



New models for prediction of breeding values for exterior traits

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In November 2021 we have switched to the new models for the estimation of breeding values for exterior traits. The main advantage about the new models is higher accuracy of predicted breeding values and higher heritability. This will enable Norwegian Red cattle faster genetic gain for exterior traits, and better prediction accuracy of the breeding values for the farmers when genotyping their female calves.

Genetic improvement is a function of four factors: genetic variability, intensity of selection, accuracy of predicted breeding values and generation interval. Genetic improvement will be faster when we increase genetic variability, intensity of selection and the accuracy of predicted breeding values and decrease the generation interval. The new models for exterior traits will improve the accuracy of predicted breeding values which will lead to a faster genetic gain.

For an easier understanding of what better accuracy of prediction means in practice we will have a look at a small example. Imagine we have two traits, one where the prediction accuracy is 0,1 and the other one where it is 0,9. Our task here is to select 50 bull calves with the highest breeding value for each of the trait from the total of 1000 bull calves. The problem that we have is that we do not know the true breeding value but only predicted breeding value. When we select animals, they will be selected based on the predicted breeding values. Because of that it could happen that we will select animals that are not among the top 50 animals with the true breeding values, or we will miss out the animal from the top 50 animals with the true breeding values.

The good news is that this can be improved with the better accuracy of prediction. You can see the illustration of this process in the Figure. The plot on the left-hand side is showing the trait with the accuracy of prediction 0,1. Here, from the 50 selected animals (coloured black and green) we have selected only 4 (coloured green) that are among the top 50 with the highest true breeding values (coloured red and green). The plot on the right-hand side is showing the trait with the accuracy of selection 0,9. Here, from the 50 selected animals (coloured black and green) we have selected 32 (coloured green) that are among the top 50 with the highest true breeding values (coloured red and green). Also, those 18 that are not among top 50 animals with the highest true breeding value are not far away which was not the case when the accuracy of prediction was 0,1.

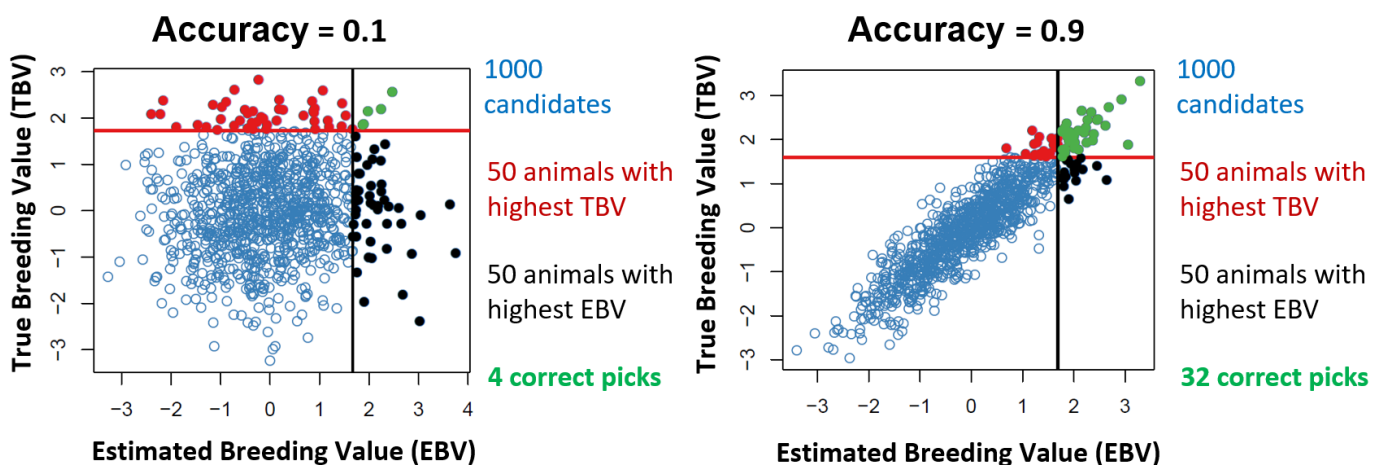


Figure: The effect of accuracy of predicted breeding values on the selection of the parents of a future generation when the accuracy of selection is 0.1 (left) and 0.9 (right).

The new models improved the accuracy of predicted breeding values for all the exterior traits for between 0,07 and 0,39. The old accuracies ranged between 0,45 and 0,72 and the new one between 0,60 and 0,95. This means that the breeding values predicted with the new models will be more accurate which will lead to a higher genetic gain in Norwegian Red. At the same time the new models have also increased heritability for all but one trait. This means that more differences between the phenotypes of animals comes from genetics and less from environment. There are several reasons causing this phenomenon.

Table: Accuracy of predicted breeding values and heritabilities for old and new models

Trait	Old accuracy	New accuracy	Old heritability	New heritability
Front Teat Placement	0,70	0,79	0,18	0,27
Rear Teat Placement	0,69	0,83	0,22	0,26
Fore Udder Attachment	0,51	0,63	0,12	0,17
Udder Depth	0,68	0,83	0,25	0,31
Rear Udder Width	0,71	0,81	0,13	0,17
Rear Udder Height	0,70	0,83	0,11	0,16
Central Ligament	0,54	0,64	0,10	0,14
Rear Legs Rear View	0,45	0,60	0,08	0,14
Rear Legs Side View	0,62	0,70	0,09	0,17
Foot Angle	0,64	0,71	0,09	0,14
Stature	0,72	0,89	0,41	0,58
Rump Angle	0,64	0,87	0,19	0,28
Body Depth	0,53	0,77	0,14	0,19
Chest Width	0,53	0,74	0,11	0,15
Rump Width	0,61	0,80	0,22	0,30
Supernumerary teat	0,56	0,95	0,21	0,17
Teat Thickness	0,64	0,82	0,20	0,29
Teat Length	0,71	0,86	0,27	0,41
Udder Balance	0,69	0,85	0,11	0,17

The most important reason for higher accuracy and heritability is that in the new models we are using the data from first five lactations while in the old models only the phenotypes from the first lactation were used. This has not only increased the number of data we are using for the estimation of the breeding values but also made possible to estimate the effect of environmental effects on individual's phenotype that are constant across repeated measures on that individual.

We simply call this effect a permanent environment effect. New fixed part of the model is another reason for higher accuracy and heritability of predicted breeding values. For each trait we have tested different fixed effects (eg. milking system, year month of calving, hours since milking) to develop the best possible model.

With this, we have corrected phenotypes for the most important fixed effects and achieved the highest possible accuracy of predicted breeding values given the available information. In order to improve the accuracy of predictions even further, we have built multitrait models with new combinations of traits. In each multitrait model we have included traits with the highest correlation. This gave us six multitrait models with different number of traits included.

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