and *GBP1* genes genotyped in 113 Korean native pigs.

Table S4 Associations of three *GBP5* and *GBP1* polymorphisms with phenotypic data of Korean native pigs ($n = 113$).

Table S5 Linkage disequilibrium and haplotypes between *GBP5* (rs340943904) and *GBP1* (WUR10000125) SNPs in 113 Korean native pigs.

Table S6 Combined frequencies of the *GBP5* (rs340943904) and *GBP1* (WUR10000125) polymorphisms in 113 Korean native pigs.
