Development and validation of genomic breeding values for heat tolerance in Holstein cattle

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Abstract

Temperature and humidity levels above a certain threshold decrease milk production in dairy cattle, and there is genetic variation associated with the amount of lost production. To enable selection for improved heat tolerance, this study first developed genomic estimated breeding values (GEBV) for heat tolerance in Holstein dairy cattle, then validated the GEBV using groups of animals with extreme GEBV for heat tolerance and climate controlled chambers. To develop the GEBV for heat tolerance, heat tolerance was defined as the rate of decline in production under heat stress. Herd test day recording data from 366,835 Holstein cows was combined with daily temperature and humidity measurements from weather stations closest to the tested herds, for test days between 2003 and 2013. Daily mean values of temperature humidity index averaged for the day of test and the four previous days (THI) was used as the measure of heat stress. Tolerance to heat stress was estimated for each cow using a random regression model, and the slope solutions for cows from this model were used to define the daughter trait deviations (DTD) of their (2735) sires, which were genotyped for 632,003 SNP. Genomic best linear unbiased prediction (GBLUP) was used to calculate GEBV for heat tolerance, for milk, fat and protein yield. To validate the GEBV for heat tolerance, GEBV were calculated for 390 primiparious Holstein heifers, and 24 extreme predicted heat tolerant and 24 extreme predicted heat susceptible heifers were selected for the trial. The 48 cows were randomly assigned to controlled-climate chambers for a 4 day heat challenge. Daily temperatures and relative humidity inside the chambers were cycled to approximate diurnal patterns and ranged from 23.3 to 31.6°C (26.3°C mean) and from 42.2 to 71.2% relative humidity (55.2% mean), (THI = 78.6 to 89.8, 82.5 mean). The predicted heat tolerant group had significantly less decline in milk production ($P<0.05$), and lower core temperature (both rectal and intra-vaginal, $P<.05$) during the simulated 4 day heat wave event, than the predicted heat susceptible group. The results of the validation study suggest the GEBV for heat tolerance developed here will enable selection for cattle better able to cope with heat stress events, which in many dairying regions are increasing in frequency and duration.
Keywords: genomic, heat tolerance