J. Anim. Breed. Genet. 106 (1989) 423–432

ISSN 0931–2668

Ms. received 20. 2. 1988

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Analysis of milk production traits of Pinzgauer Cattle in Austria

I. Non-genetic factors

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Introduction

In formulating a genetic index for use in cow and sire evaluation, there is need to account for non-genetic factors which influence an animal's performance. To this end, milk production records are currently adjusted for, amongst other things, age at calving, days open and year and month of calving. In Austria, records are corrected for age at calving, on mature equivalent basis, and month of calving (Essl and Haiger 1972), but no account is taken of days open. Analysis has shown (Soliman 1984) that age at calving and days open have a significant effect on yield, and hence further investigation into the value and methods of adjusting for these factors was deemed important.

The purpose of this study was: (1) to investigate non-genetic factors affecting milk production trait of 1st and 2nd lactations of Pinzgauer cattle with special emphasis on age at calving and days-open, and (2) to develop correction factors for age at calving and days open.

Material and methods

Data

Data in the present study consisted of 19754 first and second lactation milk records of Pinzgauer cows accumulated by the Official Federation of Austrian Cattle Breeders (ZAR) over ten consecutive years (1974 through 1983). Description of Pinzgauer cows in Austria as well as the structure of the data has been reported by Hein (1982), Holz (1982) and Hartmann et al. (1986).

As a general rule, heifers were inseminated when they reached about 320 kg body weight and cows were inseminated during the 1st heat period after the 60th days post-partum. Breeding cows were artificially inseminated using deep-frozen semen. Pinzgauer cows of the present study were mainly located in the province of Salzburg. For such regions, two data sets were obtained. The 1st set was for cows pastured on alpine grassland (alpage) denoted as (A), while the 2nd was for cows pastured in valleys (denoted as H). Only sires with at least two daughters (paternal half-sisters) were included in the analysis. Data were available on 12338 and 7416 daughters by 1614 and 1144 sires in the 1st and 2nd lactations, respectively. All records were 305-day or less completed lactations. Traits studied were: 100-day milk yield (100dMY), 305-day milk yield (305dMY), 100-day fat yield (100dFY), 305-day fat yield (305dFY), 100-day protein yield (100dPY) and 305-day protein yield (305dPY).

Statistical models

Data of each lactation were analyzed separately in each set by the Least-Squares and Maximum Likelihood program of Harvey (1977). The following mixed model was used:

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$$Y_{ijklmn} = \mu + S_i + A_j + B_k + C_l + D_m + e_{ijklmn}$$

where Y_{ijklmn} = the performance of the observation ijklmn; μ = the overall mean; S_i = random effect of the ith sire; A_j = fixed effect of the jth month of calving; B_k = fixed effect of the kth year of calving; C_l = fixed effect of the lth age-at-calving class; D_m = fixed effect of the mth days-open class, and e_{ijklmn} = a random deviation and assumed to be independently randomly distributed (0, σ^2e). It includes all the other effects not specified in the model.

However, it was not possible to examine simultaneously all factors and the interactions between them, which were likely to influence milk production traits, because the equations for estimation would have involved a matrix too large to invert. The limited numbers of records or their absence in some subclasses, did not permit the inclusions of such interactions. In some situations (e. g. NORMAN et al. 1978) the inclusion of interactions could decrease the accuracy of estimates.

Age correction factors were constructed by smoothing the curve representing the relationship between means (least-squares) and age at calving using polynomial regression analysis of third degree. In the case of nonsignificant partial cubic regression coefficient, the polynomial regression of the 2nd degree was used and if the quadratic term was not significant, the relationship between age and each of production traits were examined for linearity. The multiplicative factor for the lth age-at-calving was calculated as:

$$C_l = \mu/\mu^l$$

where: C_l = the multiplication factor; μ = the average yield at age of 35 months in the 1st and at 47 months in the 2nd lactations (model ages), respectively, and μ^l = the average yield at the lth age; as indicated the previous model.

The multiplicative factor for the mth days open was constructed by fitting a polynomial regression of 2nd degree of yield traits on days open. However, preliminary analyses showed that partial quadratic regression coefficients of yields on days open were not significant, therefore, only linear relationships were considered. The correction factor for days open was the average yield at 90 days open (mode) as a base, divided by the average yield at mth days open class.

Results and discussion

Estimation of non-genetic effects

Results of least-squares analysis of variance of estimating the effects of age at calving, days open and month and year of calving on production traits are given in Table 1.

Age at calving

Age effects on different traits in 1st lactation, except 100dPY in mountain-pastured cows, were significant ($P < 0.05$ or $P < 0.01$) in the two regions. In the 2nd lactation, effects of age were not significant for any trait except 100dMY and 305dMY in both regions and 305dFY in valleys only. The significant effect of age at calving on milk, fat and/or protein yields was reported by many investigators (e.g. LEE 1976; HANSEN et al. 1983; PAPE et al. 1983; ROMBERG et al. 1983; ALBS et al. 1984; LÔBO et al. 1984; NEIMANN-SORENSEN et al. 1987). F-ratios for different traits showed that age at calving did not account for as much variation in fat and protein yields as it did for milk yield (Table 1).

The most frequent classes of age at calving in the present data are 35 and 47 months in the 1st and 2nd lactations, respectively. The differences in age correction factors were inconsistent across traits within different regions and parities. However, the clear differences in least-squares means obtained in the present study for different ages at calving indicate the need to adjust lactation yields (milk and fat yields) for age at calving (figures 1 up to 4).

Table 1. **F-ratios of least-squares analysis of variance for milk, fat, protein yield traits in first two lactations**

Source of variation	Valley-pasture cows								Mountain-Pastured cows							
	d.f.	100dMY	305dMY	100dFY	305dFY	d.f.	100dPY	305dPY	d.f.	100dMY	305dMY	100dFY	305dFY	d.f.	100dPY	305dPY
First Lactation																
Sire	909	1.8	1.9	1.6	1.8	488	1.8	1.8	703	2.0	1.9	1.8	1.8	454	1.9	1.7
Month of calving	11	6.2	6.8	10.7	5.6	11	6.3	2.8	11	2.5	6.9	4.7	4.7	11	3.5	3.9
Age at calving	16	6.1	5.0	6.4	4.7	16	3.3	2.9	16	3.4	2.6	3.0	2.3	16	1.6^{ns}	1.9
Days open	4	8.2	53.3	5.7	36.4	4	5.7	30.0	4	0.7^{ns}	28.5	0.7^{ns}	17.6	4	0.7^{ns}	11.7
Year of calving	9	19.0	18.6	20.7	20.3	5	15.6	14.8	9	13.9	15.3	15.1	15.4	5	11.5	12.8
Remainder	6401					3192			4243					2573		
Remainder M.SQ.[a]		49923	344530	101	628		65	442		42359	268543	87	496		57	362
Second lactation																
Sire	651	1.8	1.7	1.5	1.8	360	1.5	1.5	491	1.6	1.5	1.4	1.3	331	1.4	1.4
Month of calving	11	8.9	5.6	5.3	5.1	11	6.4	2.8	11	1.3^{ns}	3.3	1.0^{ns}	2.4	11	2.0	1.5^{ns}
Age at calving	16	3.3	2.4	1.3^{ns}	2.0	16	1.5^{ns}	1.6^{ns}	16	1.8	1.8	1.3^{ns}	1.3^{ns}	16	1.1^{ns}	1.1^{ns}
Days open	4	8.5	39.1	3.9	31.7	4	5.5	20.3	4	5.1	27.9	2.8	19.3	4	2.1^{ns}	13.0^{ns}
Year of calving	8	9.0	8.2	8.5	8.4	5	4.2	3.7	8	7.1	7.1	9.6	6.8	5	7.8	7.9
Remainder	3821					1964			2373					1547		
Remainder M.SQ.[a]		82679	493251	195	946		111	641		69471	393266	162	778		88	484

^{ns} nonsignificant at $P > 0.05$, other all F-ratios are significant at $P < 0.05$ or $P < 0.01$.
[a] Remainder mean squares.

Table 2. **Significant estimates of polynomial regression analysis for production traits in the first two lactations on age at calving**[+]

Traits	1st Lactation								2nd Lactation					
	Partial regression coefficients of polynomial of 3°						Linear regression coefficients		Partial regression coefficients of polynomial 2°				Linear regression coefficients	
	Linear (kg/month)		Quadratic (kg/month²)		Cubic (kg/month³)		(kg/month)		Linear (kg/month)		Quadratic (kg/month²)		(kg/month)	
	b	S.E.	b	S.E.	b	S.E.	b	S.E.	b	S.E.	b	S.E.	b	S.E.
100dMY++							7.2**	0.8					9.0**	1.7
305dMY++	−1074.8*	421.9	33.51*	13.33	−0.338*	0.138							16.2**	3.8
100dMY							5.5**	1.3	113.8**	28.0	−1.17**	0.32		
305dMY	−4202.8**	1239.3	127.65**	39.16	−1.275**	0.407			267.0**	58.9	−2.76**	0.67		
100dFY++							0.3**	0.1					0.6**	0.2
305dFY++	−41.3*	17.5	1.28*	0.55	−0.012*	0.005								
100dFY							0.2**	0.1	4.6*	1.7	−0.05*	0.02		
305dFY							0.5**	0.1	9.1**	2.8	−0.09*	0.03		
100dPY++							0.2**	0.1					0.2**	0.1
305dPY++							0.6**	0.1					0.6**	0.2
100dPY									2.7*	1.2	−0.03	0.01		
305dPY									8.9**	2.7	−0.09**	0.03		

\+ Regression coefficients (b) are significantly different from zero at 5 % (*) and 1 % (**) probability.
++ Yield in valley pasture, otherwise, yield in mountain pastured regions.

However, similar trends were observed for protein yield. HANSEN et al. (1983) suggested a set of age correction factors within parity.

Results of polynomial regression analyses of traits studied on age at calving in the first two lactations are presented in Table 2. In the 1st lactation, the partial linear, quadratic and cubic regression coefficients of 305dMY and 305dFY on age at calving in both data sets were

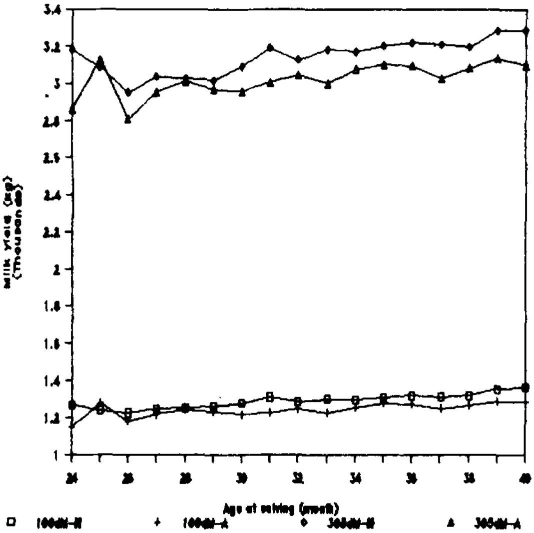

Fig. 1. Effect of age at first calving on 100- and 305-day milk yield

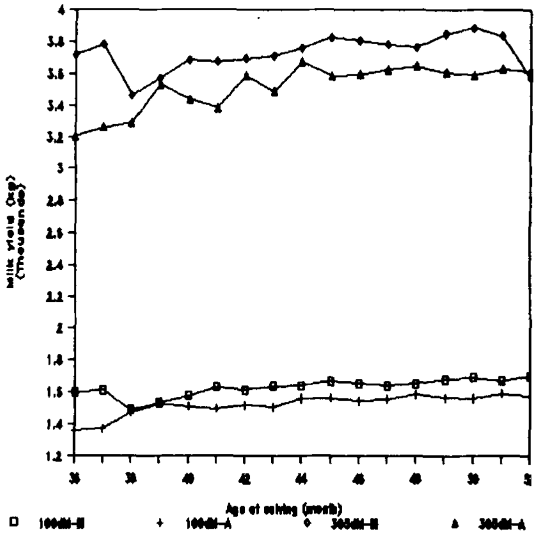

Fig. 2. Effect of age at second calving on 100- and 305-day milk yield

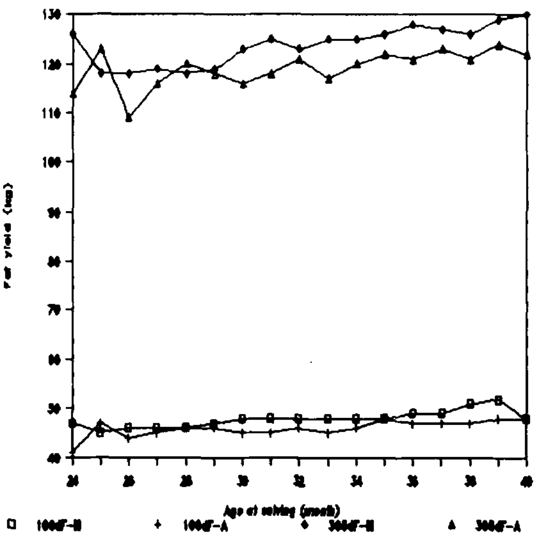

Fig. 3. Effect of age at first calving on 100- and 305-day fat yield

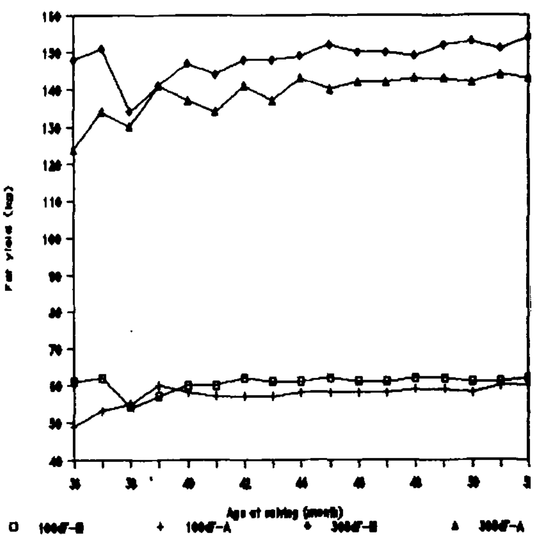

Fig. 4. Effect of age at second calving on 100- and 305-day fat yield

significant ($P < 0.05$ or $P < 0.01$). On the other hand, simple linear regressions of 100-day milk, fat and protein yields, except protein yield trait in first lactation for cows on alpine pasture, reflect increased ($P < 0.01$) performance with age of cow at calving. In the 2nd lactation, significant simple linear relationships ($P < 0.01$) performance with age of cow at calving. In the 2nd lactation, significant simple linear relationships ($P < 0.01$) between all traits and age at calving in both data set, except 100dFY, were observed while quadratic relationships ($P < 0.05$ or $P < 0.01$) in mountain pastured cows were observed. Accordingly, either linear or curvilinear curves could be fitted on the data of milk traits studied in either data set, respectively. SARGENT et al. (1967), ROMBERG et al. (1983), ALPS et al. (1984), NEIMANN-SORENSEN et al. (1987) found that the linear, quadratic and cubic effects of age at calving on milk yield were significant.

The rather high least-squares means and age correction factors for early calved heifers and cows for 305-day yield traits were not expected especially not for heifers and cows calved at 24–27 and 36–39 months in the first and second parities, respectively. The small number of heifers and cows that calved at early age in well managed farms in the whole data comprised, could be the main case in this respect. It can be also due to different shares of foreign genes (Red Friesian) in Pinzgauer cows with Red Friesian paternal grand-mothers and grand-fathers were included in Pinzgauer formation and such aspects were not considered in collecting the present data. Therefore, such heifers and cows, produced more yields and attained their maximum performance earlier than the other cows in the same lactation.

Days open

Days open affected significantly (P < 0.05) milk, fat and protein yields in 100- and 305-day in milk in the first two lactations in valley-pastured cows (Table 1). In cows on alpage, the effects were significant for all traits in the two lactations except the yields in 100-day in milk in 1st lactation and 100dPY in 2nd lactation. Significant effect of days open on production traits was reported by many investigators in European countries (e. g. ESSL and HAIGER 1972; HAGGER and CHAVAZ 1982; PAPE et al. 1983; ROMBERG et al. 1983; ALBS et al. 1984; SOLIMAN 1984; HAUG and NITTER 1987). The magnitude of days open effects, as judged by the size of the F-ratios (Table 1), were much larger for milk, fat and protein yields in 305-day than in 100-day in milk. SMITH and LEGATES (1962) attributed this trend to the competition between milk production of cow and the nutrition of her foetus especially with the beginning of the 5th month of pregnancy. They also explained such magnitude by the fact that milk-secretion hormones decrease with the advance of stage of pregnancy.

The modal value of 60–89 days open are observed for the first two lactations of the present study. SCHAEFFER and HENDERSON (1972) reported that correction factors for days open could be computed to any desirable base. THOMPSON et al. (1982) indicated that lactation yield adjusted for days open is preferred over annualized yield for measuring milk yield for sire evaluation.

As expected, milk traits studied increased linearly (P < 0.05 or P < 0.01) with the

Table 3. **Linear regression coefficients (b) and their standard errors of milk traits on days open**

	Valley-pastured cows		Mountain-pastured cows	
	Linear regression coeff. (kg/day)		Linear regression coeff. (kg/day)	
Traits	b*	S.E.	b*	S.E.
First lactation				
100dMY	0.322	0.121	N.S	
305dMY	2.543	0.413	2.108	0.241
100dFY	0.012	0.004	N.S	
305dFY	0.087	0.017	0.069	0.013
100dPY	0.011	0.007	N.S	
305dPY	0.088	0.026	0.062	0.012
Second lactation				
100dMY	0.620	0.160	0.487	0.175
305dMY	3.611	0.403	3.203	0.620
100dFY	0.019	0.005	0.009	0.010
305dFY	0.146	0.009	0.112	0.029
100dPY	0.028	0.005	N.S	
305dPY	0.132	0.018	0.076	0.032

* All the regression coefficients are significant at P > 0.05 or P < 0.01.
N.S Where non-significant effects (P > 0.05) of days open on 100-days yield traits were detected and consequently have no regression coefficients.

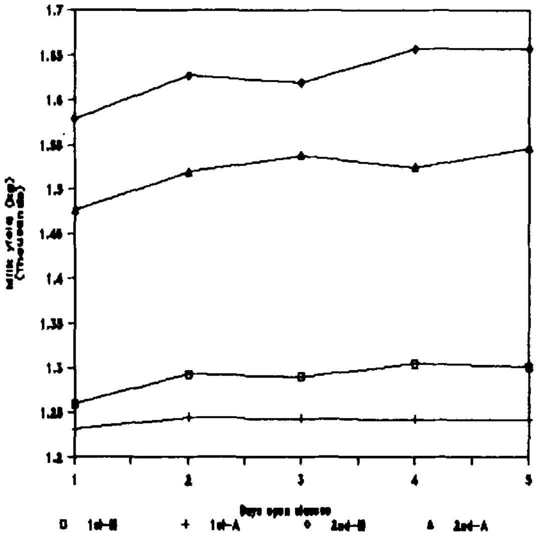

Fig. 5. Effect of days open on 100-day milk yield in first two lactations

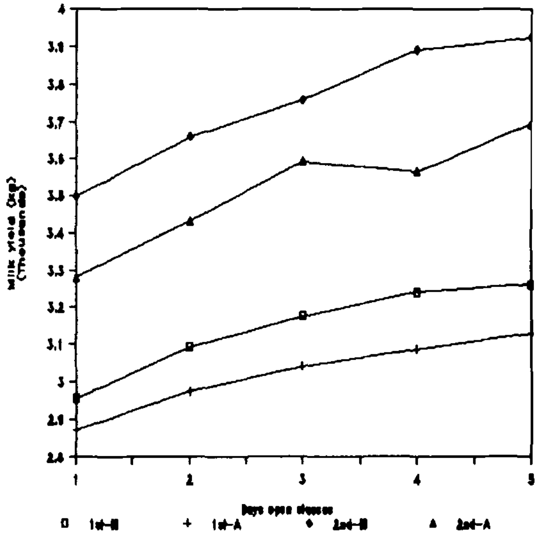

Fig. 6. Effect of days open on 305-day milk yield in first two lactations

increase of days open (Table 3 and Figures 5 and 6). It was observed that the curves for fat and protein yields were similar to the curves of milk yield. The quantity of 305-day milk yield, for instance, increased by only 308 kg, from monthly classes of 30–59 (1st class) to 150–179 days (5th class), over four months in the 1st lactation in valley-pastured cows, and 60 days open was desirable for economic production (HAGGER and CHAVAZ 1982). In practice, the farmers will inseminate their low-performance cows as early as possible. In this respect, an open period of 60 days is recommended. BAR-ANAN and SOLLER (1979) indicated that cows should be mated as early as possible for maximum production, 70–100 days open for heifers and 30–50 days open for cows in subsequent lactations.

The estimates of the simple linear regression coefficients of different traits on days open in first two lactations for valley-pastured cows and cows on alpage are presented in Table 3. For each additional day open, 305dMY increased by 2.54 and 3.61 kg/day for the 1st and 2nd lactation in valley-pastured cows, respectively, while these coefficients were 2.11 and 3.20 kg/day in mountain-pastured cows. All the regression coefficients were significant except 100-day yield traits in the 1st lactation and 100dPY in the 2nd lactation in mountain group. Unfavorable correlations between days open and milk traits reported by some European investigators (e.g. DISTL et al. 1985; HAUG and NITLER 1987) may have causes other than purely genetic ones. BLAU and SCHOLZ (1982) reported that the delaying of days open may be caused by several factors, e.g. the farmer's decision and selection policy. Accordingly, the farmers were to inseminate high-yielding cows later than moderate or low-producing cows. This could automatically produce an antagonistic relation between milk traits and days open (DISTL et al. 1985). It is also possible that high-producing cows will be afforded more chances of conceiving than low-producing cows. A significant linear relationships between milk, fat and protein yields with days open for Holstein/Friesian cattle were reported in some European studies (e.g. BROTHERSTONE 1987). She found that the linear regression coefficients were 2.78, 0.094 and 0.085 kg/day for cows in 1st lactations and 4.64, 0.168 and 0.145 kg/day for cows in 2nd lactation for 305 day milk, fat and protein yields, respectively. OLDS et al. (1979) estimated that each additional day open resulted in 4.5 kg more 305 day milk.

Month and year of calving

The effects of month and year of calving on milk traits studied were significant (Table 1). Similarly, most of the Austrian studies (e. g. ESSL 1966; HEIN 1982; SOLIMAN 1984) showed that month-and-year-of-calving effects were of some importance in influencing ($P < 0.05$ or $P < 0.01$) yield traits of different breeds of dairy cattle. Therefore, any model of analysis for describing milk, fat or protein yields should include the effect of these factors for appropriate analysis (e. g. PAPE et al. 1983; ROMBERG et al. 1983; ALPS et al. 1984). The magnitude of month and year of calving influence as judged by the size of the F-ratios is larger in valley pastured cows than in cows on alpage for different traits under study (Table 1). These marked differences must be due to the differences in management and feeding practices.

The highest frequency of calvings was observed in September through November ranging between 39 and 58%. It is noticed that the dairymen in Austria concentrated their calvings in autumn months. The milk yield and its constituents, in general, were highest after autumn and winter calvings, while the heifers and cows calving in summer months gave the lowest yields (e. g. ROMBERG et al. 1983; ALPS et al. 1984).

Year of calving means show that there was an upward trend in all traits studied over the years. The upward trend is probably due in part to genetic improvement and partly to improved feeding and management. A similar trend was reported by HEIN (1982) and HOLZ (1982) from Pinzgauer cattle in Austria.

General discussion

For 305-day yield traits in the present study, days open effect was the most prominent factor followed by the year of calving effect. The other factors investigated, namely, age at calving and month of calving affected yield traits less. In 100-day yield traits, the year and month effects were more important than other factors (age at calving and days open).

In most cases, effects of age at calving and days open on yield traits were significant. Accordingly, correcting records for age at calving and days open is recommended. SCHAEFFER and HENDERSON (1972) concluded that adjustment of milk records for days open appears necessary and would not introduce genetic biases. In Austria, it therefore seems appropriate to make corrections for days open and age at calving. Although the quadratic regression coefficients are small in magnitude, the relationship between yield traits and age at calving is quadratic in most cases. There is very little extra cost in effecting the quadratic correction, and hence a linear and quadratic adjustments of age at calving, where appropriate, would be the most suitable adjustment for yield traits. It is also noticed that, from the regression analyses, there were clear differences in age correction factors and days open correction factors for different traits and for different management. Therefore, it is necessary to construct a set of correction factors for these for every trait. The electronic processing of data could allow the inclusion of more factors if this increased accuracy.

Acknowledgements

The authors are grateful to professor E.S.E. GALAL, Department of Animal Production, Faculty of Agriculture, Ain Shams University, Cairo, Egypt for helpful comments and for reading the manuscript. We gratefully acknowledge the Official Federation of Austrian Cattle Breeders (ZAR) for supplying the data.

Summary

An analysis of cow productivity traits in Pinzgauer cattle was carried out on 19754 first and second lactation records from 1614 sires, collected in the period from 1974 through 1983 in the valley pasture and mountain pasture Salzburg regions. Yields of milk, fat and protein at 100 and 305 days of lactation were the traits examined. The effect of age at calving, days open, and year-and-month of calving on these traits were investigated. Age at calving affected ($P < 0.05$ or $P < 0.01$) most milk traits studied but no consistent pattern of such effects was observed. Age at calving did not account for as much variation in fat and protein yields as it did in milk yield. Milk traits studied increased linearly ($P < 0.05$ or $P < 0.01$) with the increase of days open. Year and month of calving exerted a pronounced effect ($P < 0.05$ or $P < 0.01$) on milk traits studied. There was an upward trend in all traits with year of calving. The highest occurence of calvings was in September and October.

Factors for adjusting milk traits of Austrian Pinzgauer cattle for calving age and days open were constructed from smoothed curves of least-squares means of age at calving and days open classes. Differences in age correction factors were inconsistent across traits in the first two lactations of Pinzgauer cows in the valley pasture and alpage, while a consistent trend was observed for days-open correction factors. In spite of increased milk production with age of cow at calving, it is recommended, economically, to the Austrian dairy cattle breeders to bred their heifers and cows as early as possible. The days open of 60 days for both lactations were suggested as optimum days open for attaining maximum production for Pinzgauer cattle in Austria.

Resumen

Análisis de características productivas lecheras en ganado lechero Pinzgauer en Austria.
I. Factores ambientales

Un análisis de la productibilidad de vacas lecheras Pinzgauer sobre 19.754 registros de primera y segunda lactancia, provenientes de 1614 toros, recolectados durante 1974 y 1983, en praderas del valle y de la montaña (alpes) de la región de Salzburgo. Las características estudiadas fueron producción de leche y porcentaje de grasa y proteína en la leche, en lactancias de 305 días. Se investigaron el efecto de edad al parto, días abiertos, año y mes de parto sobre estas características. Edad al parto afecta ($P < 0,05$ o $P < 0,01$) la mayoría de las características en la leche, pero no se observaron padrones consistentes para estos efectos. Edad al parto es responsable de muy poca variación sobre grasa y proteína en la leche, en comparación con la producción de leche. La característica de producción de leche aumenta linealmente ($P < 0,05$ o $P < 0,01$) con el incremento en los días abiertos. Año y mes de parto manifiestan un efecto pronunciado ($P < 0,05$ o $P < 0,01$) sobre las características estudiadas en la leche. Se demostró una tendencia clara en incrementar las características estudiadas en forma paralela a los partos ocurridos en años posteriores. El mayor porcentaje de pariciones ocurrió entre Septiembre y Octubre. Los factores de corrección de producción de leche en vacas austriacas Pinzgauer para edad al parto y días abiertos fueron construidos a partir de las pendientes simples de las curvas mediante las medias de los mínimos cuadrados de las clases de edad al parto y días abiertos. Diferencias en los factores de corrección por edad fueron inconsistentes entre las dos primeras lactancias de las vacas Pinzgauer en praderas del valle y alpinas. Mientrás que una tendencia consistente se observó en los factores de corrección para días abiertos. A pesar del aumento de la producción de leche a mayor edad de la vaca al parto, se recomienda a los productores de ganado lechero austriacos que en base económica sus terneras y vacas sean cruzadas lo más pronto posible. Un periodo de 60 días para las primeras dos lactancias sería como días abiertos más óptimos para alcanzar la máxima producción en las vacas lecheras Pinzgauer en Austria.

Résumé

Analyse des caractères de la production laitière du bovin Pinzgauer en Autriche.
I. Facteurs non-génétiques

Une analyse des caractères productifs de vaches Pinzgauer était réalisée de 1974 à 1983 dans les régions montagneuses et vallées de Salzbourg. L'analyse comprend 19.754 premières et secondes lactations de vaches produites de 1614 taureaux. On a examiné les rendements en lait, de graisse et de protéine à 100 et 305 jours de lactation. L'influence de l'âge au vêlage, du temps vide et la saison de vêlage (année et mois) sur les caractères fut considéré. L'influence de l'âge au vêlage sur la plupart des caractères examinés fut déterminée ($P < 0.05$ ou $P < 0.01$), toutefois une tendance conséquente de l'effet ne fut pas observée. L'âge au vêlage causait des variations plus petites sur le rendement en graisse et protéine comparé au rendement laitier. Les caractères laitiers montaient linéairement ($P < 0.05$ ou $P < 0.01$) avec l'augmentation du temps vide. L'année et le mois de vêlage exercent un effet prononcé ($P < 0.05$ ou $P < 0.01$) sur les caractères laitiers. Une tendance montante était observée dans tous les caractères. Le taux de vêlage le plus élevé était entre septembre et octobre. Les facteurs correctifs des caractères laitiers des vaches Pinzgauer pour l'âge au vêlage et temps vide étaient construits de courbes légères des moyennes leat-square de l'âge au vêlage et des classes du temps vide. Des différences dans les facteurs correctifs de l'âge étaient inconséquents à travers les caractères des deux premières lactations des vaches Pinzgauer des régions montagneuses et vallées, tandis qu'une tendance conséquente était observée pour les facteurs correctifs du temps vide. Bien qu'une augmentation du rendement laitier est prouvée par l'augmentation de l'âge au vêlage, il est recommandé aux éleveurs autrichiens, pour des raisons économiques, de laisser inséminer les vaches et génisses aussi tôt que possible. Une période de 60 jours pour les deux premières lactations est suggérée comme temps vide optimal pour atteindre la production maximale des vaches Pinzgauer.

Zusammenfassung

Analyse der Milchproduktionsleistung des Pinzgauer Rindes in Österreich. I. Umweltfaktoren

Es wurde eine Analyse der Milchleistungsmerkmale von 19754 ersten und zweiten Laktationen von Pinzgauer Kühen, Nachkommen von 1614 Stieren zwischen 1974 und 1983, bei Talsommerweide oder Alpung durchgeführt. Es wurden die Milch-, Fett- und Eiweißmenge an 100 bzw. 305 Tagen geprüft. Der Einfluß des Abkalbalters, der Leerzeit und der Abkalbzeit (Jahr und Monat) auf diese Merkmale wurde untersucht. Abkalbalter beeinflußte die meisten untersuchten Merkmale ($P < 0.05$ od. $P < 0.01$), jedoch wurde kein eindeutiger Trend beobachtet. Sein Einfluß auf Fett- und Eiweißmenge war geringer als auf Milchmenge. Die Milchleistungsmerkmale nehmen linear ($P < 0.05$ od. $P < 0.01$) mit Verlängerung der Leerzeit zu. Die Abkalbzeit (Jahr und Monat) weist einen deutlichen Einfluß ($P < 0.05$ od. $P < 0.01$) auf die untersuchten Merkmale auf. Eine deutliche Tendenz zur Steigerung der untersuchten Merkmale in späteren Abkalbjahren wurde festgestellt. Die höchste Abkalbrate war zwischen September und Oktober. Korrekturfaktoren für Milchleistungsmerkmale für Abkalbalter und Leerzeit wurden von angeglichenen Kurven an Least-Square Durchschnitte konstruiert. Es zeigte sich kein konsequenter Trend für Merkmale in den ersten zwei Laktationen bei Sommertalweide und Alpung, während ein solcher für Korrekturfaktoren der Leerzeit deutlich ist. Obwohl eine Zunahme der Milchleistung mit Zunahme des Abkalbalters vorhanden ist, wird aus wirtschaftlichen Gründen frühe Belegung empfohlen. 60 Tage werden für die ersten zwei Laktationen als optimale Leerzeit zur Erzielung der Höchstleistung empfohlen.

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