Estimation of breeding values in Danish sheep breeding

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Introduction
In Denmark sheep breeding is taking place in almost 400 herds which are all participating in an intensive registration programme. The programme was initiated at the beginning of the 1980s. Simultaneously, a performance test station for rams was founded.

In 1989-90 the registration and identification system was improved. A modern computer database was developed to collect and manage the data from the registration programme. Based on the database for sheep registrations, a system for estimation of breeding values was developed in 1991-92. Lately, in 1996, a programme for on-farm ultrasonic scanning of lambs has been initiated.

Data used for breeding value estimation
Table 1 provides a general survey of the number of animals included in estimation of breeding values. In total, data from almost 400 pure-bred herds with more than 10,000 annual lambings are included. The average number of lambings per herd is low, about 30. On the other hand, there is a very lively exchange of breeding stock between herds. A total of 25 breeds are represented. Numerically, Texel, Oxforddown, Shropshire, Dorset and Suffolk are the dominating breeds, and some of the statistics presented will concentrate on these breeds. The following types of information are used in the evaluation:

On-farm registrations
- Viability of lambs
- Lambing difficulties scored on a 5-point scale (voluntary)
- Litter size
- Birth weight, voluntary
- Weight at 2 months +/- 15 days, voluntary
- Weight at 4 months +/- 15 days, voluntary
- Ultrasonic scanning of longissimus dorsi (L.D.) muscle depth and fat depth, assistance from technician, voluntary, extra payment
- Conformation scores by classifier, voluntary, extra payment

Slaughterhouse
- Carcass weight
- EUROP-scoring of carcass quality

Performance test station for rams
- Daily gain 2 - 4 months
- Ultrasonic scanning of L.D. muscle area and fat depth

Table 1. No. of herds of selected breeds with registration of lambings. No. of sheep with progeny in the period 01.07.01 – 30.06.02. Only lambs with known dam and sire are registered.

	No. of herds	Lambs born	Dams	% 1st lambing	Sires
Breed					
Danish Oxforddown	53	1,442	810	23	111
Danish Shropshire	129	3,197	2,058	29	275
Danish Leicester	27	772	461	30	53
Danish Texel	117	4,359	2,737	27	307
Danish Marsh	23	580	311	29	42
Danish Dorset	38	1,879	972	22	84
Danish Suffolk	55	1,294	766	31	112
Danish Merino	16	329	240	35	33
Danish Peltsheep	20	279	166	42	28
Danish Finewool	14	353	140	19	26

Table 2. Information in selected breeds on lambs born in 2002

	Number of lambs	No. of records						
		Lambing difficulties	Birth weight	Weight at 2 months	Weight at 4 months	Carcass evaluation	Perf. test	Farm test scanning
Danish Oxforddown	1442	1402	1323	932	132	186	19	0
Danish Shropshire	3197	3126	3057	2131	590	290	28	221
Danish Leicester	772	755	752	579	84	8	17	64
Danish Texel	4359	4246	4095	2787	922	172	14	136
Danish Marsh	580	567	557	424	50	0	0	0
Danish Dorset	1879	1861	1818	1157	157	90	5	13
Danish Suffolk	1294	1266	1199	731	88	64	1	38
Danish Peltsheep	279	259	241	165	100	0	0	0
Danish Finewool	353	347	329	209	0	1	0	0
Danish Merino	329	329	317	46	7	0	0	0

Table 2 shows the data registered in selected breeds on lambs born in 1997-98. Even though the registration of data on lambing difficulties and birth weight is voluntary, this information is reported for almost all lambs including stillborn lambs. About 80% of the lambs are weighed at the age of 2 and/or at 4 months.

Carcass weight and carcass quality are recorded at the large slaughterhouses and transferred automatically to the database. However, it is a problem that a relatively large proportion of the lambs are slaughtered at small slaughterhouses with no facilities to report carcass records to the database.

The conformation is evaluated by a professional classifier by means of a linear scoring system. The on-farm ultrasonic scanning programme has been initiated in 1998 and therefore the number of observations is still very low. In recent years, the participation in the performance test of rams has been quite limited due to the high costs.

Method for breeding value estimation
A BLUP animal model is used to estimate the breeding values. In table 3 a survey of the fixed and random effects of different models is shown.

The fixed effects included are:
- Breed x herd x year
- Breed x sex
- Breed x lambing season:
    - Grouped according to month, but months 7 - 11 are pooled
    - Dorset is grouped according to month
    - Breed x age at recording (lambing, weight, slaughter)
- Breed x litter size (including stillborn lambs)

The calculations of all breeds are run simultaneously, but as the breed effect is included in all fixed effects, they could have been run separately for each breed.

The random effects included are:
- Breed x herd x year (carcass form score, conformation score)
- Additive genetic effect as direct effect
- Additive genetic effect as maternal trait
- Residual effect

Genetic parameters
Only few analyses of the genetic parameters have been made in Danish sheep breeds. The results of these sporadic analyses combined with commonly used genetic parameters in sheep breeding form the basis for the estimation of breeding values. The assumed genetic parameters are listed in table 4 and 5. In the statistical model all known pieces of pedigree information are utilised.

Reliability
The reliability is calculated by means of an approximative method. The calculation only includes the number of observations of own, sib and progeny performance and does not sufficiently take into account the effective number of comparisons or the effect of correlated traits.

Calculation
The estimation is made by means of the DMU programme developed at The Danish Institute of Animal Science, Research Center Foulum (Jensen, J. & P. Madsen, 1994).

Table 3. Fixed and random effects in the model for different traits in the estimation of breeding values

Trait	Fixed effects					Random effects		
	Breed x herd x year	Breed x sex	Breed x season (3) (5)	Breed x age	Breed x litter size	Breed x herd x year (4)	Ani-mal Di-rect	Ani-mal Ma-ternal
Litter size	x	-	x	x	-	-	x	-
Lambing interval(1)	x	-	x	x	-	-	x	-
Viability at birth	x	x	x	x	x	-	x	x
Viability at 2 months	x	x	x	x	x	-	x	x
Lambing difficulties	x	x	x	x	x	-	x	x
Longevity, 1 year	x	-	x	x	-	-	x	-
Longevity, 3 years	x	-	x	x	-	-	x	-
Longevity, 5 years	x	-	x	x	-	-	x	-
Growth rate , 2 months	x	x	x	x	x	-	x	x
Growth rate, 4 months	x	x	x	x	x	-	x	x
Growth rate, perf. test	-	-	x	-	-	-	x	-
Carcass, form score	x	x	x	x	-	-	x	-
LD area perf test	-	-	x	-	-	-	x	-
Fat depth perf. test	-	-	x	-	-	-	x	-
LD depth., farm test	x	x	-	x	x	-	x	-
Fat depth, farm test	x	x	-	x	x	-	x	-
Linear conf., front end	-	x	x	x	-	x	x	-
Linear conf., overline	-	x	x	x	-	x	x	-
Linear conf., hips	-	x	x	x	-	x	x	-
Linear conf., haunch	-	x	x	x	-	x	x	-
Linear cont., legs	-	x	x	x	-	x	x	-
Linear cont., type	-	x	x	x	-	x	x	-
Org. conf. body (2)	-	x	x	x	-	x	x	-
Org. conf. type(2)	-	x	x	x	-	x	x	-
Org. conf. size(2)	-	x	x	x	-	x	x	-

(1)Only Danish Dorset
(2) Traditional conformation score scale 1-10 used up to 1995
(3) Performance test and Conformation: Breed x Year
(4) Conformation: Breed x Herd
(5) Carcass, form score: lambing season and slaughter season

Table 4. Heritabilities and phenotypic standard deviation

Trait	h^2	Phenotypic std. dev. (in Danish Texel 2002)	Unit
Litter size	0.10	0.57	lamb
Lambing interval	0.025	49.5	days
Viability at birth, maternal	0.04	26.2	%
Viability at birth, direct	0.08	26.2	%
Viability at 2 months, maternal	0.05	14.7	%
Viability at 2 months, direct	0.05	14.7	%
Lambing difficulties, maternal	0,06	0.59	point
Lambing difficulties, direct	0,03	0.59	point
Longevity, 1 year	0.09	135.6*	days
Longevity, 3 years	0.14	429.2*	days
Longevity, 5 years	0.05	676.8*	days
Growth rate, 2 months, maternal	0.30	71.2	gram/day
Growth rate, 2 months., direct	0.25	71.2	gram/day
Growth rate, 4 months, maternal	0.25	52.2	gram/day
Growth rate, 4 months, direct	0.30	52.2	gram/day
Growth rate, performance test	0.50	5.0	index units
Carcass, form score	0.20	1.5	point
LD area performance test	0.57	5.1	index units
Fat depth performance test	0.53	5.1	index units
LD depth, farm test	0.40	2.6	mm
Fat depth, farm test	0.30	1.1	mm
Linear conformation, Front end	0.15	1.5	point
Linear conformation, Overline	0.15	1.1	point
Linear conformation, Hips	0.15	1.3	point
Linear conformation, Haunch	0.15	1.4	point
Linear conformation, Legs	0.15	0.9	point
Linear conformation, Type	0.15	0.7	point
Original conformation, Body	0.20	0.9**	point
Original conformation, Type	0.10	0.4**	point
Original conformation, Size	0.30	0.1**	point

* all breeds all years ** Texel 1993/1994

Table 5. Genetic correlations

Traits	Correla-tion
Genetic correlations	
Growth rate 2 - 4 months, maternal	0.60
Growth rate 2 - 4 direct, direct	0.90
Growth rate 2 months - performance test (direct)	0.72
Growth rate 4 months – performance test (direct)	0.80
Carcass form - LD area performance test	0.50
Carcass form - Fat depth, performance test	-0.13
Carcass form - LD diameter, farm test	0.50
Carcass form - Fat depth, farm test	0.30
LD area - Fat depth performance test	-0.30
LD depth. - Fat depth, farm test	0.30
Longevity 1 year - 3 years	0.93
Longevity 1 year - 5 years	0.86
Longevity 3 years - 5 years	0.96

The total merit index

Breeding values are estimated for 29 different traits. As outlined in figure 1, these 29 estimates are combined into 8 sub-indexes and a total merit index. The procedure is:

1. Within each breed the EBVs are adjusted so the average of the animals in the rolling base is zero. The rolling base includes all animals born 7 to 4 years before the actual year.

2. The adjusted EBVs are multiplied by the economic values shown in table 6 and summed within groups corresponding to the sub-index to which they belong. The general economic values listed in table 6 were calculated in profit equation model for a herd with intensive meat production. The economic values of the conformation traits were determined on the basis of a sort of “common sense”. Later, the economic values for Texel, Shropshire, Dorset, “Shorttail”, Suffolk and Merino have been adjusted by the respective breed organisations.

3. The sums of “economic EBVs” and the total sum are standardised such that the standard deviation of animals in the rolling base is 5 units. The standardisation factors have been revised from time to time.

4. On the basis of the basic economic values in table 6 and the standardisation factors for the sub-indexes, the relative importance of the sub-indexes can be calculated. The relative weight of the sub-indexes is shown in table 7.

Figur 1. Traits, Sub-indexes and Total merit index in Danish sheep breeding

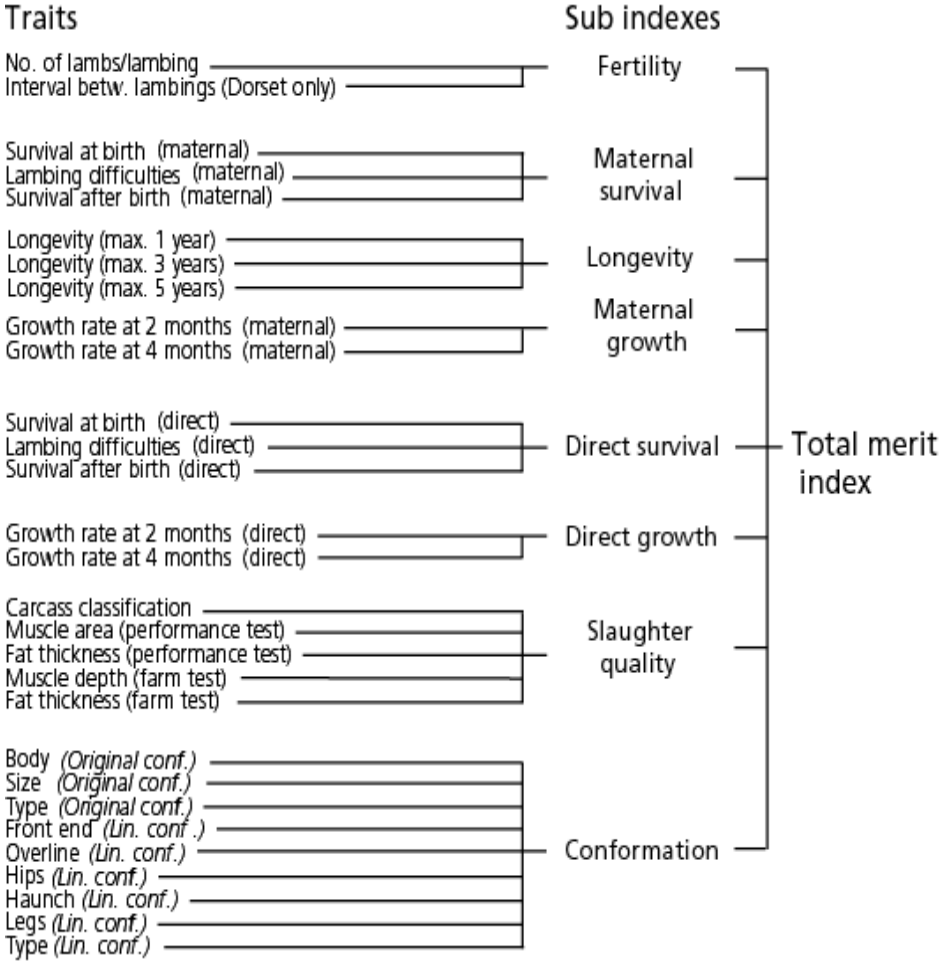

Table 6. Basic economic values in the Total merit index (used in 2002).

Trait	Value	Texel	Suf-folk	Shrop-shire	Dorset	Oxford-down	"Shorttail"	Merino	All others
Litter size	DKK/lamb	435	252	343	345	344	350	298	310
Lambing interval	DKK/day	-	-	-	-1.4		-	-	-
Viability at birth, maternal	DKK/lamb	864	423	740	740	649	760	977	740
Viability after birth, maternal	DKK/lamb	934	457	800	800	702	821	1056	800
Lambing difficulties, maternal	DKK/point	-181	-89	-155	-155	-136	-160	-205	-155
Stayability	DKK/day	0.39	0.6	0.54	0.8	0.49	1	0.25	0.8
Growth rate, 2 months, maternal	DKK/g/day	0.76	0.74	1.72	0.9	1.2	1.2	1	0.84
Viability at birth, direct	DKK/lamb	542	712	434.1	740	685	760	808	740
Viability after birth, direct	DKK/lamb	586	769	469.8	800	741	821	874	800
Lambing difficulties, direct	DKK/point	-114	-149	-91.5	-155	-144	-160	-170	-155
Growth rate, 2 months, direct	DKK/g/day	0.88	0.93	1.75	0.9	1.11	1.2	0.94	0.84
Carcass form score	DKK/point	128	203	60.3	55	38	0	25	65
Fat depth, farm test	DKK/mm	-35	-35	-35	-35	-20	0	-35	-35
Body, Org. Conf.	DKK/point	38.1	22.5	50.78	48.6	145.5	52.5	68.3	52.5
Size, Org. Conf.	DKK/point	5.44	3.23	7.28	6.9	20.85	7.5	9.75	7.5
Type, Org. Conf.	DKK/point	1.69	3.23	7.28	6.9	20.85	7.5	9.75	7.5
Front end, Linear conf.	DKK/point	1.09	0.65	1.43	1.4	4.2	1.5	1.95	1.5
Overline (Overline/Hips)*, Linear conf.	DKK/point	2.18	1.28	2.93	2.8	8.33	3	3.9	3
Hips (Wool)*, Linear conf.	DKK/point	2.18	1.28	2.93	2.8	8.33	3	3.9	3
Haunch (Uniformity)*, Linear conf.	DKK/point	3.26	1.93	4.35	4.2	12.53	4.5	5.85	4.5
Legs, Linear conf.	DKK/point	1.64	0.97	2.18	2.1	6.23	2.25	2.99	2.25
Type, Linear conf.	DKK/point	0.55	0.32	0.73	0.69	2.1	0.75	0.98	0.75

Table 7. The relative weight of the sub-indexes in the Total merit index (2002)

Sub-indexes	Texel	Suffolk	Shropshire	Oxfordd. & Schwarzk.	Dorset	”Shorttail”	Merino	All others
Fertility	0.19	0.11	0.15	0.14	0.14	0.23	0.23	0.11
Lambing	0.14	0.07	0.14	0.10	0.14	0.16	0.19	0.13
Milk	0.06	0.05	0.13	0.10	0.07	0.10	0.09	0.05
Longevity	0.09	0.13	0.13	0.10	0.16	0.19	0.09	0.13
Lamb survival	0.12	0.13	0.13	0.18	0.22	0.23	0.28	0.34
Growth rate	0.07	0.09	0.14	0.10	0.08	0.09	0.09	0.06
Slaughter	0.29	0.40	0.16	0.11	0.17	0.00	0.01	0.14
Conformation	0.04	0.03	0.04	0.16	0.03	0.01	0.00	0.04
Total merit	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Genetic trends for important traits.
Table 8 shows the genetic trend for litter size, longevity, maternal viability at birth, direct viability at birth, maternal growth rate 0-2 months, direct growth rate 0-4 months and for on-farm test of muscle depth and fat thickness . The genetic trend is calculated as the regression of EBV on the year of birth, and only animals born after 1991 are included.

Table 8. Genetic change per year for selected breeds and traits, average over 1991 – 2002

Traits	Dan-ish Ox-ford-down	Danish Shrop-shire	Danish Lei-cester	Danish Texel	Danish Marsk	Danish Dorset	Danish Suffolk	Danish Fine-wool
Litter size, number	0.002	0.006	0.005	0.005	0.011	0.003	0.009	0.005
Longevity at 5 years, days	3.0	2.6	3.1	5.0	4.3	1.6	0.6	3.2
Maternal viability at birth, %	0.04	0.03	0.07	0.04	0.00	0.02	0.06	-0.01
Direct viability at birth, %	0.004	0.003	0.004	0.004	0.002	0.005	0.003	0.005
Maternal growth rate 0-2 months, gram/day	0.8	1.5	1.7	1.4	1.1	0.9	1.2	0.1
Direct growth rate 0-4 months, gram/day	0.9	1.2	1.0	1.6	2.0	2.1	3.0	1.2
Muscle depth, farm test, mm	0.08	0.04	0.12	0.03	0.01	0.02	0.03	-
Fat thickness, farm test, mm	-0.06	-0.06	-0.04	-0.03	-0.01	-0.05	-0.04	-

References:
Jensen, J. & P. Madsen, 1994. DMU. A package for the analysis of multivariate mixed models. In. Proc. 5th World Congr. Genet. Appl. Livest. Prod. 22:45-46.