LINEAR MODEL COMPARISONS OF BLACK-AND-WHITE DAIRY BULLS FROM THE NORDIC COUNTRIES[1]

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INTRODUCTION

Desirability for extensive genetic exchanges among Nordic countries has prompted the need for accurate bull comparisons. The objective of this project was to study the feasibility of jointly ranking bulls progeny tested in the Nordic countries by applying the linear model method (Schaeffer, 1985) of combining national evaluations. The study was of specific interest because different Nordic countries apply various methods of genetic evaluation of dairy bulls; therefore a joint evaluation would have to be based on de-regressed proofs rather than daughter-yield-deviations utilized in an earlier study including countries of the European Community (Banos et al, 1992). The present study was restricted to production traits for Black-and-White bulls progeny tested in Denmark (DNK), Finland (FIN), and Sweden (SWE).

MATERIAL AND METHODS

Bull pedigree files from DNK, FIN, and SWE (Table 1) were received and added to the pedigree data-base of the INTERBULL Centre.

TABLE 1: Number of bull pedigree records per Nordic country

Country	Number of pedigree records
DNK	23623
FIN	1373
SWE	9674

With the new contributions the pedigree data base for Black-and-White bulls reached 231006 records. These were used to assign population of origin to each bull, based on the population of origin of his ancestors.

Investigation of the pedigree files revealed that many bulls progeny tested in the Nordic countries have ancestors from other populations, mainly Canada (CAN), United States of America (USA), Germany (DEU), and Netherlands (NLD). This is illustrated in Table 2, where the genetic constitution of Nordic populations of progeny tested bulls born since 1980 is shown.

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TABLE 2: Average genetic constitution (percentage) of three Nordic populations (NRD) of bulls born since 1980 by population of origin.

NRD	Populations of Origin							
	DNK	FIN	SWE	CAN	USA	DEU	NLD	Total
DNK	17	0	2	19	49	12	1	100
FIN	8	38	24	4	25	0	1	100
SWE	1	0	66	8	23	1	1	100

Since most of the ties among the Nordic populations come from elsewhere, it was decided to include the four exporting populations (CAN, USA, DEU, NLD) in the joint evaluation.

National evaluations for milk, fat, and protein yield were obtained from the above countries. National evaluation systems in the Nordic countries are: DNK-BLUP Sire Model; FIN-BLUP Animal Model; SWE-BLUP Sire-MGS Model. The four additional countries implement Animal Models. Edits excluded records with missing birth-year, missing proof and/or missing number of daughters. Further, bulls were required to be AI sampled and have at least 19 daughters. The earliest birth year of bulls progeny tested in DNK was 1980, FIN 1972, and SWE <1960. Despite the time discrepancy, all years were considered in each country to avoid possible biases due to data selection. There were no fat proofs from FIN.

Two different data-sets considered all proofs (ALP) or proofs in the country of first sampling only (FSP). National proofs based on import semen were excluded from the latter to examine potential biases. Such proofs were identified by each European country separately. In USA all proofs based on less than 100% USA daughters were excluded. In CAN imports were identified as bulls belonging to USA studs. Simultaneously tested young bulls were considered part of an AI progeny test scheme in each country and included in FSP. The final data-set description is given in Table 3.

The model of analysis was:

$$Y = Xc + ZQg + Zs + e$$

Where Y: De-regressed proofs,
c: Country effect (fixed)
g: Genetic group effect (fixed, population of origin and birth-year)
s: Sire effect (random, Var=$A\sigma^2_s$, A=relationship matrix)
e: Residual effect (random, Var=$R\sigma^2_e$, R^{-1}=No. daughters diagonal matrix)
X,Z,Q: Incidence matrices

TABLE 3: Number of bulls and national proofs considered in the inter-Nordic evaluations with all data (ALP) and data only from the country of first sampling (FSP).						
Country	ALP		FSP		Number of Imports	Date of Run
	Milk/Fat	Protein	Milk/Fat	Protein		
DNK	2319	2319	2240	2240	79	Mar 93
FIN	691	691	655	655	36	Apr 93
SWE	2014	1630	1905	1521	109	Feb 93
USA	19295	13926	19295	13926	-	Jan 93
CAN	4669	3898	4546	3821	123	Jan 93
DEU	8239	8239	7235	7235	1004	Oct 92
NLD	7190	7190	6250	6250	940	Mar 93
NATIONAL PROOFS	44417	37893	42126	35648		
BULLS	42762	36354	41433	35018		

De-regression was performed within country as follows (k=variance ratio; P=vector of national proofs):

$B=(Q'A^{-1}k)P$
$g=(Q'A^{-1}kQ)^{-1}B$ (group solutions)
$s=P - Qg$ (sire solutions)
$R^{-1}Qg + (R^{-1} + A^{-1}k)s=R^{-1}Y$ (sire right-hand-side)
$Y=RR^{-1}Y$

Prior to the analysis de-regressed proofs were standardized within country. Standardization factors were estimated as pooled within year square root of the product of de-regressed and actual proofs and are shown in Table 4.

Within year standardization factors for each Nordic country and trait are in Appendix I. Ratios of the values in Table 4 provide figures equivalent to the b-values in conversions among bull proofs expressing Estimated Transmitting Ability (ETA) in kilograms.

TABLE 4: Standardization factors, base for age adjustment in months (BA) and number of lactations considered in each national evaluations; values are in kilograms equivalent to each country and are not comparable across country.

Country	Milk	Fat Yield	Protein Yield	BA	NL
DNK	245	9.5	7.0	28	1
FIN	190	-	5.5	-	3
SWE	228	8.7	6.5	28	1
USA	330	11.0	9.0	78	5
CAN	380	13.8	11.0	84	All
DEU	224	9.4	6.4	30,42,54*	3
NLD	246	9.4	6.8	24	3

* separate BA for each lactation

RESULTS AND DISCUSSION

All values in the subsequent tables are associated with ETA-kgs of bulls, unless otherwise stated.

Comparison between international and national evaluations

Within country and birth-year correlations between international and national proofs were over .99 for all traits and data-sets, indicating consistency between the international and various national evaluation runs.

Genetic trends, defined as the average change of bull's ETA by birth year, were similar for each country when calculated by the international and national proofs. Such trends considering bulls born between 1980 and 1988, first tested in the participating Nordic countries, are shown in Table 5.

International proof trends calculated for USA, CAN, DEU, and NLD were also similar to national proof trends in all cases.

TABLE 5: Change of bull estimated transmitting ability by birth-year (1980-1988) calculated by international evaluations considering all data (ALP) and only data from country of first sampling (FSP), and by national evaluations (NAT); values are in kilograms equivalent to each country and are not comparable across country; standard errors in parentheses.									
Country	Milk			Fat Yield			Protein Yield		
	ALP	FSP	NAT	ALP	FSP	NAT	ALP	FSP	NAT
DNK	52.3 (2.4)	52.1 (2.4)	51.6 (2.4)	1.51 (.09)	1.51 (.09)	1.49 (.09)	1.63 (.07)	1.63 (.07)	1.59 (.07)
FIN	6.9 (3.8)	6.2 (3.8)	6.2 (3.8)	-	-	-	.30 (.11)	.29 (.11)	.27 (.11)
SWE	44.6 (3.7)	44.3 (3.7)	44.1 (3.7)	1.63 (.14)	1.62 (.14)	1.57 (.14)	1.06 (.11)	1.05 (.11)	1.01 (.11)

Comparison between ALP and FSP international proofs

Average differences between ALP and FSP for bulls imported into and bulls first tested in the participating Nordic countries are shown in Table 6.

TABLE 6: Average difference between international proofs considering all data and data only from the country of first sampling (ALP-FSP) for bulls imported into the Nordic countries (IMP) and bulls first tested in these countries (FST); values are in kilograms equivalent to each country and are not comparable across country.				
Country	Bulls	Milk	Fat Yield	Protein Yield
DNK	IMP	97.81	1.78	1.87
	FST	1.75	.02	.03
FIN	IMP	74.78	-	1.38
	FST	.44	-	.01
SWE	IMP	131.62	4.36	3.95
	FST	.88	.03	.02

Clearly ALP of imports were substantially inflated when compared to corresponding FSP. Over-estimation was more severe in Sweden, where imports were favoured by approximately 4-5% at the phenotypic scale for all traits. These differences indicate potential biases in the national proofs of imports which also affect their international evaluations. Such differences were not observed in domestic bulls. Assuming that national proofs of bulls first sampled in each country are unbiased, FSP should provide a more reliable international comparison.

Genetic trends and genetic differences

Genetic trend is really subject to any definition. Here, all bulls incorporated in a country's progeny test scheme are considered; these are not limited to bulls born in this country.

Changes in average international ETA for milk, fat, and protein, by birth year for bulls born between 1980 and 1988 are graphed in Figure 1 when all data are considered and Figure 2 when only data from the country of first sampling are considered. Genetic trends associated with these figures were estimated and are in Table 7.

TABLE 7: Change per birth year (1980-1988) of bull international proof when all data (ALP) and only data in country of first sampling (FSP) are considered; values are unitless.

Country	Milk		Fat Yield		Protein Yield	
	ALP	FSP	ALP	FSP	ALP	FSP
DNK	.21	.21	.16	.16	.23	.23
FIN	.04	.03	-	-	.06	.05
SWE	.20	.19	.19	.19	.16	.16

The consistency of expected versus realized international trend was assessed by comparing pedigree index (1/2 SIRE + 1/4 MGS) and actual FSP trends considering Nordic bulls with US ancestry. This exercise would also indicate the relative selection emphasis placed on yield traits by the participating Nordic countries. Expected and realized trends calculated in such way are shown in Table 8; mean pedigree indices are in Table 9. Due to small size, these trends could not be estimated for FIN bulls.

TABLE 8: Change per birth year (1980-1988) of international pedigree index (PI) and international proof (FSP) considering Nordic bulls with USA ancestry; values are in USA kilograms; standard errors in parentheses.

Country	Milk		Fat Yield		Protein Yield	
	PI	FSP	PI	FSP	PI	FSP
DNK	64.0 (2.9)	66.1 (5.0)	1.56 (.08)	1.51 (.16)	1.84 (.08)	1.89 (.13)
SWE	84.4 (6.3)	89.7 (21.0)	.96 (.36)	1.33 (1.02)	2.70 (.33)	2.90 (.74)

Expected and realized trends were similar in DNK and, within sampling variation range, in SWE as well. For this kind of pedigree index, any deviation from expectation should be attributed to differential selection policy with regards to MGD. Genetic trend estimation appears consistent among these countries.

TABLE 9: Mean FSP international pedigree index of Nordic bulls with USA ancestry, born between 1980 and 1988; values are in USA kilograms; standard errors in parentheses.

Country	Number of Bulls	Milk	Fat Yield	Protein Yield
DNK	889	83.81 (7.67)	9.41 (.20)	5.02 (.21)
FIN	9	61.84 (28.54)	-	1.07 (1.07)
SWE	90	56.49 (18.33)	10.19 (.51)	4.02 (.58)

Denmark has, on the average, utilized young bulls with USA ancestry of higher merit for milk and protein than Sweden, but the latter appears to have incorporated such bulls to the AI programme at a more accelerated pace.

An estimate of the genetic difference among the three Nordic populations was obtained by the average ETA difference of bulls first tested in these countries, born in 1987. Such differences reflect the relative merit of the most recent batch of progeny tested bulls in each country and are given in Table 10.

TABLE 10: Mean ETA differences among Nordic countries considering international proofs with all data (ALP) and data only in country of first sampling (FSP) of bulls progeny tested in these countries, born in 1987; values expressed in Swedish kilograms; standard errors in parentheses.

Countries	Milk		Fat Yield		Protein Yield	
	ALP	FSP	ALP	FSP	ALP	FSP
DNK - SWE	117 (30)	52 (30)	7.5 (1.1)	4.3 (1.1)	4.7 (0.8)	2.1 (0.8)
DNK - FIN	161 (40)	107 (40)	-	-	5.7 (1.0)	4.4 (1.1)
FIN - SWE	-44 (52)	-55 (52)	-	-	-1.0 (1.6)	-2.3 (1.6)

Excluding proofs based on import semen benefited SWE and FIN more than DNK, indicating that the former had more problems with biased proofs of imported bulls, relatively to the average merit of domestic bulls. From all values in Table 10, FSP multiplied by 2 should reflect most accurately true genetic differences.

Comparison between international evaluations and conversions

Country solution differences correspond to intercepts and standardization factors to slopes in common conversions of foreign bull proofs. Table 11 presents a comparison between intercepts and slopes officially calculated and those inferred from the international evaluation, to convert from USA and CAN to DNK and SWE. Values were transformed to Relative Breeding Values (RBV) with a mean of 100, which is the usual way of proof expression in DNK and SWE. Officially calculated coefficients convert USA and CAN kilograms to Danish RBV and USA pounds and Canadian Breed Class Averages to Swedish

RBV. Due to lack of sufficient number of common bulls, official conversions from CAN to SWE were calculated indirectly via USA.

TABLE 11: Official (OF) and estimated from international evaluation with all data (AL) and first sampling country data (FS) intercepts (a) and slopes (b) for converting United State (US) and Canadian (CA) proofs to Danish and Swedish equivalent, expressed in relative breeding values.

	Milk					Fat Yield					Protein Yield				
	a			b		a			b		a			b	
	AL	FS	OF	FS	OF	AL	FS	OF	FS	OF	AL	FS	OF	FS	OF
CONVERSION TO DENMARK															
US	99	96	98	.023	.023	93	91	92	.65	.60	96	94	94	.77	.85
CA	97	94	98	.020	.022	93	91	94	.52	.51	95	93	94	.62	.72
CONVERSION TO SWEDEN															
US	109	104	106	.010	.009	102	98	99	.28	.28	106	102	103	.32	.32
CA	106	101	105	1.00	.94	102	98	100	.95	.90	105	100	102	.96	.91

International evaluation slopes were calculated based on standardization factors shown in Table 4; the same factors were used in both ALP and FSP. In all cases country solution differences estimated by ALP would favour the exporting country when compared to FSP. This further indicates potential biases associated with national proofs based on imported semen. Official intercepts, often based on ALP, were also higher than FSP. In any pair of countries, the latter should provide the best estimates of reference base difference.

To date there are no official conversions among Nordic countries. Intercept equivalent (country solution differences) and slope equivalent (standardization factor ratios) inferred from the international evaluation based on country of first sampling data (FSP) are shown in Table 12. All values are transformed to RBV.

Coefficients in Table 12 depend on the definition of base bulls for transformation to RBV which are:

DNK: Bulls from first batch of daughters
FIN: Three latest batches of young bulls (born 1985-1987)
SWE: Three latest batches of young bulls (born 1984-1986)

These bases change every year, therefore intercepts in Table 12 are only valid until September 1993.

TABLE 12: Intercepts (a) and slopes (b) for conversion among Nordic countries calculated from international evaluation based on country of first sampling data; values are expressed in relative breeding values.

Country Pairs	Milk		Fat Yield		Protein Yield	
	a	b	a	b	a	b
DNK to SWE	12.95	.940	12.18	.933	13.77	.928
SWE to DNK	-13.78	1.063	-13.05	1.071	-14.84	1.078
DNK to FIN	31.20	.735	-	-	29.31	.756
FIN to DNK	-42.43	1.359	-	-	-38.77	1.322
FIN to SWE	-26.94	1.279	-	-	-22.19	1.227
SWE to FIN	21.07	.782	-	-	18.09	.815

CONCLUSION

Simultaneous genetic evaluation of all bulls progeny tested in the Nordic countries is possible with a linear model. Appropriate data could be made available from these countries. De-regressed proofs from various national evaluation models seem to function. There is evidence of considerable bias associated with proofs of imported bulls. Therefore an international evaluation based only on data from the country of first sampling should be the method of choice. Due to inclusion of national proofs from the exporting countries and genetic relationships among sires, data connectedness is maintained after excluding imports' proofs. Linear model evaluation also yields conversion coefficients that can be utilized between international evaluation runs among countries that might otherwise lack enough direct ties.

An example inter-country ranking of the top 50 bulls progeny tested in DNK, FIN, and SWE by international proof for protein yield is given in Appendix II.

REFERENCES

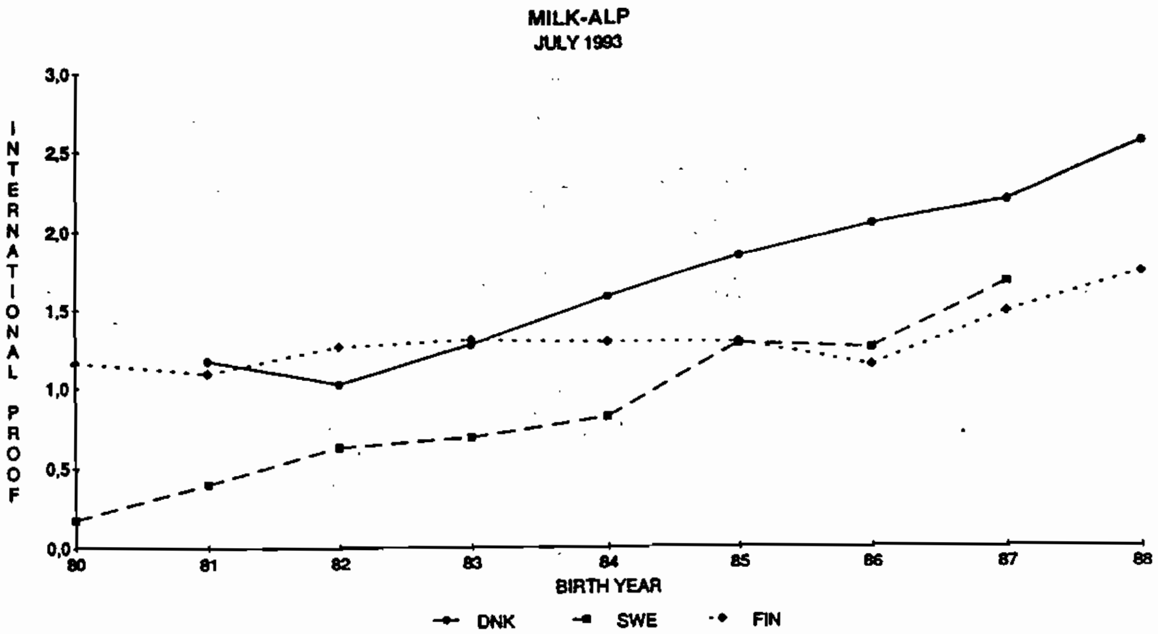
Banos G., Bonaiti, B., Carabaño M., Claus J., Leroy P., Philipsson J., Rozzi P., Swanson G., and Wilmink, J. 1992. Report on COPA/INTERBULL joint project. INTERBULL Bulletin 7.

Schaeffer L.R. 1985. Model for international evaluation of dairy sires. Livest. Prod. Sci. 12:105.

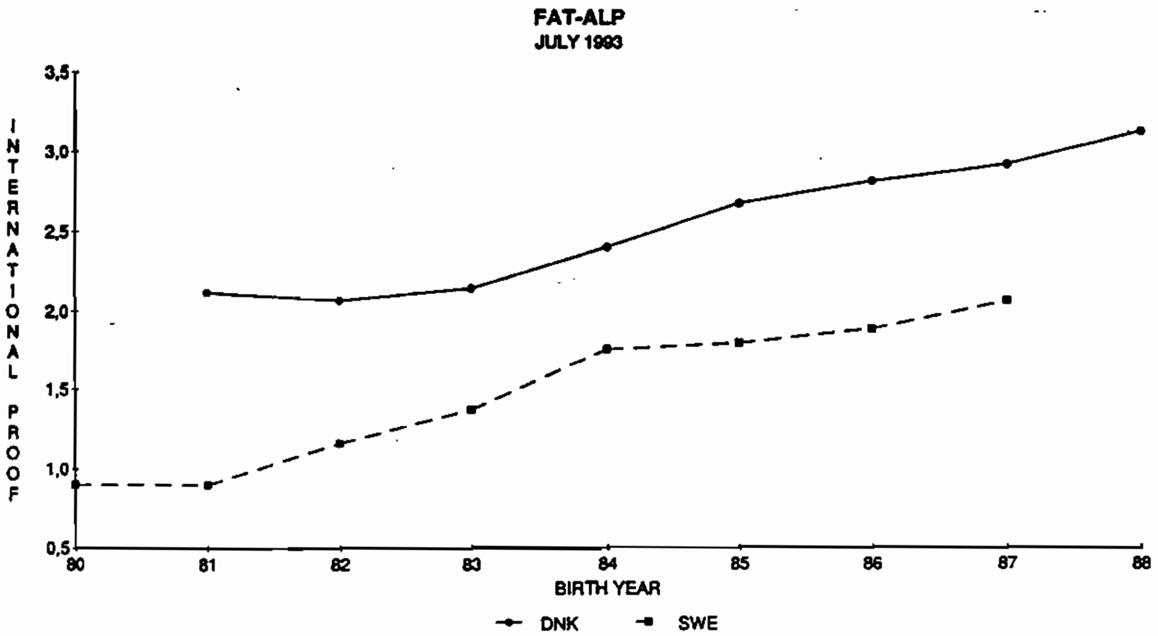
FIGURE 1: Average estimated transmitting ability of Nordic bulls born 1980-1988 for milk, fat, and protein yield, from international evaluation considering all data (ALP).

FIGURE 2 Average estimated transmitting ability of Nordic bulls born 1980-1988 for milk, fat, and protein yield, from international evaluation considering only data from the country of first sampling (FSP).

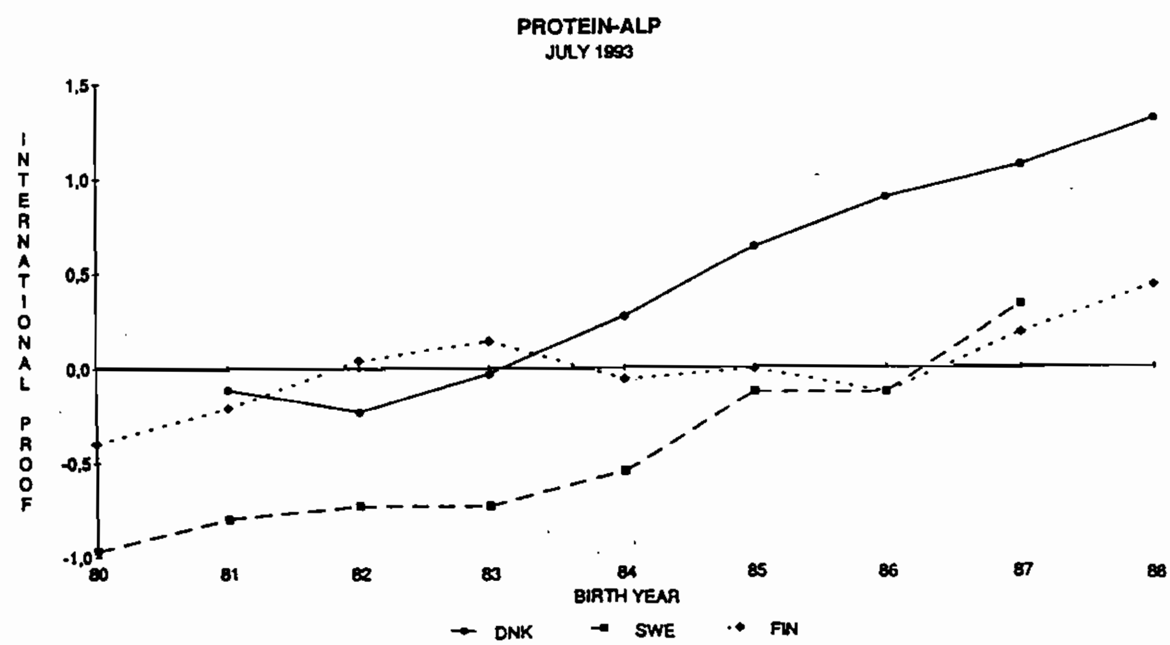
FIGURE 1



MILK-ALP
JULY 1993
INTERNATIONAL PROOF
3,0
2,5
2,0
1,5
1,0
0,5
0,0
80
81
82
83
84
85
86
87
88
BIRTH YEAR
DNK
SWE
FIN

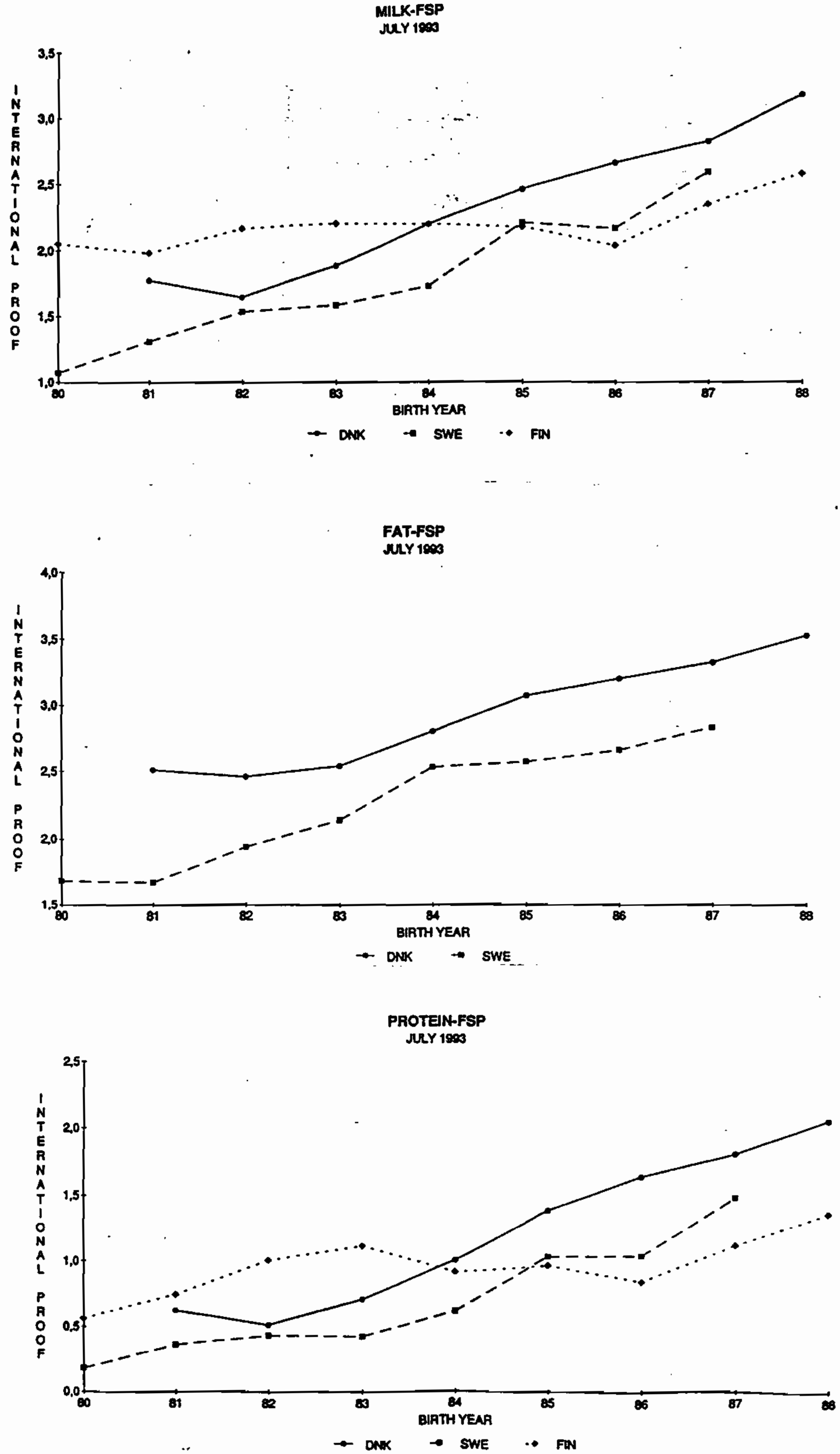


FAT-ALP
JULY 1993
INTERNATIONAL PROOF
3,5
3,0
2,5
2,0
1,5
1,0
0,5
80
81
82
83
84
85
86
87
88
BIRTH YEAR
DNK
SWE



PROTEIN-ALP
JULY 1993
INTERNATIONAL PROOF
1,5
1,0
0,5
0,0
-0,5
-1,0
80
81
82
83
84
85
86
87
88
BIRTH YEAR
DNK
SWE
FIN

FIGURE 2



MILK-FSP
JULY 1993
INTERNATIONAL PROOF
3,5
3,0
2,5
2,0
1,5
1,0
80
81
82
83
84
85
86
87
88
BIRTH YEAR
DNK
SWE
FIN
FAT-FSP
JULY 1993
INTERNATIONAL PROOF
4,0
3,5
3,0
2,5
2,0
1,5
80
81
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83
84
85
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87
88
BIRTH YEAR
DNK
SWE
PROTEIN-FSP
JULY 1993
INTERNATIONAL PROOF
2,5
2,0
1,5
1,0
0,5
0,0
80
81
82
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85
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87
88
BIRTH YEAR
DNK
SWE
FIN

APPENDIX I

Within birth year standardization factors (standard deviation of proof multiplied by standard deviation of de-regressed proof) by Nordic country and trait.

Birth Year	Milk Yield			Fat Yield			Protein Yield		
	DNK	FIN	SWE	DNK	FIN	SWE	DNK	FIN	SWE
1970			196			7.4			5.0
1971			197			7.6			5.6
1972		221	198			7.9		6.0	5.6
1973		228	236			8.2		6.1	6.2
1974		170	170			7.2		4.9	6.1
1975		220	197			7.7		6.3	5.0
1976		196	226			9.3		5.4	5.5
1977		219	240			7.5		6.9	6.9
1978		205	238			7.4		5.4	6.1
1979		150	195			8.7		4.4	6.8
1980	245	199	240	9.5		9.3	7.1	5.7	5.8
1981	265	150	239	10.6		8.3	7.6	4.9	6.7
1982	233	192	208	9.1		8.2	6.7	4.7	6.9
1983	235	175	235	10.4		9.3	6.9	4.7	6.1
1984	250	149	234	9.2		9.8	7.1	4.6	6.7
1985	252	173	267	8.8		9.9	6.9	5.2	6.8
1986	250	199	277	9.8		9.6	6.8	5.2	8.1
1987	235	175		9.2			6.2	5.4	8.2

APPENDIX II

TOP 50 BULLS FIRST TESTED IN NORDIC COUNTRIES
WITH AT LEAST 30 DAUGHTERS
BY INTERNATIONAL PROOF PROTEIN (FSP)
EXPRESSED AS EBV IN SWE-KGS
JULY 1993 RUN

	BULL ID	BULL NAME	BIRTH YEAR	NO. DAUS	EBV PROT	EBV MILK	EBV FAT
1	DNK000000220730	SDJ HOF	1985	96	45.3	1581.2	40.2
2	DNK000000018382	NJY HUBERT	1983	24507	44.1	1345.0	62.9
3	DNK000000223439	CEN BOY	1986	113	42.8	1050.6	46.3
4	DNK000000225633	VAR PORS	1988	94	40.5	1263.2	25.9
5	DNK000000225068	HJ BRAG	1987	99	40.0	1094.4	33.6
6	DNK000000223204	CEN BENGO	1986	93	39.7	1128.9	45.2
7	SWE000000044005	FOLE	1987	206	38.7	1238.3	26.3
8	DNK000000018474	SDJ GNIST	1983	345	38.3	1140.9	39.0
9	DNK000000225247	NJY MALTHE	1987	109	37.7	1298.2	39.9
10	DNK000000222471	SDJ IVANHO	1986	97	37.6	1326.3	45.4
11	SWE000000083185	SKATTEGÅRD	1982	3135	36.9	747.0	26.0
12	DNK000000224568	JY NIKE	1987	87	36.5	1292.0	22.6
13	DNK000000222034	HJ PIT	1985	143	36.5	1195.4	23.4
14	DNK000000223416	US CARTER	1986	126	36.3	973.7	15.9
15	DNK000000223144	SDJ JONAS	1986	79	36.2	1280.8	23.2
16	DNK000000225549	RGK JUMMI	1987	100	35.9	970.3	24.0
17	DNK000000224889	HJ VOGD	1987	145	35.3	1181.2	46.2
18	SWE000000039710	BONUS	1986	146	34.7	799.2	14.6
19	DNK000000223512	US KENNEDY	1986	234	34.6	1458.4	21.5
20	DNK000000224897	SK EGN	1987	104	34.6	1071.0	40.0
21	DNK000000223082	NJY KLOR	1986	106	34.6	1065.6	33.4
22	DNK000000223201	CEN GRÖN	1986	114	34.4	1310.2	24.6
23	SWE000000039521	LIVEN	1985	194	34.3	1223.1	40.4
24	DNK000000225784	VE SKUD	1988	63	34.2	1263.8	25.9
25	DNK000000225010	SK ELI	1987	85	34.2	1431.4	45.5
26	DNK000000226332	VAR RAFF	1988	61	34.0	1035.1	10.0
27	SWE000000083307	RAVELSMARK	1987	118	33.9	1020.1	13.9
28	DNK000000221058	NJY IBSEN	1985	139	33.9	759.5	25.6
29	DNK000000018394	MRS HAMM	1983	165	33.6	1293.1	17.0
30	SWE000000039736	LENES	1987	97	33.5	905.3	17.2
31	DNK000000225102	SK ENORM	1987	85	33.5	901.3	47.4
32	DNK000000224445	CEN RASK	1987	99	33.5	897.7	41.4
33	DNK000000224515	RGK JURE	1987	94	33.2	960.3	26.2
34	SWE000000039579	LÖJAN	1985	156	33.1	827.9	64.1
35	DNK000000223297	ÖDA VELO	1986	113	32.9	1269.0	21.0
36	DNK000000221538	HMT OPAL	1985	133	32.8	1305.8	57.1
37	DNK000000220528	NJY IKEA	1984	123	32.6	1071.1	19.7
38	DNK000000223741	VAR OP	1986	122	32.6	984.2	15.9
39	FIN000000091072	PUROLAN ONKI	1983	386	32.4	1296.0	
40	DNK000000220626	HV ZODIAK	1985	101	32.4	748.0	12.2
41	DNK000000220093	RGK GYLP	1984	143	32.3	701.8	39.3
42	DNK000000223600	CEN KLÖR	1986	108	32.2	1341.1	40.7
43	DNK000000225852	SK FINALE	1988	39	32.2	1177.1	47.5
44	DNK000000223816	VE RONSON	1987	137	32.2	901.6	49.7
45	DNK000000220585	KOL BELSÖ	1985	136	32.2	577.4	36.8
46	DNK000000222504	NJY KRUS	1986	107	32.0	1036.3	22.5
47	DNK000000224406	SDJ JULSÖ	1987	78	32.0	997.8	22.9
48	SWE000000041393	TAXUS	1986	31	31.7	766.3	20.3
49	DNK000000222519	VE POKER	1986	102	31.6	1123.8	28.8
50	FIN000000090510	LUSI-KOTTILAN ELVIS	1975	3837	31.5	761.0	