Genetic Relationship Among Functional Traits in the Nordic Ayrshire Populations

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Introduction

Breeding goals in the Nordic countries (DNK, FIN, NOR, SWE) include a broad array of functional traits. This is possible due to extensive participation in the national milk recording schemes that also include AI (artificial insemination) and health data.

Although the influx of data is quite similar in the Nordic countries, there are differences in: Trait expression, statistical models, parities included and time span of recorded data.

This project is a natural extension of previous work on clinical mastitis (Mark et al., 2000) and deals with other diseases, female fertility, calving ease and calf viability.

The final goal is common Nordic sire models for these traits. However, MACE methodology may be a good starting point for trait comparison and to monitor progress in harmonisation of traits.

Functional traits

Female fertility

The basic registrations are dates of: Birth, calving and each AI. Besides, heath strength (**HST**) is routinely scored by AI technicians in Sweden using a 5-level scale. Derived traits vary considerably as can be seen from Table 1.

Non-return rate (**NRR**) is a binary trait scored at 56 days (60 in Finland) after first AI. The intervals from calving to first AI (**ICF**), from first AI to last AI (**IFL**) and days open (**DOP**) are counted in days. **AIS** is number of AI per service period linearized on a 5 level scale.

Fertility traits have been combined in sub indices (**FI**).

DNK: **FI = .01 NRR_0 + .031 NRR + .104 IFL_0 + .542 IFL + .542 ICF**
FIN: **FI = .66 DOP + .33 FTR**
SWE: **FI = .85 (.75 AIS + .20 ICF + .05 HST) + .35 FTR**

A long-term goal is that each country provides data for all these traits except HST. However, utilization and economic weighting will remain national decisions.

Table 1. Heritabilities of female fertility traits

Trait	DNK	FIN	NOR	SWE
NRR	*.010*	*.014*	*.012*	-
ICF	*.070*	-	-	*.040*
IFL	*.020*	-	-	-
DOP	-	*.050*	-	-
AIS	-	-	-	*.050*
HST	-	-	-	*.020*
FI	*.052*	*.037*	-	*.055*

Diseases other than mastitis

Other treatments (**OTR**) is a binary trait scored around calving and in early lactation. Denmark include reproductive, digestive, feet and leg disorders between –10 and 100 days postpartum. Finland include all treatments apart from mastitis and fertility between 0 and 150 days pp. Norway include ketosis, paresis and retained placenta between –15 and 120 days pp. Sweden include ketosis, paresis, teat injuries, feet and leg disorders, infections and metabolic disorders between –10 to 150 days pp. Finland and Sweden keep treatment or culling due to fertility disorders as a separate trait (**FTR**).

A discussion on possible separate analyses of diseases or groups of diseases is at an early stage and work on comparison of diagnoses and incidence rates have recently been started.

Table 2. Heritabilities of disease traits

Trait	DNK	FIN	NOR	SWE
FTR	-	*.010*	-	*.020*
OTR	*.019*	*.020*	*.024*	*.020*

Calving traits

Calving Ease is scored by the farmer in 2 to 4 categories, whereas Calf Vitality is a binary trait based on whether the calf survived birth and the first 24 hours.

Twin births, ET (embryo transfer) and crossbred calves are excluded. There are differences between countries in statistical model used and, whether solutions for sire of dam and sire of calf are transformed to direct effects (**CED, CVD**) and maternal effects (**CEM, CVM**).

In Denmark first and later parities are treated as two traits and analyzed in a multitrait model containing all calving traits. For this analysis the Danish evaluations were single trait, however.

The maternal effects have been combined in calving sub indices (**CI**), and the direct effects in birth sub indices (**BI**).

DNK: $\mathbf{CI = .486\ CVM + .283\ CEM + .025\ Size + .216\ CVM_{>1} + .122\ CEM_{>1} + .016\ Size_{>1}}$
SWE: **CI = .80 CVM + .50 CEM**
DNK: **BI = .603 CVD + .559 CED**
SWE: **BI = .80 CVD + .50 CED**

Table 3. Heritabilities of calving traits

Trait	DNK	FIN	NOR	SWE
CED	*.150*[a] *.060*[b]	*.008*	*.030*	*.020*
CEM	*.060*[a] *.030*[b]	*.060*	*.026*	*.020*
CVD	*.050*[a] *.011*[b]	*.016*	*.009*	*.020*
CVM	*.030*[a] *.001*[b]	*.014*	*.015*	*.020*
CI	*.056*	-	-	*.020*
BI	*.105*	-	-	*.020*

***a)** First parity.* ***b)** Later parities.*

Material and Methods

Each country supplied national evaluations for the traits appearing in Tables 1, 2 and 3. Time span of records, parities utilized and evaluation date are summarized in Table 4. Some evaluations deviate from the official national evaluations in parties utilized to harmonize traits for this comparison.

Table 4. Time span of data, parities utilized and date of national evaluations

	DNK	FIN	NOR	SWE
Data since				
Fertility	*1985*	*1978*[a] *1990*[b]	*1978*	*1982*
Disease	*1990*	*1983*	*1978*	*1982*
Calving	*1985*	*1992*	*1989*	*1982*
Parities				
Fertility	*1-6*	*1-6*	*1*	*1*
Disease	*1-6*	*1-3*	*1*	*1*
Calving	*1, 2-6*	*1-6*	*1*	*1*
Evaluation	*0103*	*0007*[c] *0103*[d]	*0105*	*0105*

***a)** DOP.* ***b)** NRR.* ***c)**Fertility and disease.* ***d)**Calving*

The MACE procedures currently in use does not allow for residual covariances, hence analyses with one trait from each country were conducted. To set up complete four-country analyses, the closest related national trait was used to fill inn for missing traits. A total of 23 such sets were constructed with internal order of Denmark, Finland, Norway and Sweden.

Pedigree and cross-reference files from the August 2001 run were obtained from Interbull. Weighting factors were based on the actual number of daughters. There were no time edit on national proofs, but they should be based on at least 10 daughters.

To estimate correlations, well connected subsets of common bulls and common ¾ sib groups were constructed for each trait as shown in Table 5 and 6.

Table 5. Well-connected subset. Common bulls below and common ¾ sib groups above the diagonal

	DNK	FIN	NOR	SWE
DNK	-	*1*	*5*	*15*
FIN	*0*	-	*12*	*75*
NOR	*5*	*7*	-	*67*
SWE	*14*	*47*	*52*	-

Table 6. Total number of records after edit and in well-connected subset

	DNK	FIN	NOR	SWE
Total	*1825*	*4433*	*3177*	*3514*
Fertility	*23*	*188*[a] *300*[b]	*91*	*139*
Disease	*21*	*202*	*96*	*166*
Calving	*23*	*69*[c] *129*[d]	*44*[c] *52*[d]	*148*[c] *151*[d]

***a)** DOP.* ***b)** NRR.* ***c)** Direct.* ***d)** Maternal.*

Correlation estimates were obtained by an EM-REML algorithm (Klei and Weigel, 1998). A program package for MACE evaluation of conformation traits (Klei, 2001), utilizing FSPAK and DENSEOP (Misztal, 1999), was used to carry out all computations.

Results and Discussion

The connections between the Nordic Ayrshire populations are sparse, especially Denmark to Finland and Norway (Table 5). This leads to flat likelihood surfaces and rather poor REML estimates, especially for the less connected country combinations. Estimates for the same trait combination in different runs may be far apart.

Exchange of semen from elite sires has been common practice since the 70'ies. The main purpose was to recruit bull calves as candidates for progeny testing, consequently number of daughters often has been too small to obtain meaningful BV for the foreign elite sires. Differences in breeding goals (especially focus on milk in Finland and growth rate in Norway) have limited the rate of sons of foreign sires entering the progeny test and being selected as elite sires.

Correlation estimates are summarized in Tables 7-14.

Female fertility

The national trait definitions varied considerably. However, traits describing the end result like NRR, DOP and AIS were highly correlated (Tables 7-9).

Heat strength (HST) is unique to Sweden and the correlations to other traits are found in Tables 7-9. All correlation estimates to NRR were negative and of moderate size. Corresponding estimates to the time intervals ICF, IFL and DOP were positive.

Table 7. Correlations among non-return rate (NRR) or substitute traits

	FIN	NOR	SWE
DNK	*.95*[a] *.85*[b]	*.83*[a] *.92*[b]	*.83*[a] *-.59*[b]
FIN		*.88*[a] *.85*[b]	*.76*[a] *-.37*[b]
NOR			*.86*[a] *-.48*[b]

***a)** NRR, NRR, NRR, AIS.* ***b)** NRR, NRR, NRR, HST.*

Table 8. Correlations among interval calving to first AI (ICF) or substitute traits

	FIN	NOR	SWE
DNK	*.54*[a] *.39*[b]	*-.02*[a] *- .02*[b]	*.97*[a] *.84*[b]
FIN		*.74*[a] *.74*[b]	*.43*[a] *.41*[b]
NOR			*-.21*[a] *-.25*[b]

***a)** ICF, DOP, NRR, ICF.* ***b)** ICF, DOP, NRR, HST.*

The intervals ICF and IFL used in Denmark were highly correlated with ICF and AIS, but much less to DOP and NRR (Tables 8-9).

Table 9. Correlations among interval first to last AI (IFL) or substitute traits

	FIN	NOR	SWE
DNK	*-.23*[a] *.49*[b]	*.24*[a] *.11*[b]	*.74*[a] *.69*[b]
	.27[c] *.21*[d]	*.34*[c] *.22*[d]	*.77*[c] *.66*[d]
FIN		*.85*[a] *.71*[b]	*.41*[a] *.42*[b]
		.93[c] *.80*[d]	*.78*[c] *-.40*[d]
NOR			*.79*[a] *-.27*[b]
			.85[c] *-.45*[d]

***a)** IFL, DOP, NRR, AIS.* ***b)** IFL, DOP, NRR, HST.*
***c)** IFL, NRR, NRR, AIS.* ***d)** IFL, NRR, NRR, HST.*

The fertility sub indices vary with respect to weighting factors and traits included. The correlation estimates (Table 10) must therefore be expected to differ substantially.

Table 10. Correlations among Fertility sub indices (FI) or substitute traits

	FIN	NOR	SWE
DNK	*.37*[a]	*.65*[a]	*.92*[a]
FIN		*.90*[a]	*.65*[a]
NOR			*.89*[a]

***a)** FI, FI, NRR, FI.*

Diseases other than mastitis

The definitions of OTR vary with respect to diseases included and parities utilized. Therefore, many correlation estimates were only moderate, as can be seen in Table 11.

Table 11. Correlations among fertility treatments (FTR) and other treatments (OTR)

	FIN		NOR		SWE	
DNK	*.42[a]*	*.41[b]*	*.73[a]*	*.45[b]*	*.05[a]*	*.87[b]*
FIN			*.81[a]*	*.37[b]*	*.83[a]*	*.75[b]*
NOR					*.38[a]*	*.33[b]*

a) *OTR, FTR, OTR, FTR.* ***b)*** *OTR, OTR, OTR, OTR.*

Calving traits

The calving traits are similarly registered in the Nordic countries. However, the statistical treatment varies substantially. Despite these differences, most correlation estimates were medium to high (Tables 12-14).

Table 12. Correlations among component traits of calving ease

	FIN		NOR		SWE	
DNK	*.95[a]*	*.82[b]*	*.38[a]*	*.97[b]*	*.88[a]*	*.75[b]*
	.98[c]	*.58[d]*	*.17[c]*	*.94[d]*	*.83[c]*	*.65[d]*
FIN			*.56[a]*	*.81[b]*	*.91[a]*	*.83[b]*
			.27[c]	*.70[d]*	*.86[c]*	*.85[d]*
NOR					*.76[a]*	*.86[b]*
					.68[c]	*.83[d]*

a) *CED, CED, CED, CED.* ***b)*** *CEM, CEM, CEM, CEM.*
c) *CEDl, CED, CED, CED.* ***d)*** *CEMl, CEM, CEM, CEM.*

Table 13. Correlations among component traits of calf viability

	FIN		NOR		SWE	
DNK	*.75[a]*	*.95[b]*	*.57[a]*	*.79[b]*	*.93[a]*	*.65[b]*
	.94[c]	*.13[d]*	*.73[c]*	*.82[d]*	*.91[c]*	*.43[d]*
FIN			*.52[a]*	*.72[b]*	*.84[a]*	*.77[b]*
			.78[c]	*.39[d]*	*.82[c]*	*.78[d]*
NOR					*.36[a]*	*.44[b]*
					.42[c]	*.42[d]*

a) *CVD, CVD, CVD, CVD.* ***b)*** *CVM, CVM, CVM, CVM.*
c) *CVDl, CVD, CVD, CVD.* ***d)*** *CVMl, CVM, CVM, CVM.*

One might expect higher correlations among the direct effects (Tables 12-13) as these traits were sire of calf effects in all countries, but that does not seem to have been the case in these analyses.

Table 14. Correlations among birth sub indices (BI) and among calving sub indices (CI)

	FIN		NOR		SWE	
DNK	*.70[a]*	*.80[b]*	*.76[a]*	*.95[b]*	*.96[a]*	*.76[b]*
	.73[c]	*.72[d]*	*.17[c]*	*.94[d]*	*.97[c]*	*.64[d]*
FIN			*.16[a]*	*.73[b]*	*.51[a]*	*.64[b]*
			.54[c]	*.57[d]*	*.82[c]*	*.79[d]*
NOR					*.91[a]*	*.89[b]*
					.18[c]	*.46[d]*

a) *BI, CED, CED, BI.* ***b)*** *CI, CEM, CEM, CI.*
c) *BI, CVD, CVD, BI.* ***d)*** *CI, CVM, CVM, CI.*

Conclusions

The functional traits in the Nordic countries vary in trait expression, parities utilized and statistical modeling. Despite this, a lot of the correlation estimates were moderate to high, especially among non-return rate, calving ease and calf viability. Heritabilities were low and the connections between countries weak. Both are factors believed to contribute to underestimation of correlations. If the traits and the evaluation models can be harmonized, there should be valuable across country information to utilize for breeding purposes based on the current Nordic milk recording schemes.

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