

MACE for the Conformation Traits for Six Countries ¹

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The following are results of applying MACE to evaluation of conformation traits. The traits included in this analysis were 9 of the 12 linear type traits recommended in the global harmonization format that were available from the participating countries, and the trait of overall type score (final score). With the exception of foot angle, fore udder attachment and rear udder height, six countries (CAN, USA, NLD, DEU, FRA, and ITA) were used in the analysis.

Table 1 gives the number of bulls from each country used in the different parts of the evaluation. The total number of bulls from each country includes all bulls with evaluations born since 1980 with status codes of 00 (unknown) or 10 (AI bull). De-regressed proofs for this set of bulls were used to estimate the within country sire variances for each trait, and to estimate correlations between countries.

The MME for de-regression of proofs can be written as:

$$\begin{bmatrix} 1'R^{-1}1 & 1'R^{-1}Z & 0 \\ Z'R^{-1}1 & Z'R^{-1}Z + A^{pp}\alpha & A^{po}\alpha \\ 0 & A^{op}\alpha & A^{oo}\alpha \end{bmatrix} \begin{bmatrix} \hat{c} \\ \hat{a}_p \\ \hat{a}_o \end{bmatrix} = \begin{bmatrix} 1'R^{-1}Y \\ Z'R^{-1}Y \\ 0 \end{bmatrix} \quad [1]$$

where,

Y is a vector of de-regressed proofs

\hat{c} is a vector of country effect (unknown)

\hat{a}_p is a vector of proofs of bulls from each country (known)

\hat{a}_o is a vector of proofs of ancestors, phantom parent groups (unknown)

A is the relationship matrix

R^{-1} is the diagonal matrix of number of daughters in each country

Z is the incidence matrix.

Equations were solved for Y while holding \hat{a}_p constant. Estimates of within country sire variances were done simultaneously with the degression of proofs, based on a single-trait, approximate EM-REML procedure.

De-regressed proofs (Banos, *et al.*, 1993) were used to analyze all bulls assuming a zero correlation between countries. Following Sigurdsson *et al.* (1995) proofs on imported bulls were included to estimate genetic correlations. Correlations were computed using ancestors in common between pairs of countries. The genetic correlation between countries was then estimated as the ratio of the actual correlation among ancestors, and the expected correlation given the amount of information in the estimate. Some correlations were adjusted slightly so that the resulting matrix of correlations among countries was positive definite. These correlations were then used in the evaluation procedure for a

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subset of the bulls from each country (Table 1).

The across-country evaluation procedure was done following the procedure described by Schaeffer and Zhang (1993) and Schaeffer (1994) with some modifications for the use of de-regressed proofs as follows,

$$Y_i = u_i 1 + Z_i Q g_i + Z_i s_i + e_i \quad [2]$$

where,

Y_i is the vector of deregressed proofs from country i for a particular trait

u_i is a scalar of the average deregressed proof for the i^{th} country

g_i is a vector of genetic group effects of phantom parents i^{th} country

s_i is a vector of random sire genetic effects for the i^{th} country

e_i is a vector of random mean residual effects.

Z_i and Q are incidence matrices

For the evaluation, only bulls with Interbull codes of 11 or 12 were used (i.e. proofs of imported bulls were excluded). Conversion formulas were estimated by simple regression of proofs for bulls that have a proof in one of the two countries with at least 35 daughters.

Evaluation of dairy sires across countries may involve many factors that would cause a genetic correlation of less than unity. Unlike the production traits, differences in the conformation traits may be related to the definition of the trait in each country. Table 2 shows the differences in the heritabilities that each country uses for the genetic evaluation of the same trait. Table 2 also gives the estimate of the sire variance and assumed heritability for each trait in each country, in this analysis. Tables 3-12 give the estimated regression equations for converting proofs of the traits between countries based on the solutions to the MACE evaluations. Also given in these tables are the estimates of the correlation of the traits between countries.

Many improvements are planned for the existing procedure such as development of reliability calculations for MACE, the incorporation of pedigree information on bull dams to increase the number of ties between countries and methods to handle composite traits.

REFERENCES

- Banos, G., J. Philipsson, M. Gundel, J. Juga and U. Sander-Nielsen. 1993. Linear Model Comparisons of Black-and-White Dairy Bulls from the Nordic Countries. *Proceeding of the Open Session of the Interbull Annual Meeting, Aarhus, Denmark, August 19-20*. Bulletin No. 8, 1993.
- Schaeffer, L.R. and W. Zhang. 1993. Multi-trait, Across Country Evaluation of Dairy Sires. *Proceeding of the Open Session of the Interbull Annual Meeting, Aarhus, Denmark, August 19-20*. Bulletin No. 8.
- Schaeffer, L.R. 1994. Multiple-Country Comparison of Dairy Sires. *Journal of Dairy Sci.* 77:2671-2678
- Sigurdsson, A., G. Banos and J. Phillipsson. 1995. Estimation of genetic parameters within and across country. *Interbull Workshop, June 29-30th, Uppsala, Sweden*.

Table 1. Number of bulls with proofs from each country, used in MACE evaluations and in estimation of correlations between traits in each country¹

Country	Bulls with proofs	Used in MACE evaluations	Country	Bulls with proofs	Used in MACE evaluations	Used to estimate correlations
CAN	3046	2982	USA	9251	9180	209
CAN	3046	2982	NLD	3594	3385	159
CAN	3046	2982	DEU	2350	2189	183
CAN	3046	2982	FRA	4466	4466	183
CAN	3046	2982	ITA	1594	1390	147
USA	9251	9180	NLD	3594	3385	187
USA	9251	9180	DEU	2350	2189	191
USA	9251	9180	FRA	4466	4466	212
USA	9251	9180	ITA	1594	1390	158
NLD	3594	3385	DEU	2350	2189	221
NLD	3594	3385	FRA	4466	4466	181
NLD	3594	3385	ITA	1594	1390	127
DEU	2350	2189	FRA	4466	4466	195
DEU	2350	2189	ITA	1594	1390	133
FRA	4466	4466	ITA	1594	1390	151

¹ Proofs on imported bulls were used to estimate correlations between traits but not in the MACE evaluations.

Table 2. Heritabilities and estimated sire variances for type traits in each country

Country		Trait									
		Stature	Rump Angle	Rump Width	Rear Leg Set	Udder Cleft	Teat Placement	Final Class	Foot Angle	Fore Udder	Rear Udder Height
CAN	h^2	.40	.30	.24	.16	.15	.24	.18	.07	.14	.19
	sire σ^2	26.61	29.59	27.47	36.81	24.95	28.01	25.60	35.79	31.43	27.12
USA	h^2	.42	.33	.26	.21	.24	.26	.29	.15	.29	.28
	sire σ^2	1.21	1.68	1.26	2.30	1.75	1.77	.73	2.04	1.60	1.70
NLD	h^2	.62	.38	.27	.32	.22	.39	.30	.20	.32	.27
	sire σ^2	48.67	49.43	54.69	52.04	51.05	47.96	48.46	56.42	53.76	52.03
DEU	h^2	.43	.26	.24	.13	.20	.27	.30	.13	.20	.18
	sire σ^2	176.97	220.86	199.79	276.05	230.37	242.35	190.46	287.96	287.47	231.52
FRA	h^2	.47	.34	.32	.07	.26	.30	.30	—	—	—
	sire σ^2	1.64	.79	1.10	1.32	.77	1.00	.70	—	—	—
ITA	h^2	.40	.25	.29	.16	.18	.22	.15	.18	.15	.20
	sire σ^2	1.73	2.48	1.68	2.93	2.74	2.17	.54	2.52	2.78	2.32

Table 3. Estimated prediction equations for converting proofs for Stature between countries and the estimated correlation of traits between countries (only shaded areas are official)

Country A	Country B	Converting B to A		Converting A to B		No. of bulls	Estimated ¹ correlation of traits
		Alpha	Beta	Alpha	Beta		
CAN	USA	-.33	4.547	.07	.214	6540	.88
CAN	NLD	-57.74	.586	99.43	.678	5190	.43
CAN	DEU	-43.36	.426	102.68	1.702	3883	.60
CAN	FRA	.35	3.577	-.09	.239	6875	.69
CAN	ITA	-1.12	4.044	.33	.192	3806	.56
USA	NLD	-14.30	.143	99.79	3.516	6470	.54
USA	DEU	-9.69	.094	103.42	8.374	5163	.70
USA	FRA	.06	.817	-.08	1.081	8155	.72
USA	ITA	-.23	.935	.24	1.006	5086	.78
NLD	DEU	52.78	.468	-63.76	1.648	3813	.72
NLD	FRA	98.41	3.724	-13.63	.138	6805	.53
NLD	ITA	97.44	3.888	-10.27	.107	3736	.49
DEU	FRA	101.09	7.911	-10.44	.103	5498	.66
DEU	ITA	97.43	7.498	-7.79	.082	2429	.49
FRA	ITA	-.33	1.089	.28	.775	5421	.62

¹ Correlations were estimated from a data set including proofs on imported bulls.

Table 4. Estimated prediction equations for converting proofs for Rump Angle between countries and the estimated correlation of traits between countries (only shaded areas are official)

Country A	Country B	Converting B to A		Converting A to B		No. of bulls	Estimated ¹ correlation of traits
		Alpha	Beta	Alpha	Beta		
CAN	USA	-.32	3.947	.08	.238	6540	.88
CAN	NLD	-83.41	.845	98.69	.847	5190	.55
CAN	DEU	-37.61	.372	100.89	2.161	3883	.64
CAN	FRA	-.05	5.248	.01	.164	6875	.69
CAN	ITA	-.68	3.526	.18	.251	3806	.74
USA	NLD	-21.43	.217	98.81	3.855	6470	.68
USA	DEU	-9.51	.093	102.58	9.709	5163	.77
USA	FRA	-.04	1.353	.04	.669	8155	.74
USA	ITA	-.18	.881	.20	1.100	5086	.86
NLD	DEU	60.13	.390	-117.46	2.195	3813	.74
NLD	FRA	97.61	5.152	-12.79	.131	6805	.57
NLD	ITA	97.70	3.739	-19.83	.203	3736	.72
DEU	FRA	100.14	13.806	-6.63	.066	5498	.74
DEU	ITA	98.39	8.813	-10.04	.102	2429	.76
FRA	ITA	-.06	.629	.10	1.499	5421	.77

¹ Correlations were estimated from a data set including proofs on imported bulls.

Table 5. Estimated prediction equations for converting proofs for Rump Width between countries and the estimated correlation of traits between countries (only shaded areas are official)

Country A	Country B	Converting B to A		Converting A to B		No. of bulls	Estimated ¹ correlation of traits
		Alpha	Beta	Alpha	Beta		
CAN	USA	-.92	4.501	.20	.217	6540	.95
CAN	NLD	-76.47	.766	99.82	.938	5190	.63
CAN	DEU	-39.88	.397	100.48	2.320	3883	.81
CAN	FRA	-.16	4.210	.01	.176	6875	.63
CAN	ITA	-1.14	4.224	.27	.220	3806	.80
USA	NLD	-17.09	.172	99.57	4.220	6470	.65
USA	DEU	-8.59	.087	99.22	10.708	5163	.83
USA	FRA	.20	.993	-.20	.781	8155	.67
USA	ITA	-.17	.942	.18	1.008	5086	.86
NLD	DEU	59.51	.410	-86.30	1.850	3813	.63
NLD	FRA	99.08	2.679	-9.88	.098	6805	.30
NLD	ITA	98.93	4.764	-16.62	.168	3736	.82
DEU	FRA	100.35	8.302	-6.97	.069	5498	.51
DEU	ITA	97.01	10.143	-8.56	.088	2429	.75
FRA	ITA	-.21	.767	.19	.754	5421	.45

¹ Correlations were estimated from a data set including proofs on imported bulls.

Table 6. Estimated prediction equations for converting proofs for Rear Leg Set between countries and the estimated correlation of traits between countries (only shaded areas are official)

Country A	Country B	Converting B to A		Converting A to B		No. of bulls	Estimated ¹ correlation of traits
		Alpha	Beta	Alpha	Beta		
CAN	USA	-.44	3.703	.11	.247	6540	.79
CAN	NLD	-75.45	.750	100.27	.589	5190	.39
CAN	DEU	-35.92	.347	103.26	1.913	3883	.55
CAN	FRA	.42	3.974	-.10	.178	6875	.61
CAN	ITA	-1.44	3.175	.43	.217	3806	.56
USA	NLD	-21.47	.214	100.09	3.021	6470	.58
USA	DEU	-9.61	.093	103.04	8.768	5163	.69
USA	FRA	.07	1.060	-.07	.697	8155	.62
USA	ITA	-.38	.844	.43	.955	5086	.68
NLD	DEU	70.73	.295	-74.36	1.738	3813	.45
NLD	FRA	99.40	3.029	-12.81	.128	6805	.41
NLD	ITA	98.96	3.124	-19.65	.199	3736	.62
DEU	FRA	102.70	10.152	-7.98	.078	5498	.55
DEU	ITA	98.25	7.790	-9.66	.099	2429	.57
FRA	ITA	-.27	.716	.36	1.232	5421	.71

¹ Correlations were estimated from a data set including proofs on imported bulls.

Table 7. Estimated prediction equations for converting proofs for Foot Angle between countries and the estimated correlation of traits between countries (only shaded areas are official)

Country A	Country B	Converting B to A		Converting A to B		No. of bulls	Estimated ¹ correlation of traits
		Alpha	Beta	Alpha	Beta		
CAN	USA	.81	4.217	-.18	.230	1616	.93
CAN	NLD	-101.49	1.016	100.15	.636	1168	.56
CAN	DEU	-39.39	.394	100.95	1.930	877	.68
CAN	ITA	.86	3.628	-.16	.189	1303	.60
USA	NLD	-23.57	.233	101.04	3.460	1420	.71
USA	DEU	-9.19	.090	102.52	7.404	1129	.58
USA	ITA	.01	.930	.00	.949	1555	.80
NLD	DEU	73.43	.273	-76.22	1.749	681	.42
NLD	ITA	99.36	2.249	-18.02	.181	1107	.43
DEU	ITA	99.80	4.300	-6.35	.064	816	.30

¹ Correlations were estimated from a data set including proofs on imported bulls.

Table 8. Estimated prediction equations for converting proofs for Fore Udder Attachment between countries and the estimated correlation of traits between countries (only shaded areas are official)

Country A	Country B	Converting B to A		Converting A to B		No. of bulls	Estimated ¹ correlation of traits
		Alpha	Beta	Alpha	Beta		
CAN	USA	-.89	4.316	.21	.217	1616	.83
CAN	NLD	-85.69	.852	100.76	.821	1168	.57
CAN	DEU	-36.34	.354	103.34	2.058	877	.59
CAN	ITA	-1.28	3.131	.41	.245	1303	.62
USA	NLD	-19.86	.197	100.66	4.114	1420	.77
USA	DEU	-8.68	.084	103.36	10.194	1129	.76
USA	ITA	-.30	.779	.38	1.237	1555	.87
NLD	DEU	64.19	.365	-140.94	2.393	681	.81
NLD	ITA	97.98	3.169	-21.10	.216	1107	.65
DEU	ITA	96.74	7.996	-9.83	.102	816	.68

¹ Correlations were estimated from a data set including proofs on imported bulls.

Table 9. Estimated prediction equations for converting proofs for Rear Udder Height between countries and the estimated correlation of traits between countries (only shaded areas are official)

Country A	Country B	Converting B to A		Converting A to B		No. of bulls	Estimated ¹ correlation of traits
		Alpha	Beta	Alpha	Beta		
CAN	USA	-.21	3.905	.07	.241	1616	.85
CAN	NLD	-79.36	.795	100.26	.886	1168	.60
CAN	DEU	-39.75	.386	103.86	2.086	877	.63
CAN	ITA	-.60	2.940	.31	.221	1303	.51
USA	NLD	-20.47	.204	100.68	3.560	1420	.67
USA	DEU	-10.21	.098	104.87	7.676	1129	.63
USA	ITA	-.37	.826	.47	.973	1555	.69
NLD	DEU	61.61	.378	-85.10	1.870	681	.66
NLD	ITA	98.08	3.648	-19.84	.203	1107	.69
DEU	ITA	99.73	6.625	-10.53	.107	816	.56

¹ Correlations were estimated from a data set including proofs on imported bulls.

Table 10. Estimated prediction equations for converting proofs for Udder Cleft between countries and the estimated correlation of traits between countries (only shaded areas are official)

Country A	Country B	Converting B to A		Converting A to B		No. of bulls	Estimated ¹ correlation of traits
		Alpha	Beta	Alpha	Beta		
CAN	USA	1.31	3.679	-.35	.268	6540	.95
CAN	NLD	-77.57	.779	99.69	1.076	5190	.73
CAN	DEU	-35.39	.352	101.98	1.830	3883	.54
CAN	FRA	1.10	5.154	-.19	.173	6875	.74
CAN	ITA	-.09	3.121	.10	.269	3806	.68
USA	NLD	-21.96	.216	101.54	4.026	6470	.81
USA	DEU	-10.24	.097	106.22	6.805	5163	.55
USA	FRA	-.16	1.370	.11	.609	8155	.66
USA	ITA	-.49	.855	.58	1.056	5086	.75
NLD	DEU	61.08	.386	-91.75	1.927	3813	.65
NLD	FRA	100.27	5.965	-13.03	.130	6805	.63
NLD	ITA	98.99	3.332	-21.66	.219	3736	.63
DEU	FRA	103.31	11.430	-6.73	.065	5498	.56
DEU	ITA	99.91	7.332	-9.95	.101	2429	.62
FRA	ITA	-.21	.584	.36	1.358	5421	.57

¹ Correlations were estimated from a data set including proofs on imported bulls.

Table 11. Estimated prediction equations for converting proofs for Teat Placement between countries and the estimated correlation of traits between countries (only shaded areas are official)

Country A	Country B	Converting B to A		Converting A to B		No. of bulls	Estimated ¹ correlation of traits
		Alpha	Beta	Alpha	Beta		
CAN	USA	1.02	3.833	-.26	.255	6540	.93
CAN	NLD	-82.87	.844	98.32	1.007	5190	.78
CAN	DEU	-37.21	.377	99.18	2.209	3883	.70
CAN	FRA	.77	5.023	-.15	.191	6875	.85
CAN	ITA	-.11	3.696	.06	.236	3806	.75
USA	NLD	-22.71	.228	99.45	3.774	6470	.78
USA	DEU	-10.04	.099	101.68	8.854	5163	.74
USA	FRA	-.07	1.254	.06	.721	8155	.76
USA	ITA	-.36	.963	.37	.980	5086	.84
NLD	DEU	61.75	.379	-122.72	2.232	3813	.75
NLD	FRA	98.24	5.007	-14.82	.151	6805	.66
NLD	ITA	97.60	3.688	-18.60	.191	3736	.68
DEU	FRA	99.70	12.289	-7.29	.073	5498	.73
DEU	ITA	96.67	8.080	-7.84	.083	2429	.57
FRA	ITA	-.20	.745	.27	1.108	5421	.67

¹ Correlations were estimated from a data set including proofs on imported bulls.

Table 12. Estimated prediction equations for converting proofs for Final Class between countries and the estimated correlation of traits between countries (only shaded areas are official)

Country A	Country B	Converting B to A		Converting A to B		No. of bulls	Estimated ¹ correlation of traits
		Alpha	Beta	Alpha	Beta		
CAN	USA	-.72	5.559	.13	.173	6540	.91
CAN	NLD	-67.93	.679	100.07	.898	5190	.56
CAN	DEU	-38.56	.377	103.63	1.571	3883	.51
CAN	FRA	.04	5.340	.00	.153	6875	.68
CAN	ITA	-1.10	6.454	.23	.102	3806	.51
USA	NLD	-13.47	.134	100.61	5.829	6470	.77
USA	DEU	-7.66	.074	103.78	10.076	5163	.66
USA	FRA	.05	.954	-.05	.814	8155	.66
USA	ITA	-.34	1.312	.27	.687	5086	.76
NLD	DEU	53.88	.461	-64.02	1.641	3813	.69
NLD	FRA	99.36	4.878	-9.46	.095	6805	.45
NLD	ITA	98.55	7.904	-9.55	.097	3736	.77
DEU	FRA	101.46	8.301	-6.12	.060	5498	.41
DEU	ITA	97.66	13.937	-4.52	.047	2429	.54
FRA	ITA	-.22	1.086	.18	.502	5421	.41

¹ Correlations were estimated from a data set including proofs on imported bulls.