International Genetic Evaluations with the BLUP method 2014

The BLUP method

The BLUP method with animal model is used for genetic evaluation of Icelandic horses. The method is called BLUP (Best Linear Unbiased Prediction) since that describes the statistical properties of the method. Animal model means that all available pedigree information is used for correct weighting of the genetic relationships among animals. The *Best Linear Unbiased Prediction* makes optimum use of the data on the pedigree and the scored traits and weights every piece of information correctly in accordance with the statistical model used for description of the real world. The BLUP method is able to adjust for the effects of systematic environmental factors which can be registered in the data and make information on scores from different countries, years and on different gender comparable. The BLUP method has become a standard method for genetic evaluation of livestock (inclusive horses) worldwide.

The BLUP method with animal model was used as early as 1982 for simultaneous genetic evaluation for ten correlated traits of conformation and riding ability of Icelandic horses. For several years the results were introduced to breeders by meetings and stencils with listing of results. Lists with the highest ranked horses were also published in the horse magazine *Eidfaxi*. The method was officially taken in use by *The Farmers Association of Iceland (FAIC)* in 1986, and since then they have been responsible for publication of results on the genetic evaluations.

In 1992 a comprehensive upgrading of the computer programs used for computing the genetic evaluations were performed and the number of scored traits increased form ten to fourteen. Also a genetic evaluation for height at withers was added. Later genetic evaluations for mane and tail, walk and slow toelt have been added. Evaluations of the use of the BLUP method for genetic evaluations in the Icelandic horse population have shown that the method has been very effective and had positive impact on the Icelandic horse breeding

International genetic evaluations of the Icelandic horse

In 2000 *FEIF* and the *Farmers Association of Iceland* assigned an agreement on establishing a data base containing a global register for the Icelandic Horse. The web application has been termed ”WorldFengur” with the domain name www.worldfengur.com. One of the main goal with WorldFengur is to establish international genetic evaluations which enables comparison of breeding horses across countries.

The construction of the database of WorldFengur lead by Jon Baldur Lorange, *FAIC*, offers a unique possibility for the creation of effective international genetic evaluations of the Icelandic horse. In 2003 Ágúst Sigurdsson and Thorvaldur Árnason were commissioned to develop the international genetic evaluations of the Icelandic horse to be included in WorldFengur. The project should be based on solid scientific work. The project has involved comprehensive statistical analyses on pedigree files and data on judging scores from Iceland and 10 other FEIF member countries. The results were published and presented at the 55th Annual Meeting of the EAAP, Bled, Slovenia, September 5th-9th , 2004 and at the 8th World Congress on Genetics Applied to Livestock Production, Belo Horizonte, Brazil, August 13th - 18th , 2006. The main results show good pedigree completeness in the data and

good genetic connectedness between countries. The relationship between animals is almost the same across countries as within a country. The reason for this is the vast flow of genes from the Icelandic population. A very little difference was found between the level and variation in scores between Iceland and the other countries. This was only to be expected since Icelandic judges have been frequently represented in the judging groups in these countries. On the other hand it became clear that variation and heritability of most of the scored traits changed considerably around 1990. Statistical analysis confirmed that the comprehensive redefinition of the scale with the aim of increasing the variation in scores in 1990 (See: Studhorse Judging and Studshows, published by FAIC 1992, Editor Kritinn Hugason) had been successful. Therefore it seemed natural to define the same traits as two different traits depending on if they were scored before 1990 or later. Both heritability and variation increased markedly after 1989. Therefore the scores obtained before 1990 now receive less weight in the BLUP genetic evaluations. Tables with all genetic parameters used in the computation of the new BLUP indices can be revealed on http://www.ihbc.se/app/servlets/arfgengien.html. The considerable increase in the number of traits involved lead to much more complex statistical model and tricky missing patterns which required genius computing solution.

The following weighting factors are used for computing the total scores (from 2010): Head 3%, Neck, withers and shoulders 10%, Back and croup 3%, Proportions 7.5%, Leg quality 6%, Leg stance 3%, Hooves 6%, Mane and tail 1.5%, Toelt 15%, Trot 7.5%, Pace 10%, Gallop 4.5%, Spirit 9%, Expression 10% and Walk 4%.

Somewhat simplified the statistical model for each trait can be written as:

> Score = fixed effects of country and judging year + fixed effects of gender and age class + randomly distributed breeding values + randomly distributed environmental effects

All scores included in the computations are from the occasion when the horse received highest age adjusted notes for total score according to the present weighting factors. The following age adjustment coefficients are used for geldings and stallions: 4 year-old +0.30; 5 year-old +0.15; 6 year-old +0.07; and 7 year-old 0.00. The following age adjustment coefficients are used for mares: 4 year-old +0.20; 5 year-old +0.10; 6 year-old +0.05; and 7 year-old 0.00. For years 1961 – 1989 the scores pertain to 14 correlated traits, while for years 1990 – thirteen correlated traits are involved since willingness and character have been combined to one trait ”spirit”. Therefore in total there are 27 correlated traits simultaneously included in the computations. In addition genetic evaluations are computed for four single traits (height at withers, mane and tail, walk and slow toelt). The BLUP indices published in WorldFengur are estimated breeding values for the traits as they are defined after 1990. This applies also for the horses scored earlier. Their estimated breeding values for the new traits are obtained through the genetic correlations.

In total the data for year 2014 consisted of 374,512 horses. Thereof 36,282 horses had own records divided between countries as: Iceland 26,064, Sweden 3,279, Denmark 2,509, Norway 991, Finland 247, Germany 2,380, Austria 220, Switzerland 68, The Netherlands 199, Great Britain 39, Canada 94 and USA 192 horses.

The genetic evaluations on all horses in the database are now published on Worldfengur, provided that the accuracy of the estimate exceeds 30%. However one should keep in mind

that accuracy of genetic evaluations below 60% are still insecure predictions. It is important that breeding mares and stallions used for breeding are assessed in order to increase the accuracy of the genetic selection.

In the new BLUP indices the mean genetic evaluations for horses with own records obtained in the last 15 years will form the reference base. Their mean value will be constrained to 100. The distribution will be scaled such that 10 index units correspond to one genetic standard deviation for each trait. This year the reference base group will consist of horses judged 2000-2014. The base will roll each year such that next year it will be made up by horses judged 2001-2015, *etc*.

Information on the genetic evaluations published in WorldFengur

On www.worldfengur.com you will find following information concerning the genetic evaluations:

1) Head (BLUP index)
2) Neck/withers/shoulders (BLUP index)
3) Back/loin/croup (BLUP index)
4) Proportions (harmony) (BLUP index)
5) Legs (BLUP index)
6) Leg stance (correctness) (BLUP index)
7) Hoofs (BLUP index)
8) Mane and tail (BLUP index)
9) Index for body conformation
10) Toelt (BLUP index)
11) Trot (BLUP index)
12) Pace (BLUP index)
13) Gallop (BLUP index)
14) Spirit (BLUP index)
15) Form under rider (expression) (BLUP index)
16) Walk (BLUP index)
17) Index for riding ability traits
18) Slow toelt (BLUP index)
19) Index for total score
20) Height at withers (BLUP in cm as a deviation from the population mean)
21) Accuracy of the genetic evaluation (Correlation between the true and the estimated breeding value in %)
22) Standard error of the estimate
23) Progeny deviation for conformation
24) Progeny deviation for riding ability
25) Progeny deviation for total score
26) Total number of progenies registered when the genetic evaluations were computed
27) Number of progenies with complete scores
28) Inbreeding coefficient in %
29) Number of parents registered (2, 1 or 0)
30) Number of progenies with height at withers measured
31) Number of progenies with a score for mane and tail

32) Number of progenies with a score for slow toelt
33) Number of progenies with a score for walk
34) Country of scoring (IS, DK, *etc.)*

Information about the impact of offspring (progeny deviation) on the index for conformation, riding ability and total score, as a deviation from an index based solely on ancestors and the individual's own scores is published for horses assessed 1990 and later, provided they have at least one scored progeny .

Select stallion and virtual mate selection

WorldFengur now offers the possibilities to assist the breeders in selection of suitable stallions to cover their broodmares and also to examine the expected outcome of mating any couple of horses found in the database. The servlets reveals the estimated breeding value of the potential offspring, the relationship between the parents, the inbreeding coefficient of the offspring, possible genotypes of the parents and of the offspring together with the probability of each genotype in 9 loci (8 coat colour loci and the DMRT3 (pace gene) loci. Finally one gets an estimate of the probability of all possible coat colours that can appear in the offspring, illustrated by a picture of each coat colour. The predicted genotype probabilities are based on computational methods which were presented at the 58th Annual Meeting of the European Association for Animal Production, Dublin, Ireland, 26th - 29th August 2007. (Árnason, T. Prediction of genotype probabilities at eight coat colour loci in the Icelandic horse in mate selection).

In a preliminary version of the mate selection servlet it was required that both mated parents should have FEIF breeding assessment included in WorldFengur. In this version it is possible to reveal the outcome of any mating provided that both parents were in the data base when the BLUP and the genotype probabilities were computed. However, one should be aware of that estimates of breeding values for unassessed horses have large sampling error and are therefore imprecise. Unfortunately the coat colour prediction is wrong for many horses due to errors in registration of the colour code or errors in the pedigree. The reliability will hopefully improve in the coming years as errors will be corrected in the database and more information will be included.

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