Estimation and exploitation of genetic differences in environmental variance in animal breeding

Han A. Mulder, Piter Bijma, Roel F. Veerkamp, William G. Hill

There is empirical evidence that genotypes differ not only in mean trait value, but also in environmental variance of the traits they affect. Genetic heterogeneity of environmental variance may indicate heritable differences in environmental sensitivity that can be exploited in animal breeding to increase robustness and uniformity of animals by selection. The aims of our work were (1) to develop a framework for prediction of breeding values and selection responses in mean and environmental variance and (2) to estimate genetic variation in environmental variance in a commercial chicken line.

The framework was based on the assumption that both trait means and environmental variances were treated as heritable traits. Deterministic equations were derived to predict breeding values and selection responses, using information on own phenotype or information on sibs or progeny. A measure of heritability was proposed for environmental variance to standardize results in the literature and facilitate comparisons to heritability of 'conventional' traits. First results show that environmental variance has a low heritability. Therefore, a large amount of information is necessary to accurately estimate breeding values for environmental variance. Nevertheless responses in environmental variance can be substantial compared to the mean environmental variance, because of a high genetic coefficient of variation. Theoretical predictions suggest that in breeding programs with large family sizes, responses in environmental variance could be as large as 10% of the current environmental variance after one generation of directional selection, e.g. to improve uniformity.

For the second objective, we analyzed 6-week body weight of a commercial chicken line. The data sets comprised 26,972 female and 24,407 male body weight records. Heritabilities of environmental variance were 0.037 and 0.032, respectively in females and males. Genetic correlations between mean body weight and environmental variance were -0.41 and -0.45, respectively in females and males. Surprisingly, the genetic correlation between environmental variance in females and males was 0.11, suggesting that female and male environmental variance are different traits.

Results indicate that genetic differences in environmental variance exist. Our framework can be used to evaluate the consequences of artificial and natural selection on mean and environmental variance.