Genetic Relationships Among Functional Traits in the Nordic Holstein Populations

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Introduction

The Nordic countries (Denmark, Finland, Norway and Sweden) have joined forces and are working towards joint genetic evaluations for all traits of economic importance. Functional traits have traditionally received high attention in the Nordic countries and genetic evaluations for important health, fertility and calving traits have been in place for more than a decade in each of the four countries. However, little is known about the genetic relationships that exists among functional traits across countries. The aim of this project was therefore to estimate genetic correlations among functional traits in the Nordic Holstein populations to alleviate joint genetic evaluations and to identify where trait harmonizations are needed to increase benefits from such evaluations.

Table 1. Trait definitions, heritabilities (h^2) and description of national genetic evaluation procedures

Country	Trait	Definition	Parity[1]	Model[2]	h^2
Female fertility measures related to ability to conceive					
DNK	NRR	Re-AI (0), not re-AI (1) 56 days after first AI	1	MT SL SM	.008
DNK	IFL	Days from first to last AI	1	MT SL SM	.020
FIN	NRR	Re-AI (0), not re-AI (1) 60 days after first AI	1	ST SL SM	.014
SWE	AIS	No. of AI per service period scored in 5 categories: Double AI (1),..., 6-7 AI (5)	0-2	ST ML SM	.040
Female fertility measures mainly related to ability to show first heat					
DNK	ICF	Days from calving to first AI	1	MT SL SM	.070
SWE	ICF	Days from calving to first AI	0-2	ST ML SM	.040
SWE	HST	Heat strength scored in 3 categories: (1) very strong, (2) normal, (3) weak	0-2	ST ML SM	.020
Female fertility measures related to both ability to conceive and to show first heat					
FIN	DOP	Days from calving to last AI (days open)	1-3	ST SL AM	.050
FIN	FTR	Diagnose, treatment or culling due to fertility disorder (1) 0 to 150 days pp; else (0)	1-3	ST SL SM	.010
SWE	FTR	Diagnose, treatment or culling due to fertility disorder (1) -10 to 150 days pp; else (0)	1	ST SL SM	.020
Resistance to diseases other than mastitis					
DNK	OTR	Treated for reproductive, digestive or feet & leg disease -10 to 305 days pp (1); else (0)	1	MT ML SM	.020
FIN	OTR	Treated for any disorder except fertility and mastitis 0-150 days pp (1); else (0)	1-3	ST SL SM	.020
SWE	OTR	Feet & leg, infectious-, metabolic-, or other disorder -10 to 150 days pp. (1); else (0)	1	ST SL SM	.020
Calving ease					
DNK	CED	Sire of calf effect scored in 4 categories: (1) difficult with vet.,..., (4) easy	1	MT ML SM	.100
DNK	CEM	Sire of dam effect scored in 4 categories: (1) difficult with vet.,..., (4) easy	1	MT ML SM	.060
DNK	CEDL	Sire of calf effect scored in 4 categories: (1) difficult with vet.,..., (4) easy	2	MT ML SM	.060
DNK	CEML	Sire of dam effect scored in 4 categories: (1) difficult with vet.,..., (4) easy	2	MT ML SM	.030
FIN	CED	Sire of calf effect scored in 3 categories: (1) easy,..., (3) very difficult	1	ST SL SM	.008
FIN	CEM	Sire of dam effect scored in 3 categories: (1) easy,..., (3) very difficult	1	ST SL SM	.060
SWE	CED	Sire of calf effect scored in 2 categories: (1) easy, (2) hard	1	ST SL SM	.020
SWE	CEM	Sire of dam effect scored in 2 categories: (1) easy, (2) hard	1	ST SL SM	.020
Calf vitality (stillbirth)					
DNK	SBD	Sire of calf effect scored in 2 categories: (0) stillborn; (1) alive after 24h	1	MT ML SM	.06
DNK	SBM	Sire of dam effect scored in 2 categories: (0) stillborn; (1) alive after 24h	1	MT ML SM	.03
DNK	SBDL	Sire of calf effect scored in 2 categories: (0) stillborn; (1) alive after 24h	2	MT ML SM	.015
DNK	SBML	Sire of dam effect scored in 2 categories: (0) stillborn; (1) alive after 24h	2	MT ML SM	.01
FIN	SBD	Sire of calf effect scored in 2 categories: (0) stillborn; (1) alive after 24h	1	ST SL SM	.016
FIN	SBM	Sire of dam effect scored in 2 categories: (0) stillborn; (1) alive after 24h	1	ST SL SM	.014
SWE	SBD	Sire of calf effect scored in 2 categories: (0) stillborn; (1) alive after 24h	1	ST SL SM	.02
SWE	SBM	Sire of dam effect scored in 2 categories: (0) stillborn; (1) alive after 24h	1	ST SL SM	.02

1) 0=heifers; 2) ST = Single Trait; MT = Multiple Trait; SL = Single Lactation; ML = Multiple Lactation; SM = Sire Model; AM = Animal Model.

Material and Methods

The most recent national genetic Holstein evaluation results in November 2000 from Denmark (DNK), Finland (FIN) and Sweden (SWE) were collected. These included female fertility, health, calving ease and calf vitality traits as defined in Table 1. The genetic correlation between direct and maternal effects were assumed to be zero for calving ease and stillbirth in Denmark and Sweden, respectively. In Finland, however, the correlation between the direct and maternal effects was assumed to be .47 for calving ease and .91 for stillbirth. Maternal effect were estimated as two times the effect of sire/maternal grandsire minus the direct effect of the sire in Denmark and Sweden. For Finland, the BLUP solutions were used directly. All evaluations were official (or combined to yield an official index trait) except non-return rate (NRR) in Finland.

Data edits considered AI bulls with a national evaluation result based on at least 10 daughters. A well connected subset of bulls having evaluations in more than one country as well as bulls that belong to ¾-sib groups that have members with evaluations in more than one country were created and used to estimate genetic correlations as recommended by Sigurdsson *et al.* (1996). The number of bulls included in genetic parameter estimation for each country is shown in Table 2 for each estimation run.

National breeding values were first deregressed within country using a single trait sire model according to Jairath *et al.* (1998) and standardized so that all national evaluation results were expressed in the same direction i.e. high values are desirable. Genetic parameters were estimated with an EM-REML algorithm applied on a reduced set of Mace equations (Klei & Weigel, 1998). Eight-teen tri-variate estimations were run as described in Table 2.

Table 2. Traits included in the 18 tri-variate runs and number of bulls included in each estimation by country of national evaluation

		Trait			Number of bulls		
	Run	DNK	FIN	SWE	DNK	FIN	SWE
Fertility	1	NRR	NRR	AIS	1998	100	872
	2	IFL	NRR	AIS	1998	100	872
	3	IFL	DOP	AIS	1998	140	872
	4	NRR	NRR	HST	1998	100	872
	5	IFL	NRR	HST	1998	100	872
	6	IFL	DOP	HST	1998	140	872
	7	ICF	DOP	ICF	2011	140	872
	8	ICF	DOP	HST	2011	140	872
Disease-resistance	9	OTR	OTR	OTR	1646	95	806
	10	OTR	FTR	FTR	1646	95	806
Calving & stillbirth	11	CED	CED	CED	1726	45	1294
	12	CEM	CEM	CEM	1879	53	1540
	13	SBD	SBD	SBD	1726	56	1294
	14	SBM	SBM	SBM	1879	68	1540
	15	CEDL	CED	CED	1801	45	1294
	16	CEML	CEM	CEM	1897	53	1540
	17	SBDL	SBD	SBD	1801	56	1294
	18	SBML	SBM	SBM	1897	68	1540

Table 3. Estimated genetic correlations. Traits definitions are in Table 1

	Trait				Correlation estimate		
	Run	DNK	FIN	SWE	DNK-FIN	DNK-SWE	FIN-SWE
Fertility	1	NRR	NRR	AIS	.72	.74	.55
	2	IFL	NRR	AIS	.76	.74	.60
	3	IFL	DOP	AIS	.81	.75	.58
	4	NRR	NRR	HST	.82	-.38	.06
	5	IFL	NRR	HST	.75	.09	-.09
	6	IFL	DOP	HST	.80	.04	.33
	7	ICF	DOP	ICF	.62	.45	.26
	8	ICF	DOP	HST	.59	.46	.26
Disease-resistance	9	OTR	OTR	OTR	.88	.87	.64
	10	OTR	FTR	FTR	.01	.41	.01
Calving & stillbirth	11	CED	CED	CED	.63	.99	.67
	12	CEM	CEM	CEM	.49	.78	.67
	13	SBD	SBD	SBD	.49	.75	.80
	14	SBM	SBM	SBM	.93	.86	.60
	15	CEDL	CED	CED	.12	.90	.16
	16	CEML	CEM	CEM	.75	.59	.68
	17	SBDL	SBD	SBD	.98	.71	.71
	18	SBML	SBM	SBM	.74	.48	.60

Results and Discussion

For fertility traits, correlation estimates were highest between Denmark and Finland (up to .82) compared to estimates involving number of inseminations per service period (AIS) in Sweden (Table 3). One explanation for this is that Sweden includes heifer fertility, which is normally considered to be a different trait than fertility of lactating cows (Roxström, 2001). Heat strength in Sweden does not seem to be genetically related to any of the fertility trait measured in Denmark or Finland.

The estimated correlations among resistance against diseases other than mastitis were highly correlated (.87-.88), except between Finland and Sweden (.64). Sweden uses only first parity cows, whereas Denmark and Finland consider information from the three first lactations. No genetic association were found between resistance against fertility treatments in Finland and Sweden.

Direct calving ease was very highly correlated between Denmark and Sweden (.99), when only information on first calving was considered. Maternal calving ease as well as direct and maternal stillbirth was highly correlated between Denmark and Sweden, when only first calvings were considered (.75-.86). In comparison correlation estimates decreased, when second and later calvings in Denmark were correlated with first calvings in Sweden. Correlation estimates involving Finland varied more, and it is interesting to compare results from run 11-14 with those from run 15-18 to notice the impact the Danish data have on estimated correlations between traits in Finland and Sweden. Estimates involving Finland are expected to be less precise compared to estimates between Denmark and Sweden due to the limited number of common bulls between Finland and the other two Holstein populations. The number of bulls having an evaluation in both Finland and in Denmark and Sweden was 31 and 37, respectively. For Denmark and Sweden the corresponding number of common bulls was 198.

This work was aimed at supporting the development of joint Nordic Sire Models for functional traits. The goal is to enable a direct comparison of dairy sires across the Nordic countries for functional traits as soon as possible. Joint Animal Models for production traits based on performance records are being developed in another Nordic project (Pedersen *et al.*, 2001).

Interbull evaluations already enable a comparison of dairy sires across countries for production, conformation and udder health traits, and the feasibility of Mace for calving ease, stillbirth and longevity is currently being investigated by VIT and NRS. Therefore, the continued work towards joint Nordic genetic evaluations for functional traits now focuses on female fertility and resistance to diseases other than mastitis to ensure that dairy sires in the Nordic countries can be compared for all functional traits of interest in either MACE evaluations or in Nordic Sire Models. This study showed that trait harmonizations are required, and a set of common guidelines for the Nordic countries are under development within the Nordic group.

Conclusion

Genetic correlations were moderate to high between traits that are expected to be similar. Harmonizations in trait definitions, data included and in evaluation procedures could lead to higher correlations. Further studies involving more countries are needed before Interbull can consider these traits in international evaluations.

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