Characterizing the genomic background of climatic resilience in pigs through quantitative genomics, novel traits, and biological validation studies

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Summary

Heat stress is a major challenge to pig welfare and production efficiency across all stages of production. Lactating sows are particularly vulnerable due to the increased metabolic demands associated with larger litter sizes, greater milk production, and endogenous heat generation. Although genomic selection has substantially accelerated genetic progress for economically important production and reproductive traits, the lack of direct heat-tolerance indicators into breeding objectives may have inadvertently reduced the ability of modern sow populations to cope with thermal stress. The development of sustainable breeding programs requires the identification of novel phenotypes, biomarkers, and genomic evaluation strategies that enable the genetic improvement of heat tolerance and climatic resilience. Our previous research has demonstrated the existence of genetic variation in heat stress response in both gestating sows and growing-finishing pigs using routinely recorded performance data combined with environmental gradient descriptors derived from public weather databases. More recently, we have focused on identifying alternative phenotypes and biomarkers that more directly capture the physiological and behavioral mechanisms underlying heat stress response in pigs raised under challenging climatic conditions. Our research program adopts an integrative systems-biology approach that combines genomics, behavior, microbiome profiling, epigenomics, and deep phenotyping to better understand the biological basis of heat stress adaptation and climatic resilience in pigs. Particular emphasis has been placed on the development of novel resilience indicators derived from the variability of automatically recorded vaginal temperature measurements, which provide a continuous assessment of the animal's ability to maintain thermal homeostasis under environmental challenges. In this presentation, I will discuss: (1) the characterization of environmental gradient variables and critical periods relevant for genomic evaluations of heat tolerance, as well as their impact on the accuracy of genomic breeding values; (2) the genetic background of multiple heat-tolerance and climatic resilience indicators, including the development and validation of novel phenotypes and the results of divergent genetic selection for climatic resilience in pigs; (3) the role of the microbiome and epigenome in shaping individual differences in climatic resilience and adaptation to thermal stress; and (4) recommendations for the implementation of genomic selection programs aimed at improving heat tolerance, resilience, and long-term sustainability in commercial pig populations.