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Genetic Evaluation of Type Traits in Northern Part of Belgium.

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Introduction

Since 1991, the Vlaamse Rundveeteelt Vereniging is in charge of the type classification of heifers in the Northern part of Belgium. Every 7 or 8 month, voluntarily participating farms are visited by official classifiers and all unclassified first-lactating heifers are scored according to the standard European linear scoring model. Type traits for different Belgian dairy cattle breeds (Red Flanders, MRY, Hostein Friesian, Black and White, Red and White, ...) are classified according to two main conformation standards: dairy and dual-purpose.

In Belgium, selection for type traits may be considered secondary to production traits. In April 1995, the first genetic evaluation of type traits was started. Because estimates of genetic values were not available in Belgium, Dutch genetic parameters published in 1991 (Koninklijk Nederlands Rundvee Syndicaat, NRS Handboek) were used for the evaluation. However, it was not know if those parameters were adequate to the Belgian dairy industry.

The purpose of this paper is a description of the procedure used to obtain new estimates of heritability required for the next genetic evaluation of type traits in Belgium.

Materials and Methods

Data

Records on 15 type traits and 5 composite traits were collected between January 1991 and April 1995 on 56,144 first lactation cows. Type traits were measured (stature) or scored linearly from one biological extreme to another. Composite traits of the cows in relation to the conformation standards were scored from 65 to 99. Cows in lactation for at least 2 weeks were scored by 12 classifiers. Only data on cows classified at most 12 month after calving were kept in the analyses. At calving, all cows were required to be at least 22 months old, and at most 38 months old. Three cows or more had to be scored in the same herd, at the same date, by the same classifier. After editing, data on 51,445 heifers in 1,352 herds were analyzed. On average, 7.8 cows were classified per sire. Characteristics of the traits are given in Table 1. For most traits, the means were slightly greater than the median of the scale.

Model

Preliminary analyses showed that standard deviations of scores given to cows from the same herd, with the same standard of conformation, and at the same date of classification were different. Each score was therefore divided by the standard deviation of observations in the corresponding herd-standard-date cell. Thus, the variability of the standardized scores in one herd-standard-date cell was comparable to variability of the standardized scores in another herd-standard-date cell.

The distribution of all standardized scores was skewed to the right, the means for the standardized linear scores were similar to the variances, and the variances of the standardized general scores and of the standardized size increased with the means. Therefore, a square root transformation was applied to all standardized linear scores and a logarithmic transformation was applied to the standardized size and the standardized general scores. Test of kurtosis and skewness indicated data were more normally distributed after than before transformation.

For statistical analyses, years of calving were classified as before 1992, 1992, 1993, and after 1993. Seven classes for age at scoring were defined: less than 26 months, 26-29, 30-33, 34-37, 38-41, 42-44, and more than 44 months. Scores obtained after the 6th month in lactation were grouped into 1 category.

For each transformed score i, the model was, in matrix notation:

$$y_i = X_i\ b_i + Z_i\ Q_i\ g_i + Z_i\ a_i + e_i$$

where y_i is the vector of transformed scores for trait i, b_i is a vector of fixed effects including effects for herd*standard*date of classification (5514 classes), for month in lactation (7 classes), for calving year (4 classes), and for interaction between age at classification and classifier (94 classes), g_i is a vector of fixed group of unknown parents effects, Q_i is a matrix relating animals to the group of unknown ancestors (Quaas), a_i is a vector of random additive genetic values for trait i, e_i is a vector of residuals, X_i and Z_i are incidence matrices relating elements of b_i and a_i to elements of y_i, respectively. Assume a_i is $N(0, \sigma^2_a)$, e_i is $N(0, \sigma^2_e)$, and a_i and e_i are independent. All known relationships were considered and unknown parents were grouped together according to breed and birth year.

A DF-REML algorithm (Boldman, 1995) was used to estimate variance components. Heritability was estimated as the ratio of additive genetic variance to total genetic variance.

Results and Discussion

Means and standard deviations of transformed scores are shown on Table 2. Missing scores for muscularity represented 49% of all data because this trait is not economically important for the dairy farmer. Transformed scores for udder traits were highest relative to other traits.

To obtain accurate additive genetic values, it is important to determine which environmental effects influenced observed phenotypic values. When studying variation in type traits, we considered effects of herd*standard*date of classification, of year of calving, of month in lactation, and of age at classification*classifier. All the results are shown only for the transformed, pre-standardized scores because our primary goal was to obtain unitless estimates of heritability. The effect of herd*standard*date of classification on all traits was very important, as shown in previous studies (Foster et al., 1988; Klei et al., 1988, NRS Handboek, 1991, Zuchtwerschatzung Bullen, 1995).

General least-squares solutions for effects of month in lactation on scores given to cows calving the same year and classified at the same age by the same classifier are shown on Table 3. The solutions were highest for udder traits. Scores given to cows the first 2 months of lactation were increased by 10 and 17 compared to scores given to cows after the 6th month in lactation, for rear udder width and fore udder attachment, respectively. Scores increased linearly by 2.4, 2.3, and 1.3 per month in milk for suspensory ligament, teat placement, and teat length, respectively. This indicates that cows in late lactation had wider, more loosely attached udders with less visible ligament, and with longer and closer teats than cows in early lactation. It indicates also these physiological changes in udder characteristics were not accounted for by classifiers. Cows in middle lactation had lower scores for forehand, middlehand, rump width, and muscularity than cows in early or late lactation. Cows in late lactation were scored lower for rump angle, thus having higher pins. These changes in body conformation could be the result of pregnancy, or the result of increased body weight in late lactation, or the result of the negative energy and protein balance observed early in lactation, or all three. Finally, solutions for rear udder height, udder depth, milking ease, claw diagonal, and composite traits were less than |1| for the whole lactation. This observation may indicate that scores didn't change during lactation or classifiers adjusted for month in lactation when giving scores.

General least-squares solutions for effects of calving year on scores, after adjustment to a common age at classification, a common classifier, and a common month in lactation, are shown in Table 4. Scores of cows calving after 1993 were increased by 6.0 and 5.4 relative to scores of cows calving before 1991 for claw diagonal and rear leg set, respectively. Scores for udder depth decreased by 1.4 and scores for suspensory ligament decreased by.7 per calving year. The small magnitude of the variation in all scores observed with our model suggests that correcting for calving year is relatively unimportant.

Scores adjusted to a common calving year and a common month in lactation, varied with age at classification differently per classifier. On average, scores for rear udder width, rump width, forehand, middlehand and muscularity increased by .7, 1.3, 1.2, .9, and .9 per month of age at classification, respectively. Scores for suspensory ligament decreased by .5 per month. Older cows had thus deeper forehand and middlehand, wider udder with weaker suspensory ligament, and wider and coarser rumps than younger cows, as observed previously (Foster et al., 1988, Klei et al.,1988). Depending upon the classifier, the difference between scores for rear udder width of cows older than 44 months and of cows younger than 25 months ranged from +2.6 to +57.1 (mean = 19.2) (Figure 1). Similarly (Figure 2), the difference between scores for suspensory ligament of oldest and youngest cows ranged from -34.7 to +13.1 (mean = -14.6). This is because classifiers adjusted more or less correctly for age at classification when they assigned scores to these traits. For the other linear traits and for composite traits, changes in scores across age at classification were small for all classifiers except one.

Heritability estimates for the linear traits obtained with our model are shown in Table 5, along with heritability estimates used in German (Zuchtwerschatzung Bullen, 1995) and Dutch (NRS Handboek, 1991) genetic evaluations. In Northern Belgium, heritability estimates ranged from .11 for temper to .59 for stature. Linear traits and composite traits related to feet (rear leg set, claw diagonal, and legs and feet), temper, and milking ease had heritability estimates less than or equal to 20%. Traits related to stature and muscularity had estimates greater than 40%. Heritability estimates for body and rump conformation ranged from 22 % (loin & chine) to 35% (rump angle). Within udder traits that are moderately heritable (30%), heritability estimates for teat placement and teat length were greatest (>35%) and estimates for suspensory ligament were lowest (22%).

Except for traits related to body conformation (stature, body depth, and rump width and angle), our estimates were greater than German estimates and lower than estimates used in The Netherlands. The greatest differences were among heritability estimates for udder traits even if estimates were of similar rank. These discrepancies could be explained by the different statistical methodologies used in the 3 countries. For example, scores are prestandardized within classifier*year in Germany and within standard*round*classifier in The Netherlands. The Dutch statistical model (1991) included fixed effects for herd*round*classifier*standard and age at classification and the model considered in German evaluation (1995) included fixed effects for region*classifier*year, herd*year, age at first calving, and stage of lactation. Notice aslo a recent evaluation of genetic parameters for type traits by the NRS (personal communication) indicated heritability estimates closer to our estimates.

Conclusions

To improve the efficiency of the 1st genetic evaluation of linear type traits in Belgium, new estimates of heritability were obtained. Firstly, scores were divided by their respective standard deviation within herd*standard*date of classification. Next, a logarithm or a square root transformation was applied to the standardized scores. An unitrait animal model including fixed effects for herd*standard*date of classification, for year of calving, for month in lactation and for age at classification*classifier was applied to the scores. Although age at classification and year of calving influenced scores in Belgian dairy cattle, they were relatively unimportant sources of variation for most scores. On the other hand, stage of lactation influenced traits related to both udder and body conformations.

In the future, both production and type traits should be included in Belgian selection index. Indeed, genetic correlations were shown between production traits, herd life,mastitis indicators, and type traits (Schutz et al., 1993; Short and Taylor, 1992). With the discovery of more efficient algorithms to solve multiple traits animal model, routine evaluations of all type and production traits could become a reality.

References

Boldman, K.G., L. A. Kriese, L. D. Van Vleck, C. P. Van Tassell, and S. D. Kachman, 1995. A manual for use of MTDFREML. A set of programs to obtain estimates of variances and covariances. U.S. Departement of Agriculture, Agricultural Research service

Foster, W. W., A. E. Freeman, P. J. Berger, and A. Kuck. 1988. Linear type trait analysis with genetic parameter estimation. J. Dairy Sci. 71: 223-231

Klei, L., E. J. Pollak, and R. L. Quaas. 1988. Genetic and environmental parameters associated with linearized type appraisal scores. J. Dairy Sci. 71:2744-2752

NRS Handboek. 1991. Fokwaardeschatting exterieurkenmerken.

Quaas, R.L. 1988. Additive genetic model with groups and relationships. J. Dairy Sci. 71:1338-1345.

Schutz, M. M., P. M. VanRaden, P. J. Boettcher, and L. B. Hansen. 1993. Relationship of somatic cell score and linear type trait evaluations of Holstein sires. J. Dairy Sci. 76: 658-663.

Short, T.H., and T. J. Taylor. 1992. Genetic parameters of conformation traits, milk yields, and herd life in Holsteins. J. Dairy Sci. 75: 1987-1998

Zuchtwerschatzung Bullen. German sire proofs. Type traits. June 1995.

Figure 1. General least-squares solutions for effect of age at classification (month) on transformed scores for rear udder width, for classifiers A, B, C, and D.

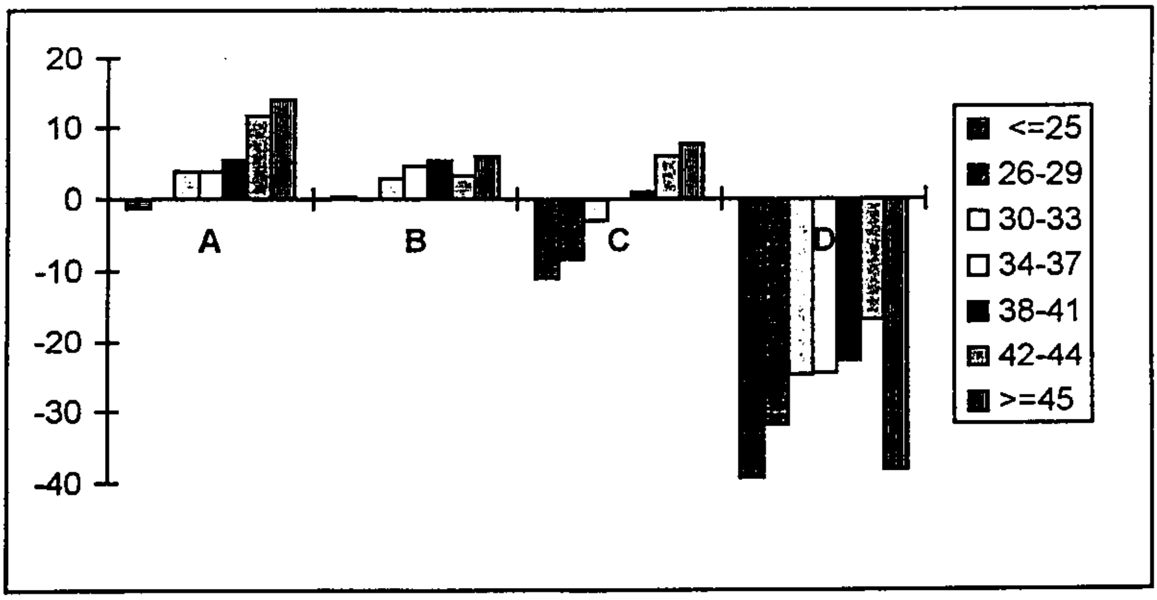

Figure 2. General least-squares solutions for effect of age at classification (month) on transformed scores for suspensory ligament, for classifiers E,F,G, and H.

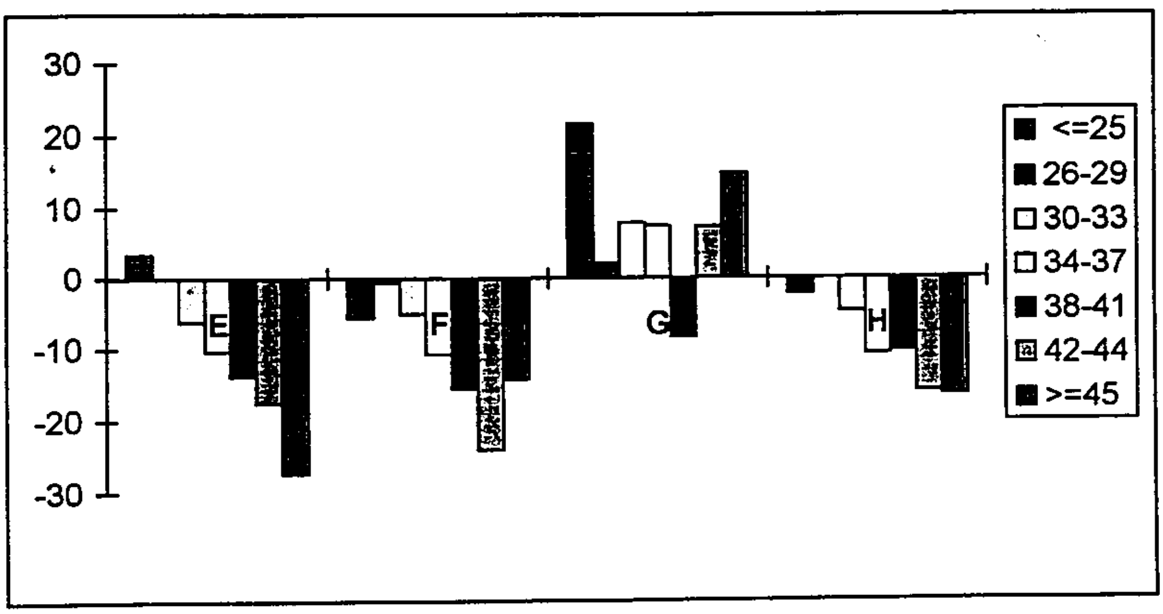

Table 1. Description of type traits

	Definition of scores		Mean	Standard deviation
Linear trait				
Stature (cm)			140.38	4.19
Forehand	shallow (1)	deep (9)	5.37	1.31
Middlehand	shallow (1)	deep (9)	5.92	1.31
Loin&Chine	weak (1)	strong (9)	5.36	1.35
Rump angle	high pins (1)	low pins (9)	4.88	1.22
Rump width	narrow (1)	wide (9)	5.27	1.34
Muscularity	shallow (1)	coarse (9)	5.07	1.32
Rear Leg Set	straight (1)	sickled (9)	5.34	1.26
Claw Diagonal	long (1)	short (9)	4.93	1.38
Fore udder attachment	loose (1)	tight (9)	5.56	1.42
Udder depth	deep (1)	shallow (9)	5.57	1.12
Rear udder height	low (1)	high (9)	5.38	1.27
Rear udder width	(1)	(9)	5.65	1.41
Suspensory ligament	weak (1)	strong (9)	5.57	1.44
Teat placement	wide (1)	close (9)	5.29	1.46
Teat length	short (1)	long (9)	4.92	1.31
Milking ease	slow (1)	fast (5)	3.56	.88
Temper	(1)	rustic (3)	2.68	.61
Composite traits				
Size	poor (65)	excellent (100)	81.48	5.01
Type	poor (65)	excellent (100)	80.38	4.08
Udder	poor (65)	excellent (100)	80.41	4.07
Legs and feet	poor (65)	excellent (100)	80.23	3.98
Muscularity	poor (65)	excellent (100)	81.29	3.93
Final score	poor (65)	excellent (100)	80.57	3.10

Table 2. Description of transformed scores

	n records	Mean	Standard deviation
Linear trait			
Stature	51406	382.80	29.83
Forehand	51354	224.65	46.53
Middlehand	51439	219.24	46.82
Loin&Chine	51444	232.81	49.10
Rump angle	51431	221.03	48.55
Rump width	51442	221.18	47.12
Muscularity	26110	229.18	52.25
Rear Leg Set	51425	223.37	48.47
Claw Diagonal	51396	204.74	43.97
Fore udder attachment	51435	215.16	47.78
Udder depth	51438	249.89	50.45
Rear udder height	51436	232.79	51.58
Rear udder width	51402	224.82	51.01
Suspensory ligament	51267	214.37	48.62
Teat placement	51431	206.24	44.73
Teat length	51431	209.37	46.49
Milking ease	50870	216.62	56.17
Temper	50905	211.65	55.89
Composite traits			
Size	51441	302.09	35.78
Type	51443	319.54	36.55
Udder	51435	322.00	38.00
Legs and feet	51428	319.32	41.98
Muscularity	26201	332.85	35.88
Final score	51445	350.58	34.04

Table 3. General least-squares solutions for month in lactation from our model

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Months >6
Linear trait							
Stature	.38	.17	-.04	-.02	-.00	.0	-.04
Forehand	5.17	.25	-2.19	-1.78	-1.40	-.88	.00
Middlehand	-2.15	-4.83	-3.82	-1.30	.00	.66	2.09
Loin&Chine	-5.03	-4.36	-2.39	-1.68	-.28	.00	.43
Rump angle	3.72	5.03	3.23	1.55	.00	-1.57	-4.58
Rump width	1.27	-.12	-1.77	-.69	-.29	.0	.16
Muscularity	2.91	.00	-.60	1.13	3.17	4.27	6.01
Rear Leg Set	-6.42	-3.78	-.71	.71	.00	.26	-.11
Claw Diagonal	.83	.01	.04	.23	.07	.87	.00
Fore udder	13.48	11.5	6.46	3.44	.00	-1.51	-3.91
Udder depth	.30	1.55	.17	-.22	.00	.65	.48
Rear udder height	.00	1.81	1.73	.56	.00	-.81	-.52
Rear udder width	9.16	10.99	7.96	4.23	2.53	.69	.00
Ligament	-14.47	-10.59	-5.53	-2.54	-.89	.00	3.01
Teat placement	-11.14	-7.03	-4.22	-1.45	.00	1.59	5.15
Teat length	-10.04	-5.73	-1.65	-1.04	.00	.80	.67
Milking ease	-.89	-2.38	-3.96	-3.34	-3.21	-2.00	.00
Temper	.83	-.89	-1.43	-1.35	.50	.45	.00
Composite traits							
Size	.87	.37	-.17	-.07	.00	-.01	.05
Type	.11	-.12	-.24	-.07	.00	.09	.03
Udder	-.12	.35	.19	.08	.00	-.05	.08
Legs and feet	1.16	.36	.09	.05	.00	.25	.45
Muscularity	-1.41	-1.11	-.63	-.08	.12	-.47	.00
Final score	.19	.09	-.16	-.16	-.15	-.12	.00

Table 4 . General least-squares solutions for year of calving from our model

	Before 1992	1992	1993	After 1993
Linear trait				
Stature	.00	-.30	-.49	-.65
Forehand	.45	-1.21	-.29	.00
Middlehand	-.54	-2.63	-.22	.00
Loin&Chine	1.92	.96	.00	-.93
Rump angle	-.44	-.54	-.35	.00
Rump width	.00	-2.44	-3.79	.26
Muscularity	.00	-.14	-.12	-.91
Rear Leg Set	-5.36	-4.16	-2.69	.00
Claw Diagonal	-1.55	-.49	2.01	4.44
Fore udder attachment	-.48	-.03	.97	.00
Udder depth	5.83	4.84	2.01	.00
Rear udder height	-1.85	.75	.10	.00
Rear udder width	.00	1.01	1.29	2.12
Suspensory ligament	3.01	.00	-.27	-.88
Teat placement	1.66	.59	.27	.00
Teat length	.13	.58	1.08	.00
Milking ease	1.21	.38	.21	.00
Temper	.00	-.73	-.98	-.32
Composite traits				
Size	1.47	.67	.34	.00
Type	1.55	.86	.43	.00
Udder	.66	.33	.18	.00
Legs and feet	.13	-.03	.04	.00
Muscularity	.33	.42	.42	.00
Final score	.91	.46	.27	.00

ble 5. Heritability estimates for type traits from our model and used in Dutch (1991) and German (1995) genetic aluation.

	Belgium	Netherlands	Germany
near trait			
ature	.59	.60	.43
›rehand	.23		
iddlehand	.31	.35 (body depth)	.31 (body depth)
›in&Chine	.22		
ımp angle	.35	.35	.26
ımp width	.28	.30	.24
uscularity	.41	.35	
:ar Leg Set	.19	.35	.13
aw Diagonal	.14	.20	.13 (foot angle)
›re udder attachment	.23	.35	.20
ıder depth	.38	.45	.31
:ar udder height	.29	.35	.18
:ar udder width	.30		
ıspensory ligament	.22	.25	.20
:at placement	.38	.45	.27
:at length	.36	.45	.24
ilking ease	.20		
:mper	.11		
›mposite traits			
ze	.55		
ʼpe	.42	.30 - .35	.30
ıder	.36	.35	.20
:gs and feet	.15	.20	
uscularity	.43	.35	
nal score	.43		