Milk Protein as a Breeding Objective in Braunvieh Cattle Breeding

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Abstract

Milk production records for valley- and mountain-pastured Braunvieh cows of Tirol region in Austria were collected in the period from 1977 to 1981. Data on 46456 lactation records including 16569 paternal half-sisters representing 1556 sires were used to estimate the genetic and phenotypic variation and covariation of and between 305-day and total yield and percentage milk traits. Measures of production were lactation period and yields of milk, fat and protein and percentage of fat and protein recorded on a 305-day and total lactation. The coefficient of variation (CV) of yield traits were about three times as large as the CV of percentage traits. Year of calving, parity and days open affected ($p < 0.001$) all traits studied. Month of calving and grazing regions had a pronounced effect ($p < 0.001$) on yield traits and lactation period, while insignificant effects on percentage traits were observed.

The sire of cow and cow-within-sire contributed ($p < 0.001$) to the variances of all milk traits. Repeatabilities for yield traits in 305-day lactation were higher (around 0.70) than those obtained for total lactation (around 0.60), while the estimates for percentage traits were almost in the same magnitudes in both 305-day and total lactation (around 0.60). The repeatability of lactation period was 0.26. Heritabilities for yield traits ranged from 0.40 to 0.54 for 305-day lactation and from 0.36 to 0.45 for total lactation, while the estimates for fat and protein percentages were 0.30 and 0.40, respectively. Protein yield and percentage had the highest estimates of repeatability and heritability among all traits studied. Correlations among yield traits were positively high and ranged from 0.85 to 0.99, while the corresponding estimates among percentage traits were from 0.28 to 0.99. Protein yield was related strongly both genetically and phenotypically with other traits in and among 305-day and total lactation. Milk yield was lowly positively correlated with fat percentage as well as a fairly low estimates were obtained between milk yield and protein percentage. The correlations between fat yield and fat percentage ranged from 0.35 to 0.45, while estimates between protein yield and protein percentage ranged from 0.40 to 0.50. Correlations between fat yield and protein percentage and between protein yield and fat percentage ranged from 0.17 to 0.40.

Introduction

Milk protein content has been getting increasingly more important, particularly in view of the lesser expensive methods of determination now available. In the last ten years and with the rising public interest in the non-fat milk content, milk of all recorded cows in Austria, in addition to fat content, were examined also for protein content. The monetary value for protein is almost equal to that for fat, hence milk in most European countries is paid for on the basis of its fat and protein *(Wilmink, 1986)*. The question has been raised whether a dairy producer should evaluate the protein content of milk of individual cows for selection purposes. *Hardie et al. (1978)* examined single trait selection and found that selection for protein yield gave the highest value under both pricing schemes: milk with fat differential and milk with fat and protein differentials. *Anderson et al. (1978)* found an additional genetic gain in milk yield when protein was included in the selection index. The increasing interest of the general public in non-fat diets has stimulated research workers to investigate the genetics of milk constituents with a special attention to protein of milk.

The purposes of this study were: (1) to investigate some non-genetic factors affecting milk protein content and other milk constituents in the Austrian Braunvieh cattle, and (2) to estimate the genetic and phenotypic parameters of protein and other milk constituents.

Material and Methods

Data on productive performance of 46456 lactation records of Braunvieh cows of Tirol province were collected from the Official Federation of Austrian Cattle Breeders (ZAR) over five consecutive calving years (1977 through 1981). All records were 305-day or shorter completed lactations. Data were available on 16569 paternal half-sisters from 1559 sires. Each sire was represented by at least two daughters each with at least two records. For each herd, one daughter per sire was represented randomly and therefore, the herd effect was eliminated.

Heifers were inseminated when they reached about 320 kg body weight and cows were artificially inseminated (AI) during the 1st heat period following the 60th day postpartum. The Braunvieh cows in Austria were pastured in valleys or alpine grassland (Alpage). Details of the breeding policy and management followed for Braunvieh cattle in Austria were described by *Hartmann et al. (1988)*. Milk traits studied for 305-day lactation were milk yield (305dMY), fat yield (305dFY), protein yield (305dPY), fat percentage (305dF%) and protein percentage (305 dP%), while the corresponding traits for total lactation were total milk yield (TMY), total fat yield (TFY), total protein yield (TPY), total fat percentage (TF%) and total protein percentage (TP%). Length of lactation period (LP), as interval productive trait, was also studied.

Harvey's (1977) mixed model computer program was utilized in analysing the data. Data of all lactations were analysed using the following mixed model:

$$Y_{ijklmnpq} = \mu + S_i + C_{ij} + A_k + B_l + P_m + D_n + G_p + (AP)_{km} + e_{ijklmnpq}$$

where $Y_{ijklmnpq}$ denotes the performance of ijklmnpq lactation; μ = the overall mean; S_i = the random effect of i^{th} sire; C_{ij} = the random effect of j^{th} cow nested within a random effect of i^{th} sire; A_k = the fixed effect of the k^{th} year of calving (1977 .... 1981); B_l = the fixed effect of the l^{th} month of calving (January .... December); P_m = the fixed effect of m^{th} parity (1 .... 8); D_n = the fixed effect of n^{th} days-open class (60-89; 90-119; 120-149; 150-179 and ≥ 180 days); G_p = the fixed effect of p^{th} grazing region (valley vs. Alpage); $(AP)_{km}$ = the effect of the interaction between year and parity, and $e_{ijklmnpq}$ = a random deviation of q^{th} lactation of ij^{th} cow and assumed to be independently randomly distributed (o, $\sigma^2 e$).

Estimates of the effects of sires ($\sigma^2 s$), cows-within-sire ($\sigma^2 c{:}s$) and remainder ($\sigma^2 e$) components of variance and covariance were computed according to Method III of Henderson. Paternal half-sib analysis of variance and covariance were utilized to obtain the estimates of heritability, repeatability and correlations. Heritabilities were estimated for milk traits, across all lactations, as four times the intraclass correlation coefficient between sire groups: $h^2 = 4\,\sigma^2 s\,/\,(\sigma^2 s + \sigma^2 c{:}s + \sigma^2 e)$. Repeatability estimates were calculated from the ratio of sire plus cow-within-sire variance components to the sum of sire, cow-within-sire and the remainder variance components. Standard errors for heritability and repeatability estimates were computed according to the method derived by *Swiger et al. (1964)*. Estimates of genetic (with standard errors) and phenotypic correlation were obtained by computing techniques described by the LSML76 program of *Harvey (1977)*.

Results and Discussion

Means and coefficients of variation (CV%) for the various traits are given in Table (1). Results from the least squares analysis of variance are given in Table (2).

Year of Calving

Quite distinct differences ($p < 0.001$) between years of calving for all the traits studied could be observed. Significant differences between years were found in other Austrian studies too (e.g. *Soliman, 1984; Soliman et al., 1989a*). *Pirchner (1959)* found that year of calving had nonsignificant effect on yield traits. In general, there was a steady decrease in all traits with the advance of years of calving. Maximum differences between years were 659 kg milk, 31 g fat, 23 kg protein, 0.08% of fat and 0.04% of protein in total lactation, while the corresponding values in 305-day lactation were 190 kg milk, 10 kg fat, 7 kg protein, 0.07% of fat and 0.01% of protein. The maximum difference between years for lactation length was a high of 64 days which may be the reason for the decrease of productive performance from a year to another. In recent years, dairy cattle breeders in Austria attempted to improve the reproductive performance of their cows by reducing the calving interval (through decreasing lactation period and days open) and this is a reason for the decrease in the lactation length with the advance of the year.

Table 1. Means, standard deviation (S.D.) and coefficients of variation (CV%) of uncorrected milk traits in Braunvieh records.

Traits	Mean	S.D.	CV%*
Yields (kg)			
305dMY	4294	536	12.5
TMY	4486	682	15.2
305dFY	171	24	14.0
TFY	179	30	16.5
305dPY	134	17	12.7
TPY	141	22	15.5
Percentages			
305dF%	3.98	0.22	5.5
TF%	3.99	0.21	5.3
305dP%	3.12	0.13	4.2
TP%	3.14	0.13	4.2
Lactation period (days)	320	40	12.3

* Coefficient of variation computed as the residual standard deviation divided by the overall least-squares means of a given milk trait (Harvey, 1977).

Month of Calving

Month of calving had pronounced effects ($p < 0.001$) on yield traits and lactation period (Table 2), while nonsignificant effects on percentage traits were observed(with the exception of TP%, $p < 0.01$). However, month-of-calving differences were evident in different Central Europe studies for milk traits *(Pirchner, 1959; Pirchner et al., 1962; Essl and Haiger, 1972; Pape et al., 1983; Alps et al., 1984; Soliman, 1984; Soliman et al., 1989a).*

The least squares means for month of calving are illustrated in figures (1 and 2). September-November were consistently the months with the highest yield traits in 305-day lactation, while cows calving in March-May, produced higher milk, fat and protein yields in total lactation than those calving during other months. This is due to the longest lactation periods (351-354 days) for March-May months of calving, while the shortest lactation periods were observed during the months of November-December. On the other hand, cows freshening in June-July and November-December had the lowest yield of milk, fat and protein in 305-day and total lactation. The different trends for

Table 2. F-ratios of least-squares analysis of variance for milk traits of Braunvieh cattle.

Source of variation	d.f.	305-day lactation					Complete lactation					LP
		305dMY	305dFY	305dPY	305dF%	305dP%	TMY	TFY	TPY	TF%	TP%	
Sire +	1558	2.9***	2.7***	3.1***	2.2***	2.2***	2.6***	2.5***	2.7***	2.2***	2.6***	1.3***
Cow within sire	15010	6.7***	6.2***	7.4***	4.3***	4.4***	4.9***	4.9***	5.3***	4.4***	5.2***	1.8***
Year of calving	4	11.3***	12.6***	4.3***	10.9***	13.3***	36.6***	40.5***	41.9***	13.3***	43.8***	102.1***
Month of calving	11	22.5***	16.5***	21.1***	1.3^{ns}	1.8^{ns}	45.3***	40.4***	46.3***	1.8^{ns}	8.4***	107.0***
Parity	7	138.6***	116.9***	143.5***	2.5**	2.9**	133.8***	122.5***	135.8***	2.9***	9.6***	61.7***
Days open	4	9.8***	12.5***	5.3***	4.0***	2.7*	24.7***	18.0***	40.3***	2.7*	33.2***	191.1***
Grazing region	1	478.0***	365.5***	37.5***	2.1^{n*}	2.0^{n*}	517.4***	452.4***	427.6***	2.0^{ns}	14.2***	207.9***
Year x parity	28	1.1^{ns}	1.2^{ns}	0.8^{ns}	0.8^{ns}	0.8^{ns}	3.2***	3.1***	3.2***	0.8^{ns}	1.3^{ns}	10.3***
Remainder M. SQ ++		199096	431	210	0.046	0.044	358153	697	386	0.004	0.016	1422

\+ Sire effect is tested against cow-within-sire and all other effects tested against the remainder mean squares.

++ Remainder degrees of freedom = 29832.

rs Non-significant at $p>0.05$; * = $p<0.05$; ** = $p<0.01$; *** = $p<0.01$.

the effects of month of calving on 305-day and total lactation yield traits were mainly due to the variation in lactation period between them.

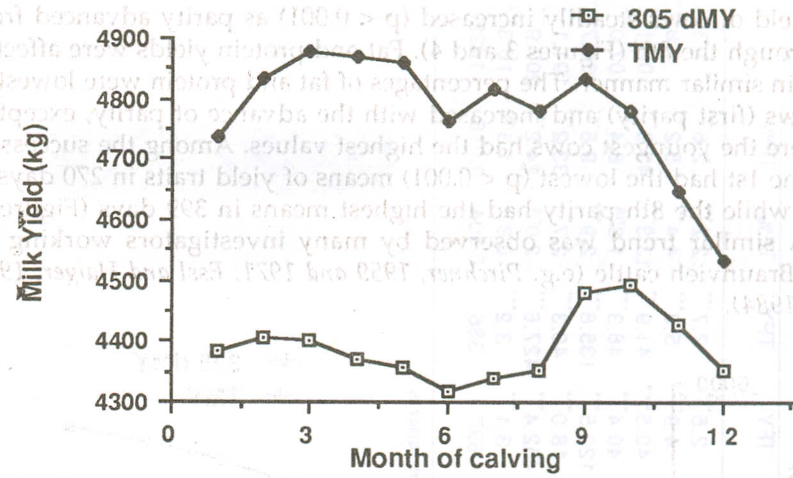

Fig. 1. Effect of month of calving on milk yield.

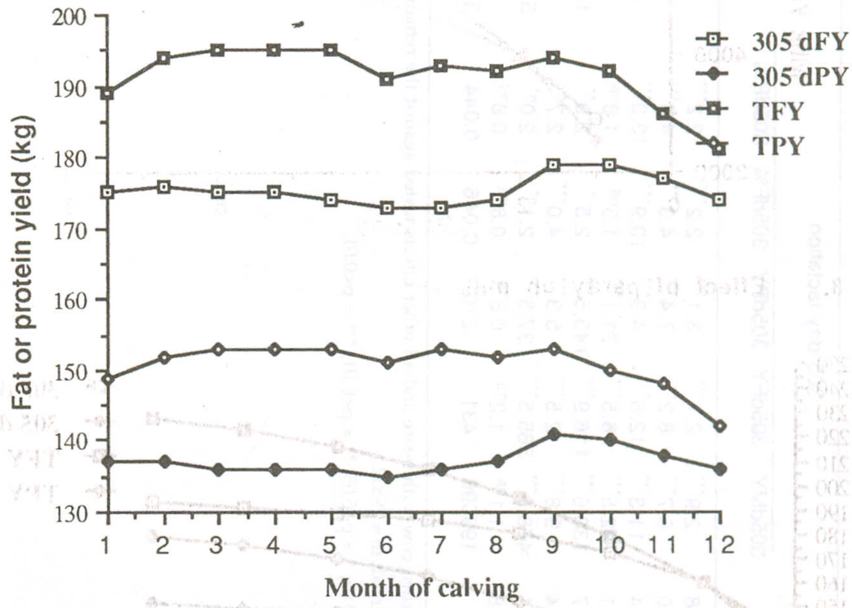

Fig. 2. Effect of month of calving on fat and protein yields.

The highest percentages of fat and protein occurred during periods of lowest yields in 305-day lactation (February and March), while the highest values were recorded during June-August. The lowest values were observed for February and March in both 305-day and total lactation. In general, this is due to the inverse relation between yield and percentage traits, i.e. the lowest yield traits is expected to have the highest percentages. These findings are in agreement with other Austrian studies *(e.g. Soliman, 1984).*

Parity

Milk yield of cows steadily increased ($p < 0.001$) as parity advanced from the 1st through the 8th (Figures 3 and 4). Fat and protein yields were affected by parity in similar manner. The percentages of fat and protein were lowest in young cows (first parity) and increased with the advance of parity, except in TP%, where the youngest cows had the highest values. Among the successive parities, the 1st had the lowest ($p < 0.001$) means of yield traits in 270 days of lactation, while the 8th parity had the highest means in 399 days (Figures 3 and 4). A similar trend was observed by many investigators working on Austrian Braunvieh cattle (e.g. *Pirchner, 1959 and 1971; Essl and Haiger, 1972; Soliman, 1984).*

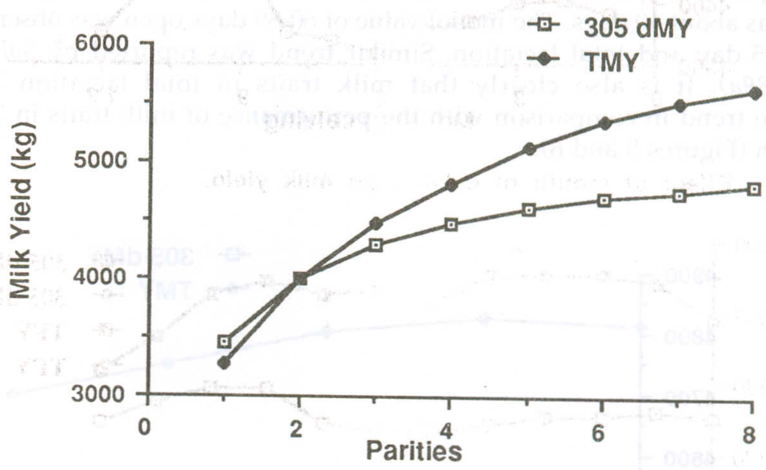

Fig. 3. Effect of parity on milk yield.

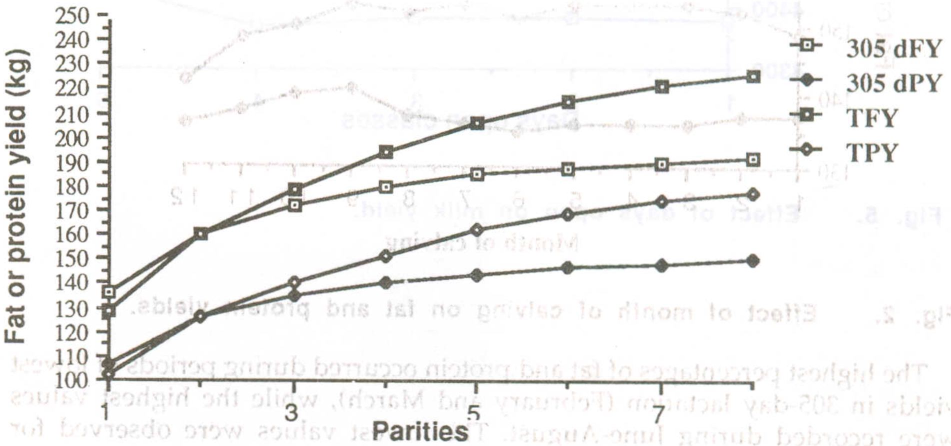

Fig. 4. Effect of parity on fat and protein yields.

Days Open

Table (2) show that days open affected significantly all yield and percentage traits studied. Significant effects for days open on milk traits was reported by many investigators in Austria and Central Europe (e.g. *Essl and Haiger, 1972; Hagger and Chavaz, 1982; Pape et al., 1983; Romberg et al., 1983; Alps et al., 1984; Soliman, 1984; Haug and Nitter, 1987; Soliman et al., 1989a).*

Milk traits studied in 305-day lactation increased linearly with the increase of days open (Figures 5 and 6). From an economic point of view, however, it would not be desirable to prolong the days open. The present investigation (Figures 5 and 6) indicated that the optimum length of days open was about 60 days. The modol value of 60-89 days open was observed for both 305-day and total lactation. Similar trend was reported by *Soliman et al. (1989a)*. It is also clearly that milk traits in total lactation had an opposite trend in comparison with the performance of milk traits in 305-day lactation (Figures 5 and 6).

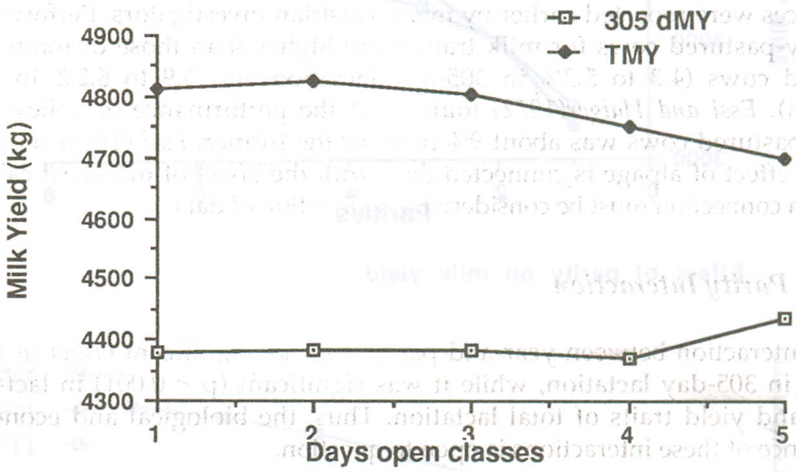

Fig. 5. Effect of days open on milk yield.

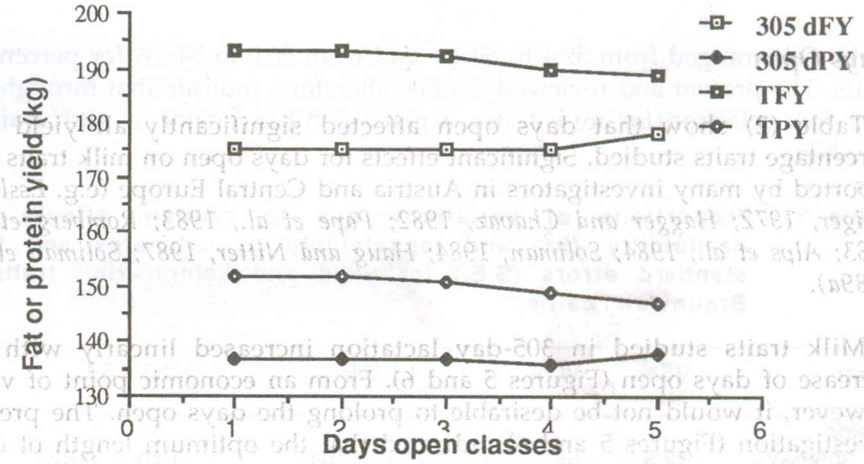

Fig. 6. Effect of days open on fat and protein yields.

Grazing Regions (Valley vs. Alpage Pasture)

Yield traits and TP% for valley-pastured cows differed greatly ($p < 0.001$) from those cows pastured in alpage region (Table 2). Such significant differences were reported earlier by many Austrian investigators. Performance of valley-pastured cows for milk traits were higher than those of mountain-pastured cows (4.3 to 5.3% in 305-day lactation and 5.9 to 6.2% in total lactation). *Essl and Haiger(1972)* found that the performance of valley- and alpage-pastured cows was about 9% in favor the former. *Essl (1966)* reported that the effect of alpage is connected only with the effect of month of calving and such connection must be considered for correction of data.

Year by Parity Interaction

The interaction between year and parity was not significant effect in traits studied in 305-day lactation, while it was significant ($p < 0.001$) in lactation period and yield traits of total lactation. Thus, the biological and economic importance of these interactions is open to question.

Variance Components

Sire and cow-within-sire effects were significant ($p < 0.001$) for all traits studied (Table 2). The proportion of variance attributable to the sire and cow-within-sire components for all traits studied are given in Table (3). Slight differences in sire or cow components of variance were observed between the different traits. The sire contribution ranged from 11.1 to 13.6% for yield traits in 305-day lactation, while the corresponding estimates in total lactation ranged from 9.1 to 10.7%. Estimates for percentage traits were in general between 7.4 and 9.1%. Most of these findings are similar to those obtained on cattle in Austria *(Pirchner, 1959; Pirchner et al., 1962; Soliman, 1984; Soliman et al., 1989b)*. The proportion of variance attributable to cow-within-sire for yield traits ranged from 52.4 to 60.1% and from 50.0 to 54.6% for percentage traits. The present and reviewed studies, therefore, indicate that through sire and cow selection for milk traits, a genetic improvement of such traits is possible.

Table 3. Proportions of variation+ due to random effects and heritability (h^2) and repeatability (t) estimates and their standard errors (S.E.) for yield and composition traits in Braunvieh cattle.

Traits	VS%	VC%	t ± S.E.	h2 ± S.E.
Yields				
305dMY	12.5	58.7	0.71 ± 0.004	0.40 ± 0.024
TMY	9.9	52.4	0.62 ± 0.005	0.39 ± 0.021
305dFT	11.1	57.7	0.69 ± 0.005	0.44 ± 0.022
TFY	9.1	52.7	0.62 ± 0.005	0.36 ± 0.020
305dPY	13.6	60.1	0.74 ± 0.004	0.54 ± 0.025
TPY	10.7	53.7	0.64 ± 0.005	0.43 ± 0.022
Percentages				
305dF%	7.4	50.0	0.57 ± 0.006	0.29 ± 0.017
TF%	7.6	50.9	0.58 ± 0.005	0.30 ± 0.017
305dP%	9.1	53.3	0.64 ± 0.005	0.40 ± 0.021
TP%	9.1	54.6	0.64 ± 0.005	0.40 ± 0.021
LP	1.2	20.8	0.22 ± 0.006	0.05 ± 0.008

\+ Contribution of sire (VS%) and cow-within-sire (VC%) to variance of all traits studied were significant ($p < 0.001$).

Repeatability Estimates

Repeatability estimates (t) for the different traits in 305-day and total lactation were ranged from 0.62 to 0.74 and from 0.57 to 0.64 for yield and percentage traits, respectively (Table 3), all with low standard errors of around 0.005. Similar findings were obtained on Austrian Braunvieh by *Pirchner et al. (1962)*. Accordingly, culling of cows for productive traits based on a single production record, as commonly practiced by dairy cattle breeders, would be efficient from a genetic standpoint and consequently, assessment of several records are not required before selecting cows for such traits. Estimates of yield traits in 305-day lactation (Table 3) were higher (around 0.70) than those obtained for total lactation (around 0.60), while the estimates obtained for percentage traits had similar magnitudes in both 305-day and total lactation (around 0.60). These estimates indicate that yield traits (especially protein yield) are slightly more highly repeatable than percentage traits in 305-day lactation. The estimates of repeatability for yield traits in the present study are higher than those estimates reported by *Butcher et al. (1967), Gacula et al. (1968), Gaunt (1973) and Lobo et al. (1984)*, while estimates for percentage traits are within the range of those reported by the previous authors.

Heritability Estimates

Estimates of heritability (h^2) for yield traits ranged from 0.40 to 0.54 for 305-day lactation and from 0.36 to 0.43 for total lactation (Table 3). Estimates of h^2 for 305-day were pronounced and higher than those for total lactation in all yield traits. Such differences could be attributed to that all yield traits for total lactation are influenced to greater extent by environmental factors than those traits during 305-day lactation. However, estimates of the present study are in agreement with findings of the other Central Europe studies on Braunvieh and other cattle (e.g. *Pirchner, 1959 and 1961; Schneeberger, 1981; Alps et al., 1984; Schneeberger and Hagger, 1984; Soliman, 1984; Graml et al., 1987*). Such high genetic variation (i.e. high estimates of h^2) for yield traits in this population could be attributed to that most of the Braunvieh cows in Austria were backcrossed with the Brown Swiss cattle, hence the possibility of generating more additive genetic variance. It could be, also, due to some effects that were not included in the model (e.g. some sire progeny-groups were slightly different in age) or may be partially confounded with the sire (in a few cases, a sire was used in just one year and season) and consequently, some upward bias in sire component of variance were obtained.

Estimates of h^2 in 305-day and total lactation for fat and protein percentage (0.30 and 0.40, respectively) were very similar (Table 3). These estimates are within the range of those estimates reported in the literature mentioned above for the Austrian and Central Europe studies, while they were slightly lower than those reported by others (*Pirchner, 1959 and 1962; Schneeberger and Hagger, 1983; Dommerholt and Wilmink, 1986; Wilmink, 1986*). However, heritabilities of fat and protein percentage reported here are somewhat lower than those estimates of yield traits and this can be explained simply on that error component of variance was inflated upward. This inflation could be attributed to that effects of some non-genetic factors (e.g. stage of lactation and gestation, preceding dry period....) were not corrected and such effects (that were not considered in collecting the data) had more effects on milk constituents than on yield traits. Intensive selection for milk constituents in recent years could be added as other cause in this respect. But the precision of these estimates (i.e. low estimates of standard errors with an order of 0.02 for all traits studied) was rather high and gives evidence for possible improvement in such percentage traits through selection.

The estimate of h^2 for lactation period (0.05 ± 0.008) was low. This was expected because collection of data for such trait was dependent mainly on the interviews of owners of the cows and one can conclude that the major part of the variation in this trait is of non-genetic origin.

Correlations

Estimates of genetic (r_G) and phenotypic (r_P) correlation among milk traits studied are presented in Table (4). Most estimates of r_G were similar to the corresponding estimates of r_P in directions and were slightly higher in magnitudes. The high r_P's obtained in this study give, in practice, a considerable advantage in management and culling policy for such breed of dairy cattle.

Estimates of correlations among yield traits studied are positive and high ranging from 0.85 to 0.99. These estimates are within the range reported in the literature of Central Europe for Braunvieh and other breeds of cattle (e.g. *Blau and Scholz, 1982; Karras and Schlote, 1982; Pape et al., 1983; Alps et al., 1984; Simianer and Papst, 1984; Neimann-Sorensen et al., 1987; Soliman et al., 1989b).* Protein yield was related strongly with the other yield traits in and among 305-day and total lactation (Table 4). These mainly part-whole genetic relationships indicate that yield traits in 305-day of lactation could be used as a good indicators for the same traits in total lactation. Consequently, early selection for high yield of milk, fat and protein at 305-day of lactation will be associated with genetic improvement in the corresponding traits of total lactation.

Milk yield was lowly positively correlated with fat percentage (Table 4). Also, fairly low correlations were obtained between milk yield and protein percentage. Such estimates of correlation disagrees with those estimates cited in the literature (mentioned above) where different estimates were obtained. Estimates of r_P between fat yield and protein percentage, and of r_P and r_G between protein yield and fat percentage are positive and low and fall within the range of estimates of some investigators (e.g. *Dommerholt and Wilmink, 1986).* These low estimates indicate that the possibility of increasing both fat yield and protein percentage (and/or protein yield and fat percentage) through indirect selection for the other traits is somewhat difficult for this breed. Estimates of correlations between fat yield and fat percentage as well as protein yield and protein percentage are positive and of moderate magnitude (Table 4). These moderate estimates are within the range of those estimates cited from literature.

Estimates of correlations obtained between percentage traits are also positive and with an order of 0.28 and 0.99 for r_G and r_P, respectively. They are agree with those of *Pirchner (1962), Blau and Scholz (1982), Alps et al. (1984), Soliman (1984) and Neimann-Sorensen et al. (1987).* Most estimates of r_G between LP and yield and percentage traits were negative and low, while the corresponding r_P were positive and low or moderate in magnitude (Table 4).

Table 4. Estimates of genetic (below diagonal)+ and phenotypic (above diagonal) correlation for different milk traits of Braunvieh cattle.

Traits	305dMY	TMY	305dFY	TFY	305dPY	TPY	305dF%	TF%	305dP%	TP%	LP
305dMY		0.93	0.92	0.88	0.95	0.89	0.08	0.08	0.06	0.08	0.22
TMY	0.99		0.86	0.94	0.88	0.96	0.07	0.08	0.04	0.08	0.52
305dFY	0.95	0.95		0.94	0.91	0.85	0.45	0.46	0.16	0.17	0.19
TFY	0.95	0.95	0.99		0.85	0.93	0.40	0.41	0.13	0.17	0.48
305dPY	0.97	0.95	0.96	0.95		0.93	0.16	0.17	0.38	0.38	0.19
TPY	0.97	0.96	0.96	0.96	0.99		0.14	0.15	0.32	0.36	0.50
305dF%	0.04	0.04	0.35	0.35	0.16	0.17		1.00	0.28	0.28	-0.01
TF%	0.03	0.04	0.34	0.35	0.16	0.18	0.99		0.28	0.29	0.02
305dP%	0.30	0.27	0.43	0.41	0.54	0.52	0.47	0.48		0.99	-0.05
TP%	0.30	0.27	0.43	0.41	0.54	0.52	0.47	0.48	0.99		0.04
LP	-0.03	0.06	-0.05	0.03	-0.11	-0.03	-0.07	-0.05	-0.30	-0.28	

+ Standard errors of genetic correlations ranged from 0.001 to 0.035.

Conclusion and Aspects on Selection

1. High genetic variation (due to sires) for yield and percentage traits of Braunvieh cattle shows the possibility for the dairy cattle breeders in Austria and other countries to improve such traits through selection.

2. High estimates of heritability and repeatability for 305-day lactation yield traits as compared with the same traits in total lactation suggest that a greater improvement will occur for this breed through early selection for such traits (with special emphasis for protein yield). Moreover, high estimates of genetic and phenotypic correlation gave grater evidence for the possibility to select for milk traits at earlier age, i.e. at 305-days of lactation.

3. Due to high repeatabilities for milk traits (with estimates ranging from 0.57 to 0.74) a single production record (first lactation, for instance) should be considered when evaluating cow records for selection or culling purposes.

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