Selection for Increased Natural Antibody Levels to Improve Disease Resilience in Pigs

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Summary and Implications

Breeding animals are typically raised under high health conditions in nucleus herds, but their offspring are often exposed to multiple disease challenges in commercial production facilities. Because breeding animals are not exposed to many common swine pathogens, it is difficult to select for resilience to disease. A possible solution is selecting for levels of natural antibodies (NAb), which can be measured in a high health environment and in this study are shown to correlate with disease resilience and to be heritable (h^2 = 0.11 to 0.39). Therefore, breeding for increased NAb levels in clean conditions could be a valuable method to improve resilience and decrease mortality in market pigs. Work is ongoing to verify the potential of this prediction.

Introduction

Because genetic nucleus farms are not typically exposed to diseases, it is difficult to selectively breed for the disease resilience that is critical in commercial production environments. Breeding for higher levels of immunoglobulin G and M (IgG and IgM) natural antibodies (NAb) may provide a solution. NAb are a part of the innate immune system and provide a rapid defense against unfamiliar pathogens by binding to conserved structures (epitopes) that are found on most pathogens. Higher NAb levels have been found to be correlated with higher survival rates in laying hens and with lower incidence of disease in dairy cattle. NAb levels are also heritable in these species, making them good candidates for selection. This is the first study to investigate NAb as a potential selection criterion for breeding for disease resilience in swine.

Materials and Methods

Data from a natural disease challenge project at the CDPQ were used in this research. Blood samples were collected from 28 batches of approximately 60 healthy Yorkshire x Landrace weaner pigs from different companies and genetic backgrounds (*n*=1,705). On these blood samples, levels of the IgG and IgM NAb that bind four common antigens (lipopolysaccharide, lipoteichoic acid, peptidoglycan, and keyhole limpet hemocyanin, abbreviated as LPS, LTA, PDG, and KLH, respectively) were measured using an indirect ELISA. These pigs were then introduced into a natural challenge facility, where they were naturally exposed to multiple bacterial and viral pathogens, including PRRSV, through contact with older animals in a continuous flow system. Growth, feed intake, and mortality/morbidity data were collected until the animals reached market age (181±9 days of age).

Genotypes on 658,692 genetic markers were also collected on these animals using a 650k SNP chip. After quality control and imputation, about 481,000 markers on 1,215 animals remained and were used to create a genomic relationship matrix. Finally, SAS was used for phenotypic analysis and ASReml for genetic analysis; in both cases, data were modeled using batch and entry age as fixed effects and sow as a random effect.

Results and Discussion

IgG NAb levels against the four antigens were significantly and positively phenotypically correlated with each other ($P<0.0001$, r = 0.28 to 0.70). Similarly, all IgM NAb levels were correlated with each other ($P<0.001$, r = 0.10 to 0.81). With the exception of IgG NAb against LTA, all IgG NAb levels were also significantly correlated with all IgM NAb levels ($P<0.001$, r = 0.11 to 0.15). This suggests that pigs with a high NAb level against a particular antigen have higher NAb levels overall. Subsequent research will evaluate the genetic correlations between NAb against different antigens to evaluate whether selecting for high NAb levels against one antigen will also select for higher NAb levels overall.

IgG and IgM NAb levels were found to be moderately heritable, with heritabilities of, respectively, 0.27 to 0.39 for IgM, and, respectively, 0.11 to 0.19 for IgG. However, as expected from previous research, there were also substantial maternal environmental effects (c^2) on NAb levels (c^2 = 0.03 to 0.10 for IgM, c^2 = 0.37 to 0.53 for IgG). This could be due to the effect of NAb in colostrum that is absorbed and still detectable in piglets after weaning. These heritabilities suggest that NAb can be improved by selective breeding and that NAb in colostrum may increase NAb in a sow's piglets, potentially improving their peri-weaning performance under disease challenge.

Higher levels of IgM against KLH, LPS, and PDG were phenotypically significantly correlated with fewer medical treatments during the 180 days in the natural challenge facility, a measure of resilience ($P<0.05$, $r = -0.091$ to -0.062). Higher levels of IgG NAb against KLH were also favorably correlated with another measure of resilience: decreased day-to-day fluctuations in feed intake ($P<0.05$, $r = -0.072$), although correlations were small. In addition, animals that survived to market age had significantly higher levels of IgG NAb against KLH, LPS, and PDG than animals that died prematurely ($P<0.01$). These results demonstrate that NAb levels collected from pigs in high-health environments can be used to phenotypically predict resilience and mortality under a disease challenge, and that higher NAb levels at a young age correspond to increased resilience and decreased mortality in swine. Subsequent research will evaluate the genetic correlations of NAb with disease resilience to determine whether selection for NAb measured on healthy pigs is expected to genetically improve disease resilience.

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