Validation Method for Beef National Genetic Evaluation Models

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Abstract

Interbeef receives data, pedigree and statistical models for Charolais and Limousin breeds from member countries. The quality of data and pedigree information is checked before they are used for an international genetic evaluation. This paper presents an attempt to validate the quality of national statistical models for beef cattle. The method aims to evaluate the soundness of national models using advanced statistical tools; the Akaike information criterion (AIC), the Bayesian information criterion (BIC) and the –2 log likelihood (Log L). AIC, BIC and Log L give similar results and in the majority of cases countries provided good statistical models. This method is easy to integrate into the national genetic evaluation system, it's flexible but the memory space required can be a limiting factor.

Keywords: information criterion, national models, beef cattle, Interbeef

1. Introduction

Currently at Interbull the genetic trends for dairy national data are validated using the three methods first developed by Boichard *et al.* (1995) and based on the function of observed vs. expected genetic trends. Weller *et al.* (2003) implemented Interbull validation Method 3 based on the empirical confidence interval for the number of new daughters per bull (δ) computed using the nonparametric bootstrap. Lidauer *et al.* (2005) made Interbull validation Method 2 more robust by using the daughter deviations of a sire by the birth year of the daughters. Unfortunately, validation Methods 1, 2 and 3 (Interbull, 2009) cannot be used to validate national beef models because:

1) Interbeef receives raw data from the member countries (i.e. for the time being only adjusted and unadjusted weaning weights) while Interbull receives proofs for dairy traits (i.e. BV or TA for production, udder health, conformation, etc.). Method 1 for dairy uses breeding values (BV) or transmitting abilities (TA) while beef data do not include this information. For this reason Method 1 (Interbull, 2009) cannot be used as validation method for beef data or statistical models.

2) Method 2 (Interbull, 2009) is based on the DYD information, which investigates the non-genetic time trend over the entire period considered in the national evaluation. Interbeef receives raw data for males and females and because the trait is measured on the animal itself, daughter yield deviation (DYD) is not provided and therefore the method is not suitable for beef data.

3) Method 3 (Interbull, 2009) analyzes the official national predicted genetic merit variation across evaluation runs for dairy data and it is designed specifically for bulls' predicted genetic merit which is not included in the beef data. Therefore, Method 3 cannot be used to validate beef data or statistical models.

Jorjani (2003) pointed out the importance of having a validation method in place which includes a validation not only for dairy data but also for national dairy models. Interbull has not yet developed a validation method for national models for dairy cattle although validation of expected genetic trends can be considered as an indirect measure of the goodness of the national model applied.

A method to validate national statistical models should be:

1) Able to detect potential errors
2) Easy to use for the member countries
3) Flexible

The aim of this paper is to present:

a) A method to validate national statistical models for beef cattle.
b) The limits of the method.

2. Material and Methods

Data and pedigree information

Countries provided data and pedigree information for each breed and trait combination following the Interbeef guidelines (Interbeef, 2009b) for the Interbeef project (Venot *et al.,* 2007; Forabosco *et al.,* 2008). Five countries (Table 1) have provided data, pedigrees and models for Charolais and Limousin breeds for adjusted weaning weight. Interbull has received a total of 3,118,878 performance and 3,742,857 pedigree data for the Charolais breed, and 1,973,112 performance and 2,582,960 pedigree data for the Limousin breed.

Data and pedigrees were transferred via ftp server. Data quality was checked and programs have been developed to detect potential errors.

Models

The quality of national statistical models provided by member countries must be checked before they can be used in an international genetic evaluation. Setting up a good national model is an essential key for a reliable international genetic evaluation (Jorjani, 2003). Models are provided by member countries using the Form Beef (Interbeef, 2009a). A short summary of national models for adjusted and unadjusted weaning weight are provided in Table 2.

Information criterion (IC)

There are a number of methods available to investigate the fit of the model to the data using a variety of statistical tools that may be implemented, depending on the statistician's school of thought, for example R^2, RMSE, deviance, or formal χ^2 goodness-of-fit, etc.
In any case, modern statisticians, prefer to use the "information criterion=IC" for a more parsimonious model (principle of parsimony being defined by Box & Jenkins, 1976 as a model with the smallest possible number of parameters for adequate representation of the data).

The Akaike information criterion (AIC) is a measure of the goodness of fit of an estimated statistical model. The AIC is not a test of the model in the sense of hypothesis testing; rather it is a tool for model selection (Burnham and Anderson, 1998). Given a data set, several competing models may be ranked according to their AIC, with the one having the lowest AIC being the best. From the AIC value one may infer that, for example, the top models are in a tie (less then 5% difference between top models) and the rest are far worse (Burnham and Anderson, 1998).

In the general case, the AIC is defined as:

$$AIC = 2k - 2\ln(L)$$

where k is the number of parameters in the statistical model and L is the maximized value of the likelihood function for the estimated model.

AIC value assigned to a model is only meant to rank competing models and tell you which is the best among the given alternatives. The absolute values of the AIC for different models have no meaning; only relative differences can be ascribed meaning.

The Bayesian information criterion (BIC), is a criterion for model selection among a class of parametric models with different numbers of parameters. BIC is very closely related to the AIC. In the general case, the BIC is defined as:

$$BIC = -2\ln(L) + k\ln(N)$$

where N is the number of datapoints used to fit the model and k is the number of parameters to be estimated. Given any two estimated models, the model with the lower value of BIC is the one to be preferred. BIC can be used to compare estimated models only when the numerical values of the dependent variable are identical for all estimates being compared.

The -2 log likelihood (Log L) is a probability density function (PDF) which is used to examine the trade off between goodness of fit and parsimony.

3. Results and Discussion

A statistical package (SAS, 2009) was used to calculate AIC, BIC and Log L (Tables 3 and 4). Mixed model procedures (PROC MIXED) were utilized to compute statistical analysis. For each trait and country-breed combination, three tests were conducted and the statistical models were ranked giving the best ranking to the lowest IC value. In all cases the difference between AIC, BIC and Log L were very small and values were almost identical. An example is given in Table 3 and 4.

In Tables 3 and 4 the models proposed by the member countries were always the best among all models tested. Model 2 and model 3 were generated by the authors to evaluate the goodness of fit of the original model. Both models were obtained changing the effects of the original model but no further assumptions were made when the models' structures were generated.

In some cases (i.e., Limousin data from the UK, Table 3) the difference between model 1 and model 2 was very small (less than 5%). When the difference is reasonably small (less than 5%), both models can be considered "the best model" and countries can choose between them.

In other cases, (i.e. Limousin and Charolais data from Denmark, Table 4) all 3 models analyzed were approved because the difference between AICs was less than 5%.

3.1 Limits of this method

- Estimating all fixed effects is time consuming and in case of complex models the memory space required is a limiting factor.
- This validation method does not include the quality and the stability of the genetic trends over time. A robust validation method needs to include the analysis of genetic trends. For this reason Method A that would fit beef data, national models and genetic trends needs to be developed.

4. Conclusions

Results for all country-breed combinations for AIC, BIC and Log L were analyzed. In the majority of cases the models provided by countries (national models) were the best models with the lowest information criterion. In some cases the model provided by member countries (national model) was among the best models (with an information criterion that differed no more than 5% from the model with the lowest one).

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Table 1. Number of animals in the pedigree and performance files.

	Pedigree		Performance	
Country	Charolais	Limousin	Charolais	Limousin
France	3,474,958	1,968,574	2,999,172	1,813,211
Ireland	39,337	23,878	14,115	8,826
UK	-----	129,068	------	99,262
Denmark	125,548	270,180	14,067	35,289
Sweden	103,014	191,260	91,524	16,524
Total	3,742,857	2,582,960	3,118,878	1,973,112

Table 2. National models provided by countries(1) for adjusted and unadjusted weaning weight (w.w.).

	Adjusted w.w.			Unadjusted w.w.	
Country	Charolais	Limousin	Country	Charolais	Limousin
Sweden	HYS*Sex,Sea, Aged, Mbirth	HYS*Sex,Sea, Aged,Mbirth	Denmark	HY,Sea,Aged*Par,Sex,, Tw,Agewei	HY,Sea,Aged*Par,Sex ,, Tw,Agewei
UK	----	HY, Bmonth, Sex, Btype,Aged (lin.,qua.)	Ireland	HYS,Sex,AAgewei,Sex* AAgewei(cov), Sex* AAgewei^2(cov), Sex* AAgewei^3(cov)	HYS,Sex,AAgewei, Sex* AAgewei(cov), Sex* AAgewei^2(cov), Sex* AAgewei^3(cov)

Note:HYS=Herd*Year*Season, Sea=Season of calving, Aged=Age of the dam, Agew=Age at weaning, Agewei=Age at weighing, AAgewei=Average age at weighing, Bmonth=Birth month, Btype=Birth type, Mbirth=multiple birth, Par= parity, Tw=Twin, lin=linear, qua=quadratic, cov=covariante.(1) For the full list of countries and models visit: http://www-interbull.slu.se/Interbeef/genev/framesida-genev.htm

Table 3. AIC, BIC and Log L for adjusted weaning weight for Charolais and Limousin breeds.

Cou (1)	Breed (2)	Model	Description of model	AIC	BIC	LogL	Rank	App./ Not app.
Swe	Cha(5)	1	National model(3)	615406	615402	615402	1	App
Swe	Cha(5)	2	No interaction between HYS and Sex	647303	647301	647301	2	Not App.
Swe	Cha(5)	3	No interaction between HYS, Sex, no Sea	655440	655438	655438	3	Not App.
Swe	Lim	1	National model(3)	132184	132182	132182	1	App
Swe	Lim	2	No interaction between HYS and Sex	141326	141324	141324	2	Not App.
Swe	Lim	3	No interaction between HYS, Sex, no Sea	141381	141379	141379	3	Not App.
UK	Lim(6)	1	National model(3)	98039	98035	98035	1	App.
UK	Lim(6)	2	Interaction HY* Bmonth, no Aged(lin.,qua)	99754	99750	99750	2	App.
UK	Lim(6)	3	No effect of Aged (lin.,qua.)	130796	130792	130792	3	Not App.

(1) Cou=country, Swe=Sweden, UK=United Kingdom; (2) Cha=Charolais, Lim=Limousin; (3) For model description see Table 2. (4) Approved /not approved=Models are approved when they are ranked 1st or alternatively the AIC value differs no more than 5% from the model with the lowest AIC value. (5) A random sample of 70.000 animals. (6) A random sample of 15.000 animals.

Table 4. AIC, BIC and Log L for unadjusted weaning weight for Charolais and Limousin breeds.

Cou (1)	Breed (2)	Model	Description of model	AIC	BIC	LogL	Rank	App./ Not app.
Dnk	Cha	1	National model(3)	115089.0	115085.0	115085.0	1	App
Dnk	Cha	2	No Aged*Par and no Tw	116294.6	116290.6	116290.6	2	App
Dnk	Cha	3	No Aged*Par, no Tw, no Sea	116543.6	116539.6	116539.6	3	App
Dnk	Lim	1	National model(3)	286406.0	286402.0	286402.0	1	App
Dnk	Lim	2	No Aged*Par and no Tw	288374.8	288370.8	288370.8	2	App
Dnk	Lim	3	No Aged*Par, no Tw, no Sea	289104.8	289100.8	289100.8	3	App
Irl	Cha	1	National model(3)	125293.1	125289.1	125289.1	1	App
Irl	Cha	2	No Agewei	127512.5	127508.5	127508.5	2	App
Irl	Cha	3	No Agewei, no all cov	131925.0	131923.0	131923.0	3	Not App
Irl	Lim	1	National model(3)	71461.8	71459.8	71459.8	1	App
Irl	Lim	2	No Agewei	73346.5	73342.5	73342.5	2	App
Irl	Lim	3	No Agewei, no all cov	76095.8	76093.8	76093.8	3	Not App

(1) Cou=country, Dnk=Denmark, Irl=Ireland; (2) Cha=Charolais, Lim=Limousin; (3) For model description see Table 2. (4) Approved /not approved=Models are approved when they are ranked 1st or alternatively the AIC value differs no more than 5% from the model with the lowest AIC value.