Preliminary report of

Interbull Pilot Study for Female Fertility Traits in Holstein Populations

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Abstract

Data from 11 populations (14 countries) on a total of 28 female fertility traits were used to estimate across country genetic correlations for these traits. Connectedness among these populations was good enough to allow for the estimation of genetic correlations. Even though many correlations were very low, there was at least one trait combination with high correlation between almost all country pairs.

Introduction

Fertility traits are among the most economically important traits in dairy cattle, partly because of costs involved in unnecessary multiple inseminations and fertility treatments, and partly because of prolonged lactations and reduced milk production which may eventually lead to involuntary culling.

Despite their economic importance there has not been any international genetic evaluation for female fertility traits, mainly because national genetic evaluation for these traits does not have a long history in a large enough number of Interbull member countries. Short history of national genetic evaluation is probably because of the complex nature of the trait, i.e. lack of a single measure that can describe the entirety of the fertility complex in heifers and cows, and lack of complete and reliable insemination records.

However, during the past several years two lines of research have contributed to our increased ability to study the female fertility traits. The first line of research is concerned with a larger number of national genetic evaluation centers and their coworkers making contributions towards a better understanding of the female fertility traits. The other line of research is concerned with the theoretical development of methods for dealing with non-zero residual variances when several traits from each country are available, i.e. the so called Multiple-Trait MACE (MT-MACE).

Aim of this pilot study is to prepare the stage for an international genetic evaluation of fertility traits at the Interbull level. The assessment of results would naturally involve a comparison of logistics and the resulting correlations from the current methodology (ST-MACE) with the new proposed one (MT-MACE). In this preliminary report, and in anticipation of software development for MT-MACE, estimates of genetic correlations for female fertility traits obtained by application of the well established ST-MACE methodology are presented.

Traits

Due to the biological complexity of the female fertility traits, and the diversity of the measurements that the Interbull member countries use in their genetic evaluations, the request for data indicated that the choice of the traits should preferably be related to the following biological abilities:

a) Traits that measure the animal's ability to become pregnant, i.e. high probability of conception. Two examples of traits for this ability are Non-Return Rate (NR) and Number of Inseminations (NI);
b) Traits that measure the animal's ability to re-cycle after calving. An example of a

trait for this ability is the interval between Calving and First insemination (CF);

c) Traits that measure a combination of the above two abilities. Combination of the above two abilities might be through single measurements (e.g. Days Open (DO), Calving Interval (CI)), through index traits (e.g. Fertility Index (FI)), or through correlated composite traits (e.g. body Condition Score (CS).

For the purpose of the pilot study for fertility traits participating countries were invited to submit up to five (5) traits in following order:

1) One heifer trait related to the (a) above;
2) One cow trait related to the (b) above;
3) One cow trait related to the (a) above;
4) One heifer/cow related to the (c) above;
5) One heifer/cow related to the (c) above.

Participating countries and submitted traits

The data request resulted in 11 countries/populations responding and eventually submitting data from their evaluations for female fertility traits in the Holstein breed. These countries were Canada (CAN), joint evaluation from Germany and Austria (DEA), joint evaluation from Denmark, Finland and Sweden (DFS), Spain (ESP), France (FRA), Great Britain (GBR), Ireland (IRL), Israel (ISR), The Netherlands (NLD), New Zealand (NZL) and the United States of America (USA). Traits submitted by these countries and their definitions are listed in Table 1. Submitted traits and their reported heritability values are shown in Table 2. Number of record submitted (results of national genetic evaluations for bulls as EBV, RBV, or PTA) is shown in Table 3.

Estimated genetic correlations

In the data request five "trait positions" were considered for the traits to be submitted. Participating countries could place each of their traits in any position that they deemed suitable. However, for the present phase of the international genetic evaluation the submitted traits were treated based on their position and not based on their definitions. Consequently, all traits reported as trait 1 were analyzed together and all traits reported as trait 2 were analyzed together, and so on. To draw a parallel to the international genetic evaluation of udder health traits, this constituted Run 1 for each trait position. In other words, five runs, all designated as Run 1, were carried out for traits 1 to 5.

For each trait position a number of Run 2's were also carried out, in which all countries / populations were included. However, if any country / population had a "missing trait" for that position, a different trait from that country / population was used. This process continued until the correlations for all trait combinations were obtained. In this way, for each trait position there was a unique Run 1, and potentially a large number of Run 2's.

Table 4 shows the estimated correlations from the unique Run 1 and one example of a Run 2 for the five trait positions.

Choice of the replacement for the "missing trait" had a large effect on the correlations among the remaining traits. One example of such a case is shown in Table 5. In this example, correlations for the trait position 1 are calculated. However, in one run two traits (Trait 2 from the Netherlands and New Zealand) are replaced by two other traits from those two countries (Trait 3). Differences between the two are shown in Table 5.

Total number of common bulls present in the submitted data is presented in Table 6. Of course, actual number of bulls, common bulls and ¾ bulls used in any single run depends on the countries / populations included in that specific run. Summary of all estimated correlations are presented in Tables 7 and 8. In Table 7 average of all correlations for any trait combination is shown. In Table 8 the corresponding maximum values are shown. For the countries submitting more than one trait the presented within country correlations are the results of Calo-type and ST-MACE calculations and therefore should be considered as biased estimates.

The correlation matrices shown in Tables 7 and 8 have not been subjected to the "post processing" or bending and therefore are most suitable for examination of the submitted traits

and their suitability for inclusion in the international genetic evaluations.

Conclusions

1- There is a widespread interest in the international genetic evaluation for female fertility trait;
2- Number of countries capable of submitting more than one trait is considerable;
3- There is enough genetic ties (both common bulls and ancestor animals) among the participating countries for fertility traits;
4- Almost all participating countries had at least one trait with a reasonably high correlations with at least one trait from another country;
5- To handle large number of available traits major computer programming and / or more computing power might be inevitable.

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Table 1- Submitted traits and their definitions

Country / Population	Trait Name[1]	Trait name[2]	Trait definition	h^2
Canada	CA1	NR	Non return rate at 56 days at first insemination, heifer	.020
	CA2	CF	Days between calving and first insemination, cow	.101
	CA3	NR	Non return rate at 56 days at first insemination, cow	.019
	CA4	AF	Age at first insemination (days)	.140
	CA5	DF	Daughter fertility (=65% NR_{cow} – 10% AF – 25 % CF)	.052
Austria – Germany	DE3	NR	Non return 90 days after 1st insemination	.020
Denmark – Finland – Sweden	DF1	NI	Number of AI's, heifer	.025
	DF2	CF	Days between calving and first insemination, cow	.042
	DF3	NI	Number of AI's, cow	.030
	DF4	FL	Days between first and last insemination, heifer	.020
	DF5	DO	Days open	.031
Spain	ES4	DO	Days open	.040
France	FR3	CR	Conception rate (success/failure) for heifers and cows evaluated separately	.020
Great Britain	GB1	NR	Non return rate at 56 days	.018
	GB4	CI	Calving interval (days between 1st and 2nd calvings)	.033
	GB5	CS	Condition score (1=thin, 9=fat)	.237
Ireland	IR2	CI	Calving interval in lactation 1	.040
	IR4	CI	Calving interval across lactations (1-3)	.040
	IR5	CS	Body condition score	.240
Israel	IS1	CP	Percent conception per insemination	.015
	IS3	CR	Inverse of the number of inseminations to conception * 100	.020
The Netherlands	NL2	CF	Interval calving to first insemination (days)	.083
	NL3	NR	Non-return rate 56 days (binary trait)	.015
	NL4	CI	Calving interval (days)	.058
New Zealand	NZ2	PM	PM21: Cow presented for mating in first 21 days of herd's mating period	.047
	NZ3	CA	CAI: Cow bearing a calf in the herd's AI calving period	.020
	NZ4	FI	Fertility index	.020
USA	US4	DP	Daughter pregnancy rate (1% DP = 4 days in DO)	.040

Trait name[1]: Trait designation used in this pilot study
Trait name[2]: Trait acronym used in this pilot study

Table 2 – Submitted traits and their heritabilities

	Trait 1 Heifer's ability to become pregnant	2 Cow's ability to recycle	3 Cow's ability to become pregnant	4 Animal's other abilities	5 Animal's other abilities
CAN	NR	CF	NR	AF	DF
	.020	.101	.019	.140	.052
DEU	-	-	NR	-	-
	-	-	.020	-	-
DFS	NI	CF	NI	FL	DO
	.025	.042	.030	.020	.031
ESP	-	-	-	DO	-
	-	-	-	.040	-
FRA	-	-	CR	-	-
	-	-	.020	-	-
GBR	NR	-	-	CI	CS
	.018	-	-	.033	.237
IRL	-	CI	-	CI	CS
	-	.040	-	.040	.240
ISR	CP	-	CR	-	-
	.015	-	.020	-	-
NLD	-	CF	NR	CI	-
	-	.083	.015	.058	-
NZL	-	PM	CA	FI	-
	-	.047	.020	.020	-
USA	-	-	-	DP	-
	-	-	-	.040	-

AF Age at first insemination
CA Cow bearing a calf
CF Calving to first insemination
CI Calving interval
CP Percent conception
CR Conception rate
CS Body condition score
DF Daughter fertility index
DP Daughter pregnancy rate
DO Days open
FL First to last insemination interval
FI Fertility index
PM Presented for mating
NI Number of inseminations
NR Non-return rate

Table 3 – Number of submitted records

		Trait 1	2	3	4
COU	*	**	**	**	**
CAN	4166	4156	4101	4151	4093
DEU	15141			15060	
DFS	14244	14082	14004	14057	14107
ESP	2839				2817
FRA	11607			11607	
GBR	4969	4963			4961
IRL	29442		18607		18607
ISR	993	234		922	
NLD	12167		11890	12113	11919
NZL	16490		8790	8895	8895
USA	43450				42499

* = Total number of bulls in the submitted data file
** = Number of bulls with valid national EBV for each trait

Table 4 – Genetic correlations for the five traits. Run 1: Only traits defined as Trait x are included. Run 2: For countries with missing Trait x another trait has been included.

Table 4, Trait 1 – Heifer's ability to become pregnant. Run 1

			CAN NR CA1	DEA	DFS NI DF1	ESP	FRA	GBR NR GB1	IRL	ISR CP IS1	NLD	NZL	USA
CAN	NR	CA1			.64			.83		.72			
DEA													
DFS	NI	DF1						.52		.55			
ESP													
FRA													
GBR	NR	GB1								.47			
IRL													
ISR	CP	IS1											
NLD													
NZL													
USA													

Table 4, Trait 1 – Heifer's ability to become pregnant. Run 2

			CAN NR CA1	DEA NR DE3	DFS NI DF1	ESP DO ES4	FRA CR FR3	GBR NR GB1	IRL CI IR2	ISR CP IS1	NLD CF NL2	NZL PM NZ2	USA DP US4
CAN	NR	CA1		.89	.73	.15	.71	.70	.15	.53	-.27	-.05	.22
DEA	NR	DE3			.71	.25	.88	.50	.27	.43	-.18	-.03	.37
DFS	NI	DF1				.38	.57	.62	.32	.70	.09	.26	.38
ESP	DO	ES4					.56	.41	.86	.34	.87	.69	.93
FRA	CR	FR3						.49	.56	.35	.17	.20	.66
GBR	NR	GB1							.38	.55	.17	.28	.38
IRL	CI	IR2								.35	.79	.75	.85
ISR	CP	IS1									.19	.25	.34
NLD	CF	NL2										.76	.78
NZL	PM	NZ2											.56
USA	DP	US4											

Table 4, Trait 2 – Cow's ability to recycle. Run 1

			CAN CF CA2	DEA	DFS CF DF2	ESP	FRA	GBR	IRL CI IR2	ISR	NLD CF NL2	NZL PM NZ	USA
CAN	CF	CA2			.97				.80		.98	.64	
DEA													
DFS	CF	DF2							.83		.97	.66	
ESP													
FRA													
GBR													
IRL	CI	IR2									.87	.80	
ISR													
NLD	CF	NL2										.76	
NZL	PM	NZ2											
USA													

Table 4, Trait 2 – Cow's ability to recycle. Run 2

			CAN CF CA2	DEA NR DE3	DFS CF DF2	ESP DO ES4	FRA CR FR3	GBR NR GB1	IRL CI IR2	ISR CR IS3	NLD CF NL2	NZL PM NZ2	USA DP US4
CAN	CF	CA2		-.37	.96	.73	-.05	.05	.57	.16	.94	.52	.64
DEA	NR	DE3			-.19	.26	.88	.45	.30	.60	-.21	-.03	.38
DFS	CF	DF2				.83	.14	.16	.73	.30	.97	.65	.75
ESP	DO	ES4					.57	.44	.84	.53	.87	.70	.93
FRA	CR	FR3						.46	.57	.67	.15	.19	.68
GBR	NR	GB1							.43	.78	.22	.33	.38
IRL	CI	IR2								.69	.77	.76	.83
ISR	CR	IS3									.30	.27	.63
NLD	CF	NL2										.73	.76
NZL	PM	NZ2											.54
USA	DP	US4											

Table 4, Trait 3 – Cow's ability to become pregnant. Run 1

			CAN	DEA	DFS	ESP	FRA	GBR	IRL	ISR	NLD	NZL	USA
			NR	NR	NI		CR			CR	NR	CA	
			CA3	DE3	DF3		FR3			IS3	NL3	NZ3	
CAN	NR	CA3		.90	.80		.78			.72	.70	-.01	
DEA	NR	DE3			.72		.92			.65	.47	.26	
DFS	NI	DF3					.75			.96	.62	.38	
ESP													
FRA	CR	FR3								.70	.42	.40	
GBR													
IRL											.64	.51	
ISR	CR	IS3											
NLD	NR	NL3										-.04	
NZL	CA	NZ3											
USA													

Table 4, Trait 3 – Cow's ability to become pregnant. Run 2

			CAN	DEA	DFS	ESP	FRA	GBR	IRL	ISR	NLD	NZL	USA
			NR	NR	NI	DO	CR	NR	CI	CR	NR	CA	DP
			CA3	DE3	DF3	ES4	FR3	GB1	IR2	IS3	NL3	NZ3	US4
CAN	NR	CA3		.86	.69	.10	.66	.54	.17	.68	.74	-.02	.22
DEA	NR	DE3			.69	.30	.89	.29	.36	.62	.48	.12	.39
DFS	NI	DF3				.68	.76	.64	.61	.86	.59	.42	.77
ESP	DO	ES4					.59	.37	.83	.57	.09	.80	.93
FRA	CR	FR3						.31	.61	.70	.38	.37	.67
GBR	NR	GB1							.38	.66	.60	.40	.33
IRL	CI	IR2								.66	.07	.86	.82
ISR	CR	IS3									.67	.46	.67
NLD	NR	NL3										-.01	.20
NZL	CA	NZ3											.64
USA	DP	US4											

Table 4, Trait 4 – Animal's other abilities. Run 1

			CAN	DEA	DFS	ESP	FRA	GBR	IRL	ISR	NLD	NZL	USA
			AF		FL	DO		CI	CI		CI	FI	DP
			CA4		DF4	ES4		GB4	IR4		NL4	NZ4	US4
CAN	AF	CA4			.33	.23		.18	.25		.18	.04	.15
DEA													
DFS	FL	DF4				.61		.63	.46		.70	.50	.61
ESP	DO	ES4						.91	.79		.92	.84	.93
FRA													
GBR	CI	GB4							.85		.96	.83	.87
IRL	CI	IR4									.82	.90	.78
ISR													
NLD	CI	NL4										.82	.93
NZL	FI	NZ4											.73
USA	DP	US4											

Table 4, Trait 4 – Animal's other abilities. Run 2

			CAN	DEA	DFS	ESP	FRA	GBR	IRL	ISR	NLD	NZL	USA
			AF	NR	FL	DO	CR	CI	CI	CR	CI	FI	DP
			CA4	DE3	DF4	ES4	FR3	GB4	IR4	IS3	NL4	NZ4	US4
CAN	AF	CA4		.10	.31	.22	.11	.20	.11	.36	.26	.12	.17
DEA	NR	DE3			.47	.29	.89	.09	.34	.42	.09	.11	.40
DFS	FL	DF4				.67	.47	.63	.55	.71	.67	.55	.65
ESP	DO	ES4					.56	.89	.82	.79	.90	.83	.93
FRA	CR	FR3						.34	.58	.57	.34	.36	.66
GBR	CI	GB4							.84	.79	.96	.84	.85
IRL	CI	IR4								.80	.79	.87	.80
ISR	CR	IS3									.80	.70	.80
NLD	CI	NL4										.83	.88
NZL	FI	NZ4											.73
USA	DP	US4											

Table 4, Trait 5 – Animal's other abilities. Run 1

			CAN DF CA5	DEA	DFS DO DF5	ESP	FRA	GBR CS GB5	IRL CS IR5	ISR	NLD	NZL	USA
CAN	DF	CA5			.51			-.09	.04				
DEA													
DFS	DO	DF5						.43	.50				
ESP													
FRA													
GBR	CS	GB5							.92				
IRL	CS	IR5											
ISR													
NLD													
NZL													
USA													

Table 4, Trait 5 – Animal's other abilities. Run 2

			CAN DF CA5	DEA NR DE3	DFS DO DF5	ESP DO ES4	FRA CR FR3	GBR CS GB5	IRL CS IR5	ISR CR IS3	NLD CF NL2	NZL PM NZ2	USA DP US4
CAN	DF	CA5		.82	.38	.39	.80	-.14	.09	.56	.05	.12	.50
DEA	NR	DE3			.19	.23	.89	-.25	.03	.48	-.14	.01	.36
DFS	DO	DF5				.91	.48	.46	.48	.73	.88	.59	.91
ESP	CR	ES4					.54	.34	.41	.69	.87	.66	.93
FRA	CR	FR3						-.14	.09	.61	.17	.21	.65
GBR	CS	GB5							.91	.52	.63	.43	.28
IRL	CS	IR5								.67	.60	.52	.34
ISR	CR	IS3									.61	.53	.73
NLD	CF	NL2										.74	.77
NZL	PM	NZ2											.53
USA	DP	US4											

Table 5 – An example of the effect of choice of "alternative traits" on the Run 2 correlations. In this example NL2 and NZ2 have been replaced by NL3 and NZ3.

			CAN NR CA1	DEA NR DE3	DFS NI DF1	ESP DO ES4	FRA CR FR3	GBR NR GB1	IRL CI IR2	ISR CP IS1	NLD	NZL	USA DP US4
CAN	NR	CA1		.04	-.04	.00	.08	.15	-.04	-.03			.00
DEA	NR	DE3			.02	-.06	-.01	.20	-.09	-.07			-.05
DFS	NI	DF1				-.02	.03	.06	-.05	-.04			-.01
ESP	DO	ES4					-.05	.01	.01	.07			.00
FRA	CR	FR3						.16	-.07	-.03			-.03
GBR	NR	GB1							-.03	.04			.02
IRL	CI	IR2								.00			.02
ISR	CP	IS1											.12
NLD													
NZL													
USA	DP	US4											

Table 6 – Number of common bulls across traits.

	CA1	CA2	CA3	CA4	CA5	DE3	DF1	DF2	DF3	DF4	DF5	ES4	FR3	GB1	GB4	GB5
CA1	**4156**	1992	2041	2314	2041	173	116	90	92	116	91	167	229	320	266	205
CA2		**4101**	2788	1975	2788	197	144	119	122	144	124	220	290	404	342	249
CA3			**4151**	1983	2841	234	173	144	148	173	150	262	338	454	391	289
CA4				**4093**	1983	133	87	66	67	87	66	128	172	266	216	161
CA5					**4151**	234	173	144	148	173	150	262	338	454	391	289
DE3						**15060**	323	291	298	324	300	887	661	551	499	349
DF1							**14082**	7485	7535	8127	7562	363	351	330	318	233
DF2								**14004**	8234	7478	8241	317	308	288	274	204
DF3									**14057**	7529	8262	329	314	293	279	207
DF4										**14107**	7555	369	351	333	320	234
DF5											**14032**	330	317	296	282	209
ES4												**2817**	848	686	652	418
FR3													**11607**	672	625	402
GB1														**4963**	3640	1920
GB4															**4961**	1770
GB5																**4962**
IR2																
IR4																
IR5																
IS1																
IS3																
NL2																
NL3																
NL4																
NZ2																
NZ3																
NZ4																
US4																

Table 7 - Average value of across trait correlations.

	CA1	CA2	CA3	CA4	CA5	DE3	DF1	DF2	DF3	DF4	DF5	ES4	FR3	GB1	GB4	GB5	IR2	IR4	IR5	IS1	IS3	NL2	NL3	NL4	NZ2	NZ3	NZ4	US4
CA1		-0.62	0.99	-0.55	0.85	0.84	0.57	-0.33	0.33	0.19	-0.03	0.12	0.65	0.65	-0.05	-0.49	0.16	-0.18	-0.18	0.36	0.28	-0.36	0.72	-0.22	-0.08	-0.22	-0.43	0.15
CA2			-0.71	0.48	-0.14	-0.39	0.19	0.92	0.36	0.57	0.81	0.70	-0.07	0.02	0.72	0.60	0.61	0.53	0.48	0.44	0.33	0.92	-0.42	0.82	0.54	0.66	0.69	0.64
CA3				-0.54	0.88	0.86	0.38	-0.47	0.48	0.19	-0.18	-0.05	0.67	0.43	-0.13	-0.47	0.04	-0.03	-0.27	-0.14	0.49	-0.55	0.74	-0.26	-0.29	-0.14	-0.41	0.07
CA4					-0.11	-0.10	0.01	0.31	0.16	0.23	0.25	0.21	0.09	-0.40	0.14	0.14	-0.03	0.11	0.00	0.17	0.16	-0.39	-0.41	0.20	0.13	0.43	0.19	0.17
CA5						0.81	0.59	0.15	0.61	0.47	0.41	0.42	0.77	0.51	0.42	-0.11	0.39	0.37	0.12	-0.08	0.59	0.05	0.63	0.38	0.12	0.25	0.21	0.49
DE3							0.63	-0.06	0.66	0.45	0.27	0.28	0.89	0.34	0.07	-0.26	0.27	0.23	0.05	0.37	0.49	-0.26	0.50	0.08	-0.05	0.19	0.11	0.38
DF1								0.46	0.92	0.95	0.72	0.45	0.65	0.57	0.47	0.07	0.36	0.31	0.23	0.54	0.55	0.22	0.44	0.49	0.27	0.31	0.27	0.47
DF2									0.66	0.77	0.96	0.86	0.23	0.26	0.91	0.53	0.78	0.76	0.60	0.23	0.52	0.95	-0.24	0.92	0.64	0.76	0.79	0.79
DF3										0.96	0.88	0.74	0.73	0.61	0.70	0.21	0.63	0.54	0.37	-0.02	0.82	0.51	0.51	0.71	0.33	0.41	0.43	0.77
DF4											0.91	0.68	0.52	0.59	0.68	0.31	0.52	0.52	0.45	0.44	0.69	0.31	0.27	0.74	0.40	0.74	0.60	0.67
DF5												0.90	0.51	0.52	0.91	0.44	0.74	0.75	0.51	0.20	0.72	0.88	0.12	0.93	0.53	0.70	0.76	0.89
ES4													0.57	0.41	0.90	0.29	0.83	0.81	0.43	0.31	0.64	0.85	0.09	0.90	0.67	0.79	0.84	0.93
FR3														0.39	0.37	-0.16	0.57	0.58	0.13	0.36	0.60	0.13	0.39	0.33	0.19	0.40	0.36	0.67
GB1															0.66	-0.28	0.43	0.54	0.22	0.51	0.62	0.22	0.49	0.49	0.26	0.34	0.22	0.35
GB4																0.42	0.86	0.85	0.61	0.21	0.80	0.88	-0.01	0.95	0.64	0.72	0.79	0.84
GB5																	0.38	0.55	0.86	0.10	0.45	0.61	-0.18	0.54	0.41	0.49	0.52	0.25
IR2																		0.99	0.80	0.30	0.73	0.77	-0.02	0.80	0.73	0.80	0.73	0.81
IR4																			0.83	-0.11	0.80	0.76	-0.10	0.81	0.68	0.78	0.84	0.79
IR5																				-0.02	0.66	0.65	-0.03	0.61	0.53	0.61	0.66	0.35
IS1																					0.46	0.20	0.07	0.26	0.20	0.24	0.18	0.29
IS3																						0.44	0.51	0.80	0.44	0.51	0.70	0.70
NL2																							-0.44	0.97	0.73	0.79	0.82	0.75
NL3																								0.04	-0.16	-0.09	-0.19	0.16
NL4																									0.67	0.76	0.80	0.88
NZ2																										0.99	0.99	0.53
NZ3																											0.99	0.65
NZ4																												0.73
US4																												

Table 8 - Maximum value of across trait correlations.

	CA1	CA2	CA3	CA4	CA5	DE3	DF1	DF2	DF3	DF4	DF5	ES4	FR3	GB1	GB4	GB5	IR2	IR4	IR5	IS1	IS3	NL2	NL3	NL4	NZ2	NZ3	NZ4	US4
CA1		-0.81	0.99	-0.57	0.85	0.89	0.77	-0.53	0.45	0.31	-0.18	0.15	0.72	0.83	-0.28	-0.51	0.19	-0.18	-0.33	0.72	0.28	-0.45	0.76	-0.37	-0.11	-0.41	-0.43	0.22
CA2			-0.84	0.49	-0.18	-0.52	0.38	0.97	0.57	0.66	0.87	0.73	-0.16	0.09	0.74	0.61	0.80	0.53	0.48	0.44	0.49	0.98	-0.55	0.83	0.64	0.66	0.69	0.68
CA3				-0.69	0.88	0.90	0.45	-0.55	0.80	0.33	-0.18	-0.20	0.78	0.54	-0.28	-0.47	0.17	-0.15	-0.27	-0.43	0.72	-0.71	0.76	-0.37	-0.29	-0.40	-0.41	0.22
CA4					-0.16	-0.33	0.12	0.36	0.27	0.33	0.31	0.23	0.11	-0.41	0.20	0.22	-0.06	0.25	0.06	0.33	0.36	-0.39	-0.46	0.26	0.13	0.43	0.39	0.18
CA5						0.83	0.62	0.25	0.67	0.54	0.52	0.43	0.80	0.51	0.42	-0.22	0.39	0.37	0.17	-0.08	0.67	0.05	0.64	0.44	0.12	0.29	0.21	0.53
DE3							0.71	-0.19	0.72	0.53	0.32	0.32	0.92	0.50	0.18	-0.32	0.36	0.34	0.09	0.50	0.65	-0.43	0.54	0.09	-0.15	0.26	0.11	0.41
DF1								0.54	0.93	0.97	0.73	0.58	0.89	0.62	0.54	0.16	0.44	0.32	0.26	0.74	0.55	0.42	0.51	0.50	0.33	0.33	0.27	0.55
DF2									0.72	0.77	0.96	0.89	0.31	0.42	0.91	0.64	0.83	0.76	0.61	0.23	0.70	0.97	-0.37	0.93	0.66	0.76	0.79	0.81
DF3										0.96	0.89	0.77	0.76	0.66	0.73	0.32	0.67	0.54	0.39	-0.02	0.96	0.64	0.62	0.71	0.33	0.43	0.43	0.82
DF4											0.95	0.77	0.56	0.59	0.84	0.49	0.61	0.66	0.49	0.57	0.71	0.31	0.31	0.87	0.43	0.74	0.74	0.72
DF5												0.91	0.56	0.52	0.93	0.55	0.74	0.75	0.55	0.20	0.74	0.88	0.12	0.95	0.59	0.75	0.76	0.92
ES4													0.61	0.49	0.91	0.34	0.86	0.82	0.47	0.34	0.79	0.87	0.11	0.92	0.70	0.80	0.84	0.94
FR3														0.49	0.39	-0.21	0.63	0.58	0.15	0.37	0.71	0.17	0.42	0.34	0.21	0.45	0.36	0.69
GB1															0.71	-0.32	0.58	0.59	0.24	0.55	0.78	0.37	0.61	0.52	0.37	0.43	0.22	0.39
GB4																0.56	0.88	0.86	0.62	0.27	0.81	0.94	-0.14	0.96	0.68	0.78	0.84	0.87
GB5																	0.38	0.62	0.92	0.28	0.52	0.67	-0.24	0.64	0.44	0.56	0.57	0.28
IR2																		0.99	0.84	0.39	0.82	0.87	-0.18	0.81	0.80	0.86	0.73	0.85
IR4																			0.85	-0.21	0.80	0.82	-0.16	0.82	0.68	0.84	0.90	0.80
IR5																				-0.12	0.72	0.68	-0.15	0.65	0.58	0.68	0.70	0.38
IS1																					0.46	0.22	0.17	0.32	0.25	0.33	0.29	0.34
IS3																						0.61	0.67	0.80	0.53	0.57	0.70	0.80
NL2																							-0.60	0.99	0.76	0.85	0.87	0.78
NL3																								0.12	-0.23	-0.25	-0.19	0.22
NL4																									0.70	0.82	0.84	0.93
NZ2																										1.00	1.00	0.56
NZ3																											1.00	0.66
NZ4																												0.73
US4																												