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RELATIVE EFFICIENCIES OF CONTEMPORARY COMPARISON AND BLUP METHODS FOR SIRE EVALUATION USING PART AND COMPLETE LACTATION RECORDS

BY

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ABSTRACT

A total of 7959 first-lactation records were used in evaluating 69 Fleckvieh sires. Only sires with at least 100 daughters were included. Sire transmitting abilities (STA) were estimated using the non-matricized method of contemporary comparison (CC) and the matricized method of best linear unbiased predictor (BLUP). Records of 100-day lactation for yields of milk (M100), fat (F100), protein (P100), fat-plus-protein (FP100) and carrier (C100) were used. The product-moment correlation (r_{PM}) and Spearman rank correlation (r_S) were used as criteria for judging the merits of the two methods of sire evaluation. To assess the accuracy of the methods, standard error (SE) of sire evaluation by each method was calculated along with the percentage of reduction in standard error (RSE) due to replacing CC by BLUP. Efficiency of STA estimated by a method at 100-day lactation relative to 305-day lactation was assessed.

For CC and BLUP methods, there were differences in minimum and maximum estimates of STA of 840 and 442 kg for M100; 840 and 414 kg for C100; 34 and 16 kg for F100; 24 and 11 kg for P100 and 57 and 28 kg for FP100. For all traits, the largest differences in STA were obtained when using CC and the lowest by using BLUP. The top ten sires were not identical (% of common sires in both methods) in CC when compared with BLUP (70-90%). For all traits, the lowest percentages of sires occupying the same rank were found in the CC method when compared with BLUP (0-50%).

Estimates of r_{PM} between CC and BLUP were relatively low (0.763-0.874). The same observation was noticed when considering r_S but with lower estimates (0.434-0.666). For all traits, BLUP had the lowest estimates of SE,

while CC had the largest. RSE from using BLUP instead of CC ranged from 27.5% to 53.1%.

Product-moment correlations among proofs for part-lactation and complete-lactation traits were high and positive, >0.817 for CC and >0.921 for BLUP. Rank correlations were also high and positive; >0.797 for CC and >0.876 for BLUP. Correlations among proofs at the two production scales (100- and 305-day of lactation) indicate that sires may be ranked differently when using CC method rather than when using the BLUP, i.e. ranking of sires at 100 days using BLUP will be almost the same at 305 day of lactation .

Keywords: Dairy cattle, Sire evaluation, contemporary comparison, BLUP, part lactation, complete lactation.

INTRODUCTION

Most research on methodologies of sire evaluation in dairy cattle has been undertaken in developed countries (Freeman, 1988). In these countries, evaluation methodology has been applied to large, balanced and connected data sets containing full genealogy. The situation in many developing countries is far from such type of data sets in respect to size, blance and connectedness, . . .etc. Thus, the efficiency of sire evaluation methods should be tested before introducing expensive techniques which could be unnecessary (Tajane and Rai, 1990).

Unbiased ranking of young sires is difficult when progeny information is not adequate. On the other hand, comparisons of different methods of sire evaluations in field data is always a troublesome task. Therefore, analytical methods for comparisons of alternative sire evaluation methods should be preferred (Henderson, 1975). From animal breeding theory (Henderson, 1984), the BLUP method can be considered as a better method than the contemporary comparison or herdmate method (Henderson, 1972). Criteria to define the best method are not uniform from one research to another (Hargrove *et al.*, 1974).

The present study was undertaken (1) to detect which method (CC or BLUP) is the best under limited data set structure, and (2) to evaluate the efficiency of part-lactation record relative to complete lactation milk yield in progeny testing Fleckvieh bulls.

MATERIALS AND METHODS

Data:

Data of 100-day lactation of Fleckvieh cattle were obtained from the Official Test Federation of Austrian Cattle Breeders (ZAR) in lower Austria. Detailed description of these data was published by Hartmann *et al.*, (1992). Milk traits of 100-day lactation included yields of milk (M100), fat (F100),

protein (P100), fat-plus-protein (FP100) and carrier (C100). To avoid bias due to differences among sires, each record was expressed as deviation from the average of the herd. Also, if the cow was moved from a herd to another, her record was eliminated. Each sire was represented in at least two herds and had at least 100 daughters in different herds (one daughter per sire per herd). Data satisfying these restrictions and used in the present study included 69 sires having 7959 daughters extracted from 10886 first-lactation records.

Methods and Models:

Records were collected between 1977 and 1982 years. To avoid bias resulting from the effect of cow selection, only records of first lactation were used in the sire evaluation. A total of 10886 first lactation cows sired by 647 bulls were used in estimating variance components and heritabilities of the first lactation. Data were analysed using the following sire model:

$$Y_{ijklm} = \mu + S_i + YS_j + A_k + D_l + e_{ijklm} \quad \text{..... (Model 1)}$$

where: Y_{ijklm}= 2X-305 milk record expressed as a deviation from the herd average, μ = the overall mean, S_i= the random effect of i^{th} sire, YS_j= the fixed effect of j^{th} year-season combination (j=16), A_k= the fixed effect of k^{th} age at calving (38 class classified monthly from <24 month to 61 month), D_l= the fixed effect of l^{th} days open (6 classes starting from <45 days as a first class with an interval of 30 days thereafter) and e_{ijklm}= the random error $(0,\sigma^2_e)$. The two methods described below were used in sire evaluation.

Contemporary Comparison (CC):

Procedure of contemporary comparison (CC) was described in details by Johanson and Rendel (1968). For applying this method on the present data set, all lactation records(50788 records) were adjusted for non-genetic effects (age at calving and days open, and year-season effects) using the least-squares constants obtained from model 1. Records of daughters of each sire were expressed as weighed average deviations from contemporaries calving in the same herd-year-season (Kennedy and Moxley, 1977; Vinson *et al.*, 1982) and therefore the transmitting ability of each sire (STA) was calculated as:

$$STA = bD_w$$

where $b = nh^2/4+(n-1)h^2$, since n= number of daughters per sire and h^2= heritability; $D_w = w(D - HA)/w$, since $w = n_1n_2/n_1+n_2$ (i.e. effective number of daughters per sire), D= daughters average and HA= herd average.

BLUP :

The BLUP procedure and its applications to sire evaluation were described by Henderson (1972). In the present study, one set of crossclassified non-interacting random sire effect is used (Harvey, 1990), i.e. sire model was applied. In BLUP method, sire model was applied using restricted maximum likelihood (REML) for estimating variance components. In this case, the equations of the sire model were used to obtain best linear unbiased predictors (BLUP) of the random sire effects, best linear unbiased estimators (BLUE) of the fixed effects and minimum normal quadratic unbiased estimators (MINQUE) of

the variance components. In this situation, the sire model with three fixed factors (in matrix notation) was:

$$y = X\beta + Zs + e. \quad \text{..... (Model 2)}$$

where y= a vector of observation of milk trait, X and Z= known incidence matrices for fixed and random effects, respectively, s= unknown vector of sire effect (effect common to daughters of sire with variance σ^2_s), β= unknown column vector of the fixed effects of year-season (14 class) , age at calving (15 class) and days open (6 classes), and e= a column vector of the random error. $E(y)=X\beta$, $E(s)= E(e)= 0$, $V(e)= I\sigma^2_e$ and $V(s)=Ik^{-1}$, where I= an identity matrix. The mixed model equations were:

$$\begin{bmatrix} X'X & X'Z \\ Z'X & Z'Z+Ik \end{bmatrix} \begin{bmatrix} \beta \\ s \end{bmatrix} = \begin{bmatrix} X'y \\ Z'y \end{bmatrix}$$

where $k= \sigma^2_e/\sigma^2_s$ estimated by REML procedure (i.e. K= 6.74, 8.91, 10.96, 8.62 and 6.77 for M100, F100, P100, FP100 and C100, respectively). In such a case, no relationships are assumed to exist (A^{-1} = I, the identity matrix). The Minimum variance normal quadratic unbiased estimates (MINQUE) of sire (s) and error (e) variance components as described by Henderson (1984) were calculated using LSMLMW program of Harvey (Harvey, 1990). Searle (1989) found that iterative MINQUE estimators are equal to REML estimators and therefore s and e were obtained as REML estimators.

Evaluation and accuracy of methods:

Criteria used in this study for judging the efficiency of the two methods of sire evaluation were the correlations between the two methods (SAS, 1988): product-moment correlation and Spearman-rank correlation (Kemp *et al.*, 1984; Mabry *et al.*, 1987; Vig and Tiwana, 1988; Tajane and Rai, 1990). Other criteria used to assess the accuracy of different methods of sire evaluation were the standard error (SE) of each method and the percentage of reduction in standard error (RSE) due to using one method instead of another. Reduction in standard error (RSE) was calculated as $[(SE_{cc} - SE_{BLUP})/SE_{cc}]x100$.

RESULTS AND DISCUSSION

Estimates of sire transmitting ability (STA):

Considering all sires, the minimum and maximum estimates of STA for part lactation (100-day) yield traits are presented in Table 1. For CC and BLUP methods, there was a range of 896 and 442 Kg for M100, respectively. The same trend of ranges were also observed for C100 (840 and 414 Kg), F100 (34 and 16 Kg), P100 (24 and 11 Kg) and FP100 (57 and 28 Kg). For all traits, the largest ranges were obtained by CC and the lowest ranges were observed by BLUP (Table 1). In contrast, Raheja (1992) reported that differences in STA estimated by CC were much lower than those estimated by BLUP without A^{-1} for milk yield.

For all milk traits, percentage of sires common between CC and BLUP methods ranged from 70 to 90%. The percentages of sires remaining in the same position (i.e. don't changing their rank) ranged from 0 to 50% between BLUP and CC for all part-lactation yield traits (Table 1).

Criteria for comparison between methods:

A rank correlation that is significantly less than 1.0 would indicate that the animals were re-ranked (Kemp *et al.*, 1984; Carlson *et al.*, 1984; Tajane and Rai, 1990). Estimates of r_{PM} between CC and BLUP showed low correlations (Table 2). The estimates ranged from 0.763 to 0.874. This means that there was larger disparity between the matricized method (BLUP) on one hand and the non-matricized method (CC) on the other hand. Comparable estimate was obtained by Kennedy and Moxley (1977) for fat percent who reported r_{PM} of 0.85 between CC and BLUP.

In comparison between CC and BLUP, estimates of rank correlation (r_S) had the same trend for all milk traits where estimates ranged from 0.434 to 0.666 (Table 2). These findings indicate that sires were reranked when using the matricized method (BLUP) and nonmatricized method (CC). Ranks of the matricized method are different from those ranks obtained by CC method. Theoretically, CC is biased due to the presence of genetic trend and non-random distribution of herdmates sires (Kennedy and Moxely, 1977; Freeman, 1988). The REML estimation for variance components in a sire model leads to a substantial reduction in biasness due to cow culling (Ouweltjes *et al.*, 1988).

Estimates of SE and RSE are presented in Table 3. Estimates of SE were also used by many investigators as measures of accuracy for different methods of sire evaluation (Ufford *et al.*, 1979; Kumar and Narian, 1980). For all traits, BLUP had the lowest estimates of SE, while CC had the highest estimates. For 305-day milk yield, Raheja (1992) found that SE for STA estimated using BLUP was smaller (28.43 kg) than for those estimated using CC (30.2 kg).

For all traits, estimates of RSE using BLUP instead of CC were large and ranged from 27.5 to 53.1% (Table 3). Including variance components estimated by REML in calculation of BLUP led to a great difference in sire estimates when compared with CC and BLUP (Henderson, 1975; Carlson *et al.*, 1984). Carlson *et al.*, (1984) reported that BLUP without A^{-1} drastically reduced the predicted error variance (PEV) by about 59.3% from CC, while BLUP with A^{-1} reduced PEV by about 17.0% more than BLUP without A^{-1}. The same conclusion was reached by Zahed (1994) for the same methods using 305-day records.

Table (1): Minimum and maximum estimates(kg) for sire transmitting abilities (STA) estimated by CC and BLUP methods[+] for milk traits.

Traits and methods	Minimum estimates	Maximum estimates	Comparison of CC vs. BLUP[++]	
			CS%	RS%
Milk yield at 100-day of lactation (M100)				
CC	-315	581	80	30
BLUP	-126	316		
Fat yield at 100-day of lactation (F100)				
CC	-12	22	70	50
BLUP	-5	11		
Protein yield at 100-day of lactation (P100)				
CC	-9	15	90	0
BLUP	-3	8		
Fat+protein yield at 100-day of lactation (FP100)				
CC	-22	35	80	30
BLUP	-9	19		
Carrier yield at 100-day of lactation (C100)				
CC	-292	548	80	30
BLUP	-116	298		

[+] CC= Contemporary comparison method, and BLUP= Best Linear Unbiased Predictor.

[++] Percentage of sires common (CS%) and remaining in the same position (RS%) in CC compared with BLUP.

Table (2): Product-moment correlations (r_{PM}) and Spearman rank correlation (r_S) coefficients among STA estimated by the two methods of sire evaluation for 100 - day (partlactation) milk traits.

Correlations	Traits[+]				
	M100	F100	P100	FP100	C100
r_{PM}	0.869	0.818	0.767	0.763	0.874
r_S	0.616	0.434	0.518	0.451	0.666

[+] Traits as defined in Table 1.

Table (3): Standard error (SE) of each method of sire evaluation for 100-day (part-lactation) milk traits.

Method	Traits				
	M100	F100	P100	FP100	C100
CC	20.54	0.51	0.54	1.25	19.31
BLUP	9.67	0.37	0.26	0.63	9.05
RSE[+]					
CC vs. BLUP	52.9	27.8	51.9	49.6	53.1

[+] Percent of reduction in SE due to using BLUP instead of CC.

Effectiveness of methods using part vs. complete lactations

Criteria to assess the effectiveness or accuracy of each method of sire evaluation using records of part lactation compared with complete lactation are presented in Tables 4 & 5.

(i) STA for 100-day lactation vs 305-day lactation

Through the same method of sire evaluation, the percentages of sires common (CS%) and sires remaining in the same position (RS%) in 100-day lactation yield traits compared with 305-day milk traits are presented in Table 4. Using BLUP as a method for estimating STA in part lactation, 80-90% of the sires remained as the top 10 sires when selected on 305-day production record. This percent ranged from 70 to 90 when using CC. These results indicate that an improvement in lactation traits could be achieved through early selection of bulls based on STA estimated by BLUP for part-lactation production. Jain et al. (1991) concluded that selection of bulls on basis of part-lactation records of their daughters is expected to be more efficient when compared to records of complete-lactation.

The percent of sires which do not change their ranks (RS%) ranged from 25 to 45% for CC and form 45-63% for BLUP (Table 4). Across all yield traits, it is clear that BLUP is more effective than CC when choosing the top ten sires at the two scales of production.

(ii) Correlations between STA of 100-day and 305-day lactation

Estimates of product-moment correlation (r_{PM}) and Spearman rank correlation (r_S) are presented in Table 5. For all milk traits, product-moment correlations (r_{PM}) between STA estimated for 100-day and 305-day were high and positive (>0.817 for CC and >0.921 for BLUP). For the two methods, BLUP has higher correlation between STA of 100-day and 305-day compared with CC. High correlations obtained indicate that efficiency of BLUP at 100-day lactation will be of comparable degree of accuracy to that at 305-day lactation.

Estimates of r_S were higher than 0.797 for CC and greater than 0.876 for BLUP (Table 5). These high rank correlations estimated between the two methods of bull evaluation on the base of 100-day and 305-day production

Table (4): Percentages of sires common (CS%) and remaining in the same position (RS%) within the same method of sire evaluation for 100-day lactation traits compared with 305-day milk traits.

Trait	Methods	
	CC	BLUP
M100 & M305		
CS%	80	90
RS%	25	45
F100& M305		
CS%	70	80
RS%	32	49
P100& M305		
CS%	90	80
RS%	33	45
FP100& M305		
CS%	90	80
RS%	45	63
C100& M305		
CS%	90	90
RS%	33	56

records indicate that using early evaluation is more efficient compared to that evaluation based on the standard record (305-day). Using early evaluation of bulls will give more benefits of progeny testing through the reduction of the generation interval along with a higher genetic gain. Jain et al. (1991) reported that progeny testing of bulls on the basis of yield of complete lactation will be expected to result in lower genetic gain. They attributed this trend to that lactation milk yield is relatively influenced by the temporary environmental effects especially during the early (30 to 60 days) and late stages of lactation. Using the animal model, Karras (1991) found that correlations between breeding values for 100-day and 200-day milk yields with 305-day yield were highly significant (0.97-0.98). Also, close correlations between breeding value for milk yield in the first 200 days with that for complete lactation (0.995) were obtained.

Table (5): Product-moment correlations (r_{PM}) and Spearman rank correlations (r_S) among STA estimated within the same method of sire evaluation for 100 - day lactation compared with 305-day lactation traits.

Traits[+]	305-day lactation				
	M305	F305	P305	FP305	C305
Product-moment correlations (r_{PM})[++]					
CC					
M100	**0.977**	0.921	0.844	0.927	0.977
F100	0.772	**0.823**	0.808	0.807	0.763
P100	0.693	0.768	**0.818**	0.771	0.684
FP100	0.875	0.884	0.804	**0.892**	0.868
C100	0.975	0.910	0.830	0.919	**0.976**
BLUP					
M100	**0.922**	0.848	0.850	0.860	0.922
F100	0.879	**0.933**	0.870	0.917	0.871
P100	0.883	0.880	**0.936**	0.914	0.876
FP100	0.899	0.938	0.920	**0.941**	0.891
C100	0.954	0.877	0.883	0.889	**0.954**
Spearman rank correlations (r_S)[++]					
CC					
M100	**0.959**	0.742	0.719	0.799	0.964
F100	0.890	**0.808**	0.794	0.837	0.877
P100	0.857	0.781	**0.798**	0.750	0.840
FP100	0.921	0.797	0.796	**0.825**	0.917
C100	0.957	0.735	0.711	0.792	**0.962**
BLUP					
M100	**0.877**	0.819	0.809	0.848	0.924
F100	0.801	**0.900**	0.845	0.916	0.840
P100	0.802	0.809	**0.913**	0.889	0.841
FP100	0.815	0.874	0.881	**0.916**	0.855
C100	0.877	0.808	0.795	0.836	**0.924**

[+] Traits as defined in Table 1.

[++] All estimates of correlation are significant (P<0.001).

CONCLUSION

(1) Choice among various methods for sire evaluation depends, to a great extent, upon the computational facilities and the relative accuracy for each method.

(2) The rank correlations between CC and BLUP methods were low.

(3) BLUP had the lowest estimates of SE and large RSE relative to CC.

(4) The efficiency of BLUP method at 100-day lactation is comparable to that of 305-day in sire evaluation.

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الكفاءة النسبية لطريقتى مقارنة المعاصرات وأفضل المتنبئات الخطية غير المتحيزة لتقييم الطلائق بإستخدام سجلات اللبن الجزئية والكاملة

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إستخدم فى هذه الدراسة عدد ٧٩٥٩ سجلا للموسم الأول لتقييم ٦٩ طلوقة من طلائق ماشية الفلاكفى. تم إستخدام الطلائق التى لها ١٠٠ بنت على الأقل. تم تقدير القيمة التمريرية للطلوقة بإستخدام اسلوبين هما طريقة المعاصرات (CC) وطريقة أفضل المتنبئات الخطية غير المتحيزة (BLUP) . تم استخدام سجلات إنتاج اللبن والدهن والبروتين والدهن+البروتين واللبن الحامل (منزوع الدهن والبروتين). تم الحكم على كفاءة الطريقتين عن طريق حساب معامل الإرتباط العزومى (r_{PM}) وكذلك معامل الإرتباط لسبيرمان (r_S). ولتقدير دقة الطريقتين تم إستخدام الخطأ القياسى (SE) لكل طريقة ونسبة الإنخفاض فى الخطأ القياسى (RSE) الناتج من استخدام طريقة BLUP بدلا من CC ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلى:-

١. أظهرت الطلائق التى تم تقييمها بطريقة المعاصرات أعلى فروق بين أعلى القيم التمريرية وأدناها، بينما كانت هذه الفروق أقل عند استخدام طريقة BLUP. على مستوى جميع البيانات، كانت أقل نسبة للطلائق التى تحافظ على ترتيبها موجودة فى طريقة CC عند مقارنتها بطريقة BLUP (صفر ٥٠٪).

٢. كانت قيم معاملات الإرتباط العزومى بين طريقتى CC و BLUP (٠,٧٦٣ ٠,٨٧٤) وهذا يعنى أن BLUP تختلف عن CC. كذلك لوحظ نفس هذا الإتجاه عند استخدام معامل إرتباط إسبيرمان.

٣. كانت نسبة الإنخفاض فى الخطأ القياسى كبيرة عند إستخدام BLUP بدلا من CC حيث تراوحت بين ٢٧,٥ – ٥٣,١٪.

٤. كانت معاملات الإرتباط العزومى بين القيم التمريرية المحسوبة بإستخدام السجلات الجزئية (١٠٠-يوم حليب) وكذلك المحسوبة بإستخدام السجلا الكاملة (٣٠٥-يوم حليب) عالية وموجبة (أكبر من ٠,٨١٧) عند إستخدام CC ، بينما كانت أكبر من ٠,٩٢١ عند إستخدام BLUP. كذلك كان معامل إرتباط الرتب عالى القيمة وموجب حيث كان أكبر من ٠,٧٩٧ عند إستخدام CC و أكبر من ٠,٨٧٦ عند إستخدام BLUP. أظهرت BLUP أعلى قيم لمعاملات الإرتباط بين القيم التمريرية المقدرة من إستخدام بيانات كل من ١٠٠ يوم حليب و٣٠٥ يوم حليب، بما يشير إلى أن ترتيب الطلائق عند ١٠٠ يوم من الإدرار قد لا يختلف كثيرا عند إستخدامها عند ٣٠٥ يوم وعلى العكس من ذلك فإن إستخدام طريقة CC سوف تؤدى إلى إختلاف فى ترتيب الطلائق كثيرا لمرحلتى الإدرار عند ١٠٠، ٣٠٥ يوم.