Genetic evaluation of longevity in Italian Brown Cattle Breed

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Abstract

Description of genetic evaluation for longevity in Italian Brown population is presented. A total of 49,520 records of first parity cows, born from 1983 to 1986, were used to analyse longevity, type and production traits and to estimate genetic parameters. Functional longevity was defined as total production days (lifetime) adjusted for within herd-year-season class deviation from average herd milk yield (linear and quadratic effects). Genetic parameters were estimated using a REML multiple trait sire model procedures that considered the fixed effects of herd, stage of lactation, age at the first type scoring, interaction between calving year and type classifier, and time interval between milking and type scoring. Heritability values were 0.24, 0.06 and 0.04 for milk yield, true and functional longevity, respectively. Genetic correlations between milk yield and functional longevity was negligible. Longevity exhibited positive genetic associations with udder depth (0.43), rear teats view (0.21) and fore udder attachment (0.15). Negative genetic correlations between functional longevity and type traits were -0.42, -0.29 and -0.13 for teats length, set of rear legs and stature, respectively. An index to predict functional longevity was developed using stature, set rear legs, udder fore attachment, udder depth and teats length estimated breeding values (index weights: -0.31, -0.02, 0.17, 0.33 and –0.17, respectively). The genetic expected response to the selection aimed to improve functional longevity was computed. A ratio of 1 to 6 for functional longevity and production traits was used. Using the new selection index, the genetic progress per year was predicted to be 70 kg, 3.2 kg, 2.6 kg and 0.11 months, for milk yield, fat yield, protein yield and functional longevity, respectively. Since January 1998, the new selection index is used for the Italian Brown population.

1. Introduction

Improvement of longevity in dairy cattle affects profitability by reducing replacement costs and increasing the proportion of cows yielding at mature level (White, 1973; Burnside et al., 1984; van Arendonk, 1985).

Two definitions of longevity are often proposed in literature: true and functional longevity. True longevity is usually defined as observed total productive life and relay on the ability of the cow to delay culling (Strapak, 1997). Functional longevity can be considered as an ”involuntary” culling trait which is able to give a measure of vitality, health status and reproductive performance (Ducrocq, 1987; Dekkers, 1993). To this purpose type classification traits could be regarded as predictors of longevity. Indeed, some conformation traits as body size, feet and legs and udder characteristics exhibited genetic associations with longevity in different breeds (Harris et al., 1992; Short and Lawlor, 1992; Boldman et al., 1992; Bagnato et al., 1995; Vukasinovic et al., 1995).

The Italian Brown breed have a consistency of fairly 400,000 cows, 125,231 of which are registered in the herdbook. Nearly 90% of these are bred artificially. Average size of herds is about 11 cows. The population is appreciated for high quality milk and for longevity (3.4 lactations per cow). The Italian National Association of Brown cattle (ANARB) decided in the 1996 to include in the official selection index (ITE) the longevity trait for reducing involuntary culling rate.

This paper aims to describe the process of implementing longevity in the breeding program for the Italian Brown population.

2. Material and methods

2. 1. Data

The data used in this study were the productive and classification records of first parity Italian Brown cows, born from 1983 to 1986 and their culling date. Type data included 20 traits scored on a scale from 1 to 50. All cows were required to have had an opportunity to remain in the herd at least 84 months after the first calving. Bulls with less than 10 daughters were not considered in the analysis. The statistical analysis used 49,520 records (593 sire progeny groups).

2. 2. Definition of longevity

Total herd life (THL) is defined as the time from first calving to culling date. Other two measures of longevity were defined: true and functional productive life. True productive life (TPL) was defined as THL excluding dry time. Functional productive life (FPL) was defined as TPL adjusted for herd-year-season class deviation from average herd milk yield. Because the effect of average herd deviation was expected to be higher for animal below average yield than for those above average yield, both linear and quadratic effects of average herd deviations were considered. The within herd-year-season class deviation from the average herd was available from the official genetic evaluation procedures for milk traits.

2*. 3. Estimates of genetic parameters*

Genetic parameters for production, type and longevity traits were estimated using REML multiple trait sire model procedures (Meyer, 1986). The relationship matrix included sires and maternal grandsires. Records were analysed using the following model:

$$y_{ijklmno} = \mu + h_i + s_j + a_k + e_l + t_m + sire_n + e_{ijklmno}$$

where $y_{ijklmno}$ = observed value for milk production, type and longevity traits; μ = overall mean; h_i = fixed effect of herd visit; s_j = fixed effect of stage of lactation; a_k = fixed effect of age at first type scoring; e_l = fixed effect of the interaction between calving year and type classifier; t_m = fixed effect of time interval from milking and type scoring; $sire_n$ = random effect of sires; $e_{ijklmno}$= random residual.

2. 4. Predicted FPL index using type traits

The index to predict FPL was computed assuming that predicted breeding values (BV) for all type traits were obtained by a multiple-trait model. Hence, index weights (**w**) were computed as described by Schneeberger et al. (1991):

$$\mathbf{w} = \mathbf{G}_I^{-1}\,\mathbf{G}_{IT}$$

where $\mathbf{G}_I^{-1}$ = matrix of genetic (co)variances among type traits, and $\mathbf{G}_{IT}$ = matrix of genetic (co)variances between type traits and FPL. This method was used to calculate index weights for the five type traits that exhibited the highest heritability and absolute genetic correlations with FPL.

2. 5. Expected response to selection

A selection index including production and longevity traits was compared with the official selection index, currently in use (ITE). Expected responses to selection were computed using the four paths to selection: sires and dams of bulls and sires and dams of cows. For these paths, generation intervals of 8, 5, 5, and 5 years, accuracy of predicted BV of 90, 50, 80 and 50 % and a selected fraction of 2, 1, 10 and 90 % were assumed. Following selection index theory (Hazel, 1943), expected response to selection for production, type and longevity traits was estimated.

3. Results

3. 1. Longevity

Average THL was 50.9 months with a standard deviation of 22.3 months. Figure 1 illustrates occurrence of culling as a function of time since the first calving. As expected, cows were less culled during dry periods than when lactating. The largest culling frequency occurred 22 months after the first calving (6.2% of culled cows).

Total productive life (TPL) was 41.4±17.9 months. This measure was adjusted for herd-year-season class deviation (DEV) from average herd milk yield. A total of 30 classes of DEV using a step of 100 kg of milk yield were defined. Distribution of DEV is reported in Figure 2 and effect of DEV on TPL is showed in Figure 3. The quadratic effect on TPL confirms the assumption that DEV is more important for cows below average yield than for those above average yield.

The estimated function was used to adjust TPL for production level. Estimated linear and quadratic coefficients were 0.834 and -0.045 months/100 kg of milk yield, respectively ($P<0.0001$).

Functional productive life (FPL) was estimated adjusting TPL for DEV. Average FPL was 43.4 months with a standard deviation of 17.0 months. Figure 4 shows frequencies of culling for FPL trait. The distribution of FPL resulted quite similar to a normal distribution with a slight skewness.

3. 2. Genetic parameters

Estimates of heritability and genetic correlations for milk yield, type and longevity traits are reported in Table 1. Heritability estimates for milk and type traits were moderate, ranging from 0.06 (pasterns) to 0.32 (stature). Heritabilities for TPL and FPL were 0.06 and 0.04, respectively. Standard errors of estimated heritabilities ranged from 0.02 to 0.09.

Genetic correlations between milk yield and type traits ranged from –0.38 (udder depth) to 0.55 (fore udder attachment and rear attachment width). Size traits as stature, body depth and rump length showed positive correlations with milk yield (0.17, 0.34 and 0.17, respectively). Genetic correlations between milk and longevity traits were 0.66 and –0.02 for TPL and FPL, respectively.

Genetic correlations between FPL and type traits ranged from –0.42 (teat length) to 0.43 (udder depth) Size traits as stature, rump length and rump width were negatively correlated with FPL (-0.13, -0.24 and –0.12, respectively). Rear legs side view showed a moderate negative genetic correlation with FPL (-0.29).

Genetic correlation between FPL and TPL was 0.73.

3. 3. Predicted FPL index

Choice of type traits for a longevity index was based on a multiple threshold approach on levels of heritability and genetic correlations between FPL and type traits. Only type traits with heritability greater than 0.25 and genetic correlation with FPL greater, in absolute value, than 0.20 were considered. Estimated weighting factors for FPL index for stature, rear legs side view, fore udder attachment, udder depth and teat length are reported in Table 2.

3. 4. Expected response to selection

The official selection index, named total economic index (ITE), for ranking Italian Brown cows and bulls is published every four months by ANARB. Standardised index weights for the old and the new ITE are presented in Table 3. Ratio between economic values for milk and linear type traits was 4:1 and 6:1 for the old and the new ITE, respectively. Relative economic values for fat yield, protein yield, fat percentage and protein percentage are 1, 3, 0.1 and 0.4, in both indexes. Expected responses to selection for the old and the new ITE, are presented in Table 4. When selection was based on the new ITE, genetic change per year was predicted to be 70 kg, 3.2 kg, 2.6 kg, 0.11 months, for milk yield, fat yield, protein yield and FPL, respectively.

4. Discussion

4. 1. Longevity

Average TPL for Italian Brown population was 3.1 months higher when compared to that reported by Vukasinovic et al., 1995 for the Swiss population. In both studies, the same opportunity to stay in the herd was used but an higher percentage of bounded records was reported for the Italian than for the Swiss population (29 and 20 %, respectively). Hence, TPL for the Italian population seems to be more underestimated than in the Swiss study. Pattern of culling frequencies for TPL (Figure 1) clearly shows points where minimum and maximum risk of culling occurs. Minimum number of culling is expected during the dry period and increases with parity (0.3-1.0%). Maximum number of culling occurs during the last period of lactation and decreases with parity (1.5-6%), excluding first parity cows. A different behaviour between primiparous and multiparous cows for culling is evident too. More chances to end the lactation seem to be given to first parity cows. Peak of culling for primiparous cows occurred at 300-330 d from calving whereas it occurred after 4-5 months of lactation for multiparous cows.

Major reason for considering FPL more appealing than TPL is avoiding of double counting for milk yield in the breeding goal and a measuring of the ability of a cow to delay involuntary culling (Vollema, 1998). The reduction of effect of within-herd production level on FPL (Figure 3) might be due to involuntary culling reasons as low fertility and health (Bascom and Young, 1998).

4. 2. Genetic parameters

Heritability estimate for milk yield was in agreement with values reported by Santus et al. (1993), in the same population. Despite both studies used multiple-trait sire model procedures, heritability estimates for type traits were generally lower than values reported by Vukasinovic et al. (1995). Heritability estimate for TPL was 0.06, considerably lower than the value reported by Vukasinovic et al. (1995). Similar estimates were found by Short and Lawlor (1992) and Bagnato et al. (1995). Heritability estimate for FPL was consistent with other studies in different populations (Boldman et al., 1992; Harris et al., 1992; Vukasinovic et al. 1994 and Bagnato et al., 1995).

Values of genetic correlations between milk yield and type traits suggest that genetically high productive cows are heavier cows, with steeper rear legs, strong fore udder attachment and a depth mammary system. Different results were found for Holstein Friesian cows by Short and Lawlor (1992) and Bagnato et al. (1995). In those studies high productive cows exhibited average stature, closer rear legs side view, normal fore udder attachment and depth mammary system. Genetic correlations between milk yield and longevity traits were in agreement with literature values for TPL (Vukasinovic et al., 1995; Short and Lawlor, 1992; Bagnato et al., 1995) whereas results for FPL are consistent with values reported by studies on Holstein Friesian cattle only (Short and Lawlor, 1992; Bagnato et al., 1995). Moderate positive genetic correlations between milk yield and FPL were reported for Brown Swiss and Guernsey populations (Vukasinovic et al., 1994 and Harris et al., 1992). Differences in procedures used to adjust TPL for obtaining FPL might explain different results.

Genetic correlations between type traits and FPL are in agreement with results of Boldman et al., 1992; Harris et al., 1992; Bagnato et al., 1995 and Short and Lawlor, 1992.

Genetic correlation between TPL and FPL indicates that these measures of longevity can be assumed to be different traits. Higher values for the correlations were reported by Vukasinovic et al. (1994), Boldman et al. (1992), and Harris et al. (1992), in Brown Swiss, Holstein and Guernsey cattle, respectively. A value close to 1 (0.98) was found by Bagnato et al. (1995), in the Italian Holstein Friesian population.

4. 3. Predicted FPL index

The scale used to express the FPL index is based on standardisation of each index using the FPL average of 130 decades with a standard deviation of 0.68. Any official ranking for FPL is currently available for Italian Brown cattle. Information on FPL index is reported as additional information in the official genetic evaluations publications.

4. 4. Expected response to selection

Starting from January 1998, the new selection index (ITE) has been used for Italian Brown population. The Central Technical Committee of ANARB decided to adopt the new ITE to guarantee an higher response to longevity keeping the response for milk, fat and protein yield unchanged when compared to the old ITE.

5. Conclusion

The interest in implementing longevity in the breeding goal for the Italian Brown population is mainly due to the need of dairy farmers to have cows with higher economic efficiency. Selection for functional longevity is attractive for reducing involuntary culling rate which is becoming an high cost in Italian dairy herds.

In Italy, type traits scoring play an important role as it gives the National Association of Brown cattle chances to maintain closer contacts with farmers.

The correction of TPL for relative yield within herd was adopted to define the functional productive life, allowing to evaluate sire differences for disposal reasons other than low milk yield. Genetic parameters estimates for longevity were generally in agreement with other studies and suggested that, when accounting for yield level, cows having average body size, good steeper rear legs, a strong fore udder attachment, a low udder depth and a shorter teats length, are more likely to have a longer productive life in this polulation.

A major advantage of new ITE is the better use of type traits to improve longevity trait with unchanged response in milk traits. A genetic change in stature and final score is also expected with new ITE, even though these traits have a negative and zero weights in the FPL index, respectively.

Further studies to better predict FPL using survival analysis and a more precise definition of economic values for milk and longevity traits for the Italian Brown dairy farmers are needed.

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Figure 1 Frequency of culling for total herd life.

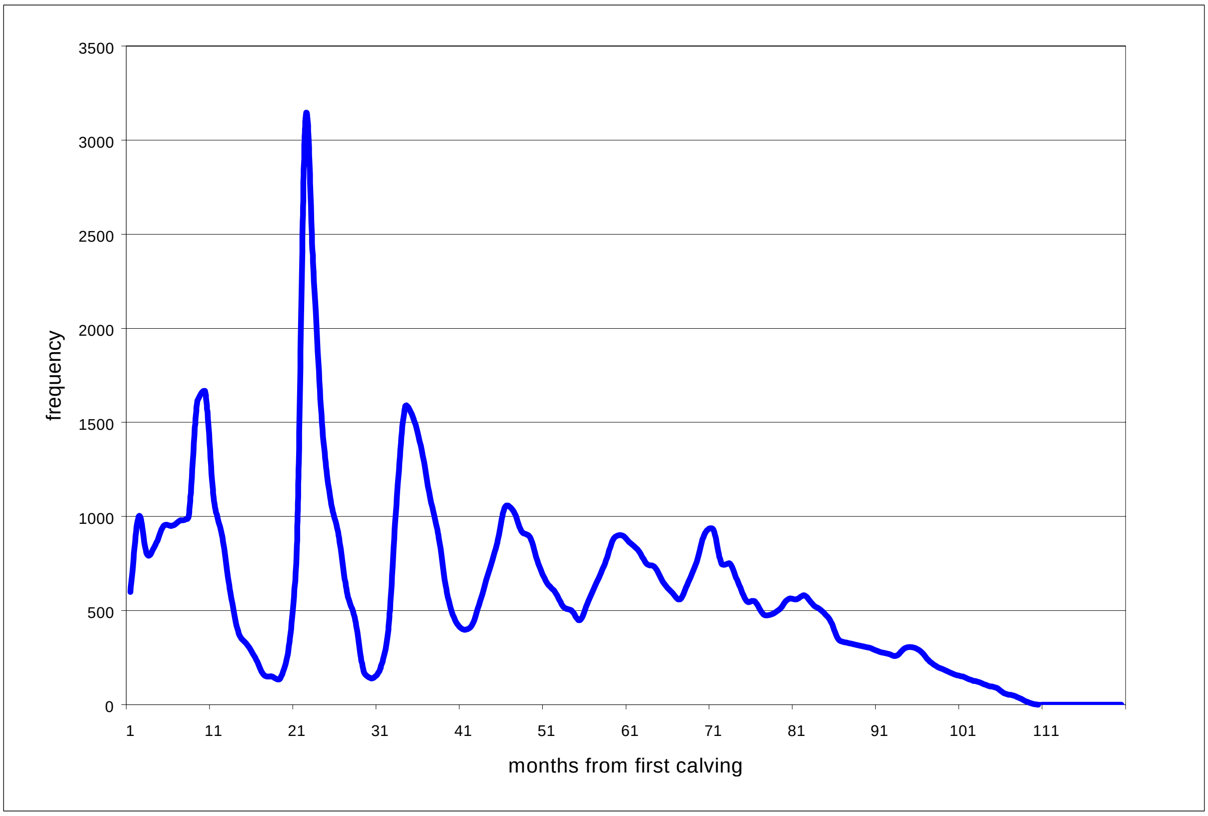

Figure 2 Frequency of herd-year-season classes deviation from average milk yield.

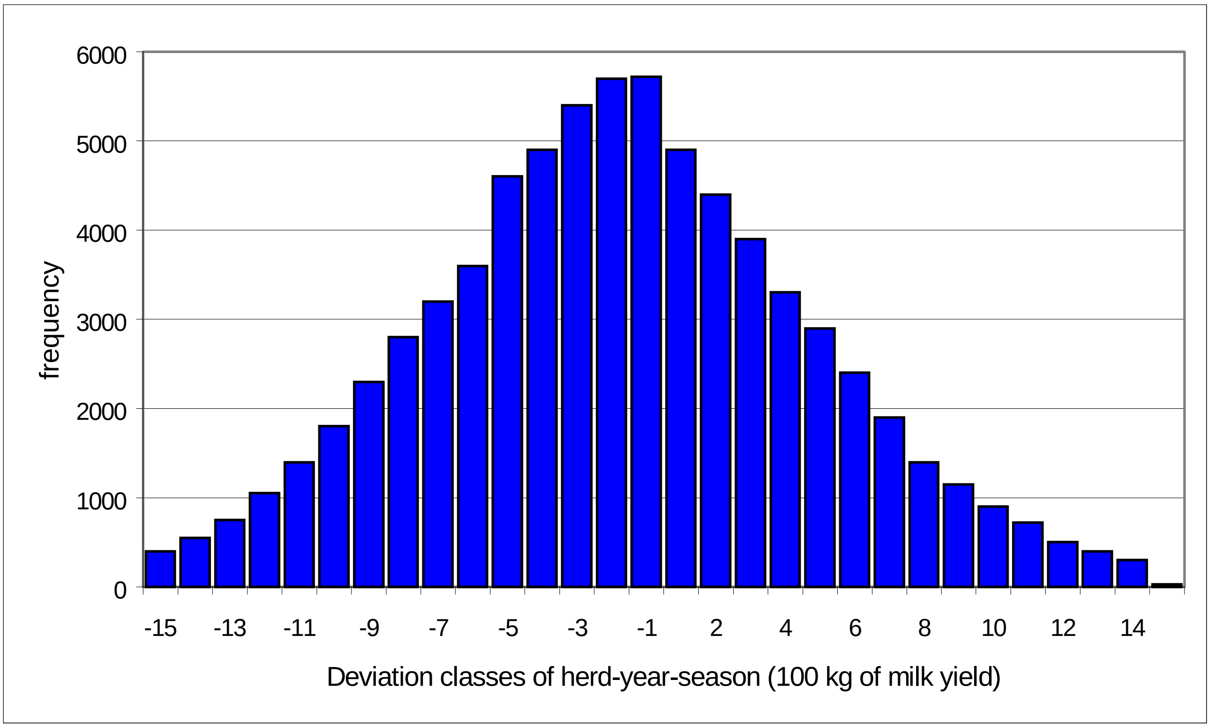

Figure 3 Effects of herd-year-season classes deviation from average herd milk yield.

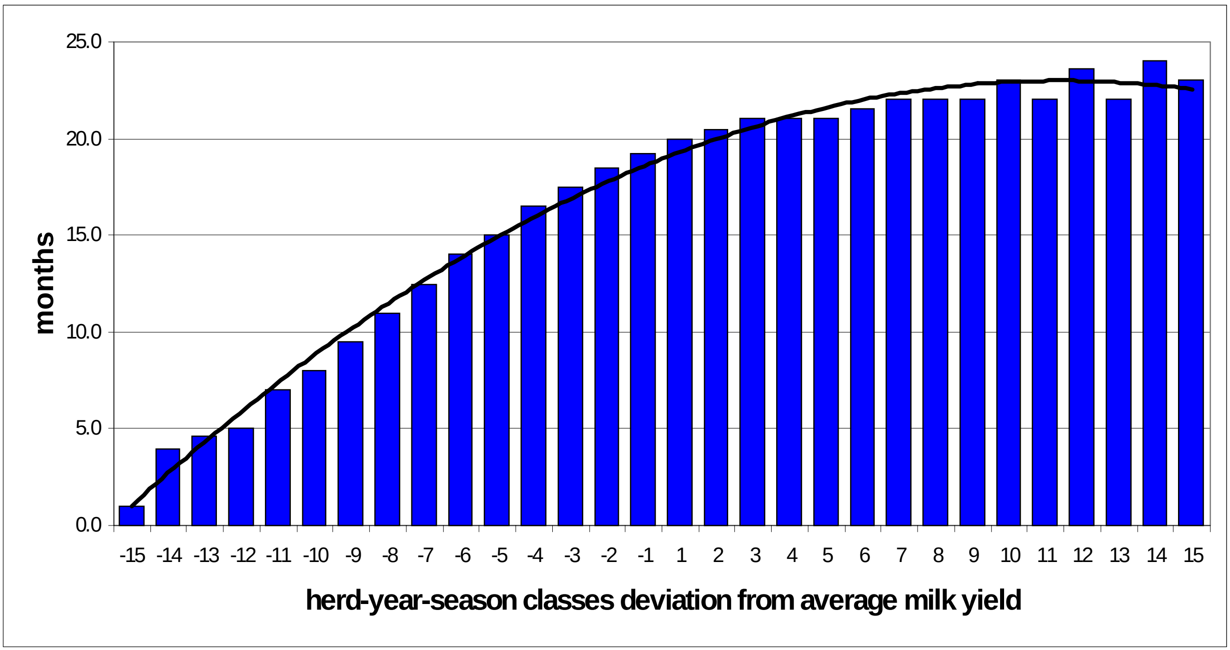

Figure 4 Frequency of culling for functional productive life

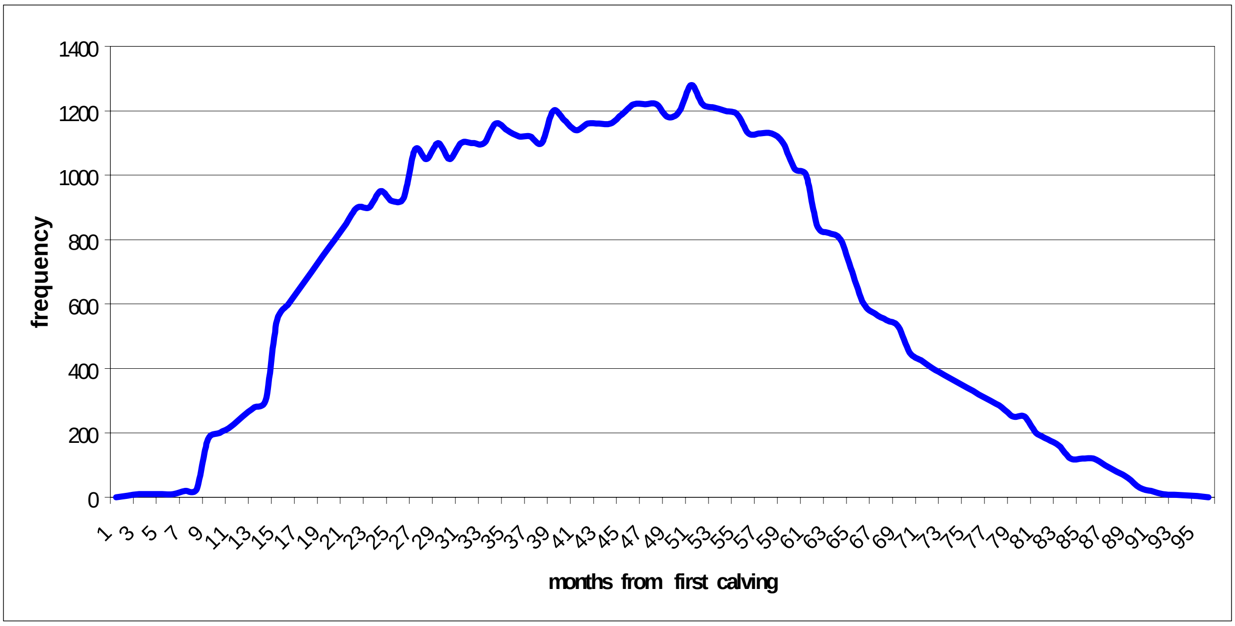

Table 1: Heritabilities, genetic standard deviation and genetic correlations for milk, longevity and type traits.

Traits	h^2 %	σg	rg Milk	rg FPL
Milk yield	0.24	420[1]	1.00	-
True productive life	0.06	5.24[2]	0.66	0.73
Functional productive life (FPL)	0.04	3.01[2]	-0.02	1.00
Type:		(s.d. unit)		
Final score	0.41	1.77	0.50	0.04
Stature	0.32	3.18	0.17	-0.13
Strength	0.11	1.51	0.02	0.01
Body depth	0.21	1.89	0.34	-0.03
Angularity	0.19	1.10	0.16	-0.17
Back line	0.12	1.30	-0.16	-0.02
Rump angle	0.19	1.55	-0.19	-0.01
Rump length	0.12	1.27	0.17	-0.24
Rump width	0.07	1.00	-0.02	-0.12
Tail attachment	0.20	1.63	0.19	0.06
Rear legs side view	0.10	1.36	-0.20	-0.29
Pasterns	0.06	1.38	-0.02	0.02
Fore udder attachment	0.31	2.95	0.55	0.15
Rear attachment width	0.25	2.76	0.55	-0.09
Rear attachment height	0.19	2.13	0.51	-0.04
Udder support	0.13	1.56	0.33	0.12
Udder depth	0.17	1.41	-0.38	0.43
Teats size	0.18	1.99	0.19	0.21
Teats rear view	0.08	0.92	-0.10	-0.13
Teats length	0.20	1.51	-0.07	-0.42

Standard errors estimates ranged from 0.02 to 0.09. [1] Kg, [2] months

Table 2 Standardised index weights for functional productive life (FPL).

Type traits	Direction	FPL
Stature	Medium body size	-31
Rear legs side view	Steeper	-2
Fore udder attachment	Stronger	17
Udder depth	Shallower	33
Teats length	Shorter	-17

Table 3 Standardised index weights for old and new official selection indexes.

Traits	Old	New
Production/Type ratio	4/1	6/1
Production traits:		
Fat yield (kg)	18	19
Protein (kg)	55	58
Fat (%)	2	2
Protein (%)	7	7
Type traits:		
Final Score	18	
Stature		-4.3
Rear legs side view		-0.3
Fore udder attachment		2.4
Udder depth		4.6
Teats length		-2.4

Table 4: Expected response to selection after 10 years for old and new official selection indexes.

Traits	Old	New
Production/Type ratio	4/1	6/1
Production:		
Milk yield (kg)	691	700
Fat yield (kg)	32	32
Protein (kg)	25	26
Fat (%)	0.12	0.12
Protein (%)	0.03	0.04
Type (s.d.):		
Final Score	2.50	1.89
Stature	2.33	1.15
Rear legs side view	-0.16	-0.31
Fore udder attachment	4.07	3.46
Udder depth	-0.92	-0.93
Teats length	-0.45	-0.52
Longevity (months):		
Functional productive life	0.59	1.12