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Effect of birth type on milk production traits in East Friesian ewes

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Abstract
A total of 5,592 240d-lactation records of 2,102 East Friesian ewes collected between 1990 and 2003 were used to analyse the effect of birth type and other environmental and genetic effects on milk production (milk, fat, and protein yield; fat and protein percentage). In a separate analysis for first and higher lactations, effects accounted for were herd*year*season, lactation number, birth type at lambing, birth type of the ewe, lambing interval, stillbirth, and age at lambing. Birth type at lambing significantly affected all production traits in higher lactations, and milk yield, fat yield and fat percentage in first lactations. Yield traits and protein percentage increased with higher number of lambs whereas fat percentage slightly decreased. The birth type of the ewe showed a less significant effect on milk production traits. Ewes born as singles had significantly higher protein percentages in higher lactations and were in tendency superior to ewes born as multiples for other production traits. Estimated heritabilities for yield traits ranged from 0.25 to 0.37 and from 0.26 to 0.27 in first and higher lactations, respectively. Heritabilities for protein and fat percentage were 0.63 and 0.42 in first, and 0.53 and 0.45 in higher lactations.

Keywords: East Friesian sheep, Milk production traits, Birth type, Genetic parameters

Introduction

Currently, approximately 1,200 purebred herdbook dairy ewes under milk recording are kept in Austria. The main breed is the East Friesian milk sheep, originating in Northern Germany and The Netherlands, with a share of about 85%. The remaining animals belong to the French Lacaune breed. Until 2004, performance data were recorded and maintained by eight different breeding organisations with no electronic exchange of data. In 2004, a central data bank for all Austrian sheep and goats was implemented. For the first time, lactation data of the entire Austrian sheep population could be analysed. As test day records are not available yet and due to the small population size and restrictions with regard to costs and personnel, a test day model for dairy sheep will not be introduced during the next few years. However, the analysis of various environmental effects and the estimation of genetic parameters for lactation records is a first step towards a breeding value estimation by means of a lactation model which is needed for efficient selection.

The objective of this study is to analyse environmental effects on milk production traits (milk, fat, and protein yield; fat and protein percentage) in sheep. As the improvement of reproductive traits is of great importance in sheep breeding, the main focus is on the effect of birth type at lambing and birth type of the ewe. Additionally, results for heritabilities and genetic correlations for milk production traits are presented.

Data

Data for Austrian milk sheep were provided by the Austrian Federal Association for Sheep and Goats (ÖBSZ). ICAR regulations (AT) are followed in milk recording, the standard lactation in milk sheep is 240 days. Partial lactations, incomplete data sets, herds with less than 20 lactation records, records of the Lacaune breed, records with an age at first lambing <270 or >1000 days, with fat or protein percentages > 10% and with a lactation number >15 were not considered. In total, 5,592 240d-lactation records of 2,102 East Friesian ewes collected in 45 herds between 1990 and 2003 were analysed. Ewes were sired by 235 rams, only 55 rams had daughters in more than one herd as artificial insemination is not practised in Austrian sheep breeding. The pedigree file contained 9,146 animals with an average complete generation equivalent of 3.16. In Table 1 an overview of the data structure is given. As the East Friesian milk sheep is a seasonal breed, the majority of lambings (79%) occurred in January and February. However, lambings were also observed in all other months except August. The number of lambs born ranged from 1-5 with an average of 1.90 and twins (53%) being the most frequent. In 7.2% of lambings stillborn lambs (born dead or died within 48 hours) were recorded. Average age at first lambing for first lactations was 13.8 months, average lambing age for higher lactations was 39.7 months.

Table 1: Data structure

Lactation number	No. of records	Lambing year	No. of records
1	1758	1990	45
2	1506	1991	158
3	1026	1992	337
4	636	1993	418
5	363	1994	509
6	195	1995	399
7+	108	1996	407
Lambing season		1997	528
January-February	4435	1998	436
March-July	917	1999	409
September-December	240	2000	442
		2001	530
		2002	537
		2003	437
Birth type at lambing		Birth type of ewe	
Singles	1639	Single	313
Twins	2977	Twin	1182
Triples	891	Triple	541
Quadruplets	83	Quadruplet	64
Quintuplets	2	Quintuplet	2

Statistical Analysis

First and higher lactations were analysed separately. For the analysis of environmental effects the GLM procedure of SAS (SAS, 1999) was used. The following models were applied:

$Y_{ijklmnop} = \mu + hys_{ijk} + btl_l + bte_m + still_n + int_o + b1{*}age + \varepsilon_{ijklmnop}$ (first lactations) [1]

$Y_{ijklmnopq} = \mu + hys_{ijk} + btl_l + bte_m + still_n + int_o + lact_p + b1{*}age(lact_p) + \varepsilon_{ijklmnopq}$ (higher lactations) [2]

where $Y_{ijklmnop(q)}$ = individual observation (kg milk, fat or protein; % fat or protein), μ = the overall mean, hys_{ijk} = fixed interaction effect of herd i (i = 1-45), year j (j = 1990-2003) and season k (k = 1-3) with 387 and 419 levels in total for first and higher lactations, respectively, btl_l = fixed effect of birth type at lambing (l = 1-3; Triplets, Quadruplets and Quintuplets were merged), bte_m = fixed effect of bith type of the ewe (m = 1-3, Triplets, Quadruplets and Quintuplets were merged), $still_n$ = fixed effect of stillbirth (n = 1-2 with 1 = no and 2 = at least 1 lamb stillborn), int_o = fixed effect of lambing interval to next lactation to account for stage of parity (o = 1-4 with 1 = int < 0.95 years, 2 = 0.95 years <= int <= 1.01 years, 3 = int > 1.01

years, 4 = unknown lambing interval), $lact_p$ = fixed effect of lactation number (p = 1-7), b1 = partial regression coefficient, age = age at first lambing (first lactations) or age at lambing within lactation number (higher lactations), and $\varepsilon_{ijklmnop(q)}$ = random residual. For milk yield in higher lactations the interaction effect between birth type at lambing and birth type of ewe was found to be significant and therefore included in the model.

For the estimation of (co)variance components by means of trivariate analyses and VCE 4 (Groeneveld, 1998), the same models including the random animal effect and the permanent environmental effect for higher lactations were applied.

Results

In Table 2 means and standard deviations are given for milk production traits. The average standardized 240-day milk yield was 374±106 kg with 5.62±0.65 % fat and 4.91±0.39 % protein in first and 496±125 kg with 5.69±0.60 % fat and 4.89±0.40 % in higher lactations, respectively.

Table 2: Means and standard deviations (S.D.) for standardized 240-d milk production traits

Trait	Mean ± S.D. (first lactation)	Mean ± S.D. (higher lactations)
Milk yield (kg)	374±106	496±125
Fat yield (kg)	21.0±6.3	28.1±7.3
Protein yield (kg)	18.35±5.50	24.24±6.5
Fat %	5.62±0.65	5.69±0.60
Protein %	4.91±0.39	4.89±0.40

In Table 3, levels of significance and coefficients of determination (R^2) for models [1] and [2] are provided. Values for R^2 ranged from 0.38 (fat-% in higher lactations) to 0.69 (milk and fat yield in first lactations). Herd*Year*Season highly significantly influenced all milk production traits in first and higher lactations.

Table 3: Coefficient of determination (R^2) and levels of significance[1] for milk, fat and protein yield, fat and protein percentage and models [1] and [2]

	Model	Milk kg	Fat kg	Protein kg	Fat-%	Protein-%
R^2	[1]	0.69	0.69	0.72	0.56	0.62
	[2]	0.60	0.59	0.65	0.38	0.51
Herd*Year*Season	[1]	***	***	***	***	***
	[2]	***	***	***	***	***
Birth type ewe	[1]	ns	ns	ns	ns	ns
	[2]	+	ns	ns	ns	**
Birth type at lambing	[1]	*	ns	*	*	ns
	[2]	***	*	***	**	**
Birth type ewe*Birth type at lambing	[2]	*	-	-	-	-
Stillbirth	[1]	+	ns	ns	ns	ns
	[2]	*	ns	*	*	ns
Lambing interval		ns	ns	ns	ns	ns
[1]		***	***	***	+	*
	[2]					
Lactation number		***	***	***	ns	*
[2]						
Age at first lambing	[1]	***	***	***	ns	ns
Age at lambing(lact. no)	[2]	***	***	***	+	*

*[1] *** P<0.001; ** P<0.01; * P<0.05; + P<0.10*

S4.5

Birth type at lambing significantly affected all production traits in higher lactations, and milk yield, fat yield and fat percentage in first lactations. Yield traits and protein percentage increased with higher number of lambs whereas fat percentage slightly decreased (Table 4). The birth type of the ewe showed a less significant effect on milk production traits. For higher lactations, the interaction effect birth type at lambing*birth type of ewe was found to have a significant influence on milk yield. Highest milk yields could be observed for ewes born as singles having multiples (Table 5). Ewes born as singles had significantly higher protein percentages in higher lactations and were in tendency superior to ewes born as multiples for other production traits (data not shown). As birth type of ewe and birth type at lambing may be confounded, a correlation analysis between these traits was performed. The correlation was significant, but small ($r = 0.09$). To further validate the evaluation, additional analyses with only one of both effects in the model were performed. The results for the respective effect were similar to the full model.

Table 4: LS-Means and residual standard deviation (RSD) for milk, fat and protein yield and fat and protein percentage for birth types at lambing and models [1] and [2]

Birth type at lambing		Milk kg	Fat kg	Protein kg	Fat-%	Protein-%
Singles	[1]	385	21.7	18.8	5.67	4.88
	[2]	536	31.1	26.3	5.85	4.89
Twins	[1]	396	22.1	19.3	5.59	4.88
	[2]	554	31.8	27.1	5.82	4.92
≥Triples	[1]	397	22.2	19.5	5.60	4.91
	[2]	563	31.7	27.4	5.76	4.95
RSD	[1]	67.0	3.9	3.3	0.49	0.27
	[2]	84.0	5.0	4.1	0.50	0.30

Table 5: LS-Means for milk yield for birth types at lambing*birth type of ewe and model [2]

Birth type at lambing	Birth type ewe	Milk kg
Single	Single	530
	Twin	544
	≥Triple	534
Twins	Single	557
	Twin	552
	≥Triple	552
≥Triples	Single	582
	Twin	557
	≥Triple	549

Stillbirth did not have a significant impact on milk production traits in first lactations. However, results were similar to higher lactations (Table 6): in lactations following lambings with no stillbirth, higher yields for milk, fat and protein were obtained while fat percentage was lower. Lambing interval to the next lactation showed no effect on production traits in first lactations but was highly significant for yield traits in higher lactations. Ewes with average and high lambing intervals achieved higher yields than ewes with low or unknown lambing intervals (data not shown).

Table 6: LS-Means for milk, fat and protein yield and fat and protein percentage for stillbirth and model [2]

Stillbirth	Milk kg	Fat kg	Protein kg	Fat-%	Protein-%
no	557	31.7	27.3	5.74	4.94
yes	545	31.4	26.5	5.80	4.91

Lactation number had a significant effect on all traits except fat percentage in higher lactations. Yield traits increased with lactation number up to the 6th lactation but decreased for highest lactation numbers (Table 7). In first lactations, an increase of the age at first lambing of one month resulted in +3.37 kg milk, +0.20 kg fat and +0.18 kg protein. In higher lactations, a small positive effect of higher lambing age within lactation number was only observed for milk and protein yield (+0.57 kg and +0.03 kg per month, respectively). From the third lactation upwards, a higher lambing age contributed to reduced milk performance (e.g., 1.06-4.60 kg milk per month).

Table 7: LS-Means for milk, fat and protein yield and fat and protein percentage for lactation number and model [2]

Lactation Number	Milk kg	Fat kg	Protein kg	Fat-%	Protein-%
2	498	27.3	24.0	5.48	4.84
3	513	28.4	24.6	5.58	4.81
4	534	30.5	25.7	5.74	4.83
5	607	34.4	29.1	5.78	4.82
6	613	37.0	32.2	6.06	5.49
≥7	541	31.6	25.8	5.98	4.72

Heritability estimates for 240-day standard lactation were moderate to high and ranged from $h^2 = 0.24$ to $h^2 = 0.63$ (Table 8). The estimated additive genetic correlations between yield traits were highly positive and ranged from $r_g = 0.62$ to $r_g = 0.94$. Genetic correlations between milk yield and milk contents were generally negative. Repeatability estimates for higher lactations were between 0.57, 0.52 and 0.56 for milk, fat and protein yield and 0.56 and 0.61 for fat and protein percentage, respectively.

Table 8: Estimates of heritabilities (diagonal) and genetic correlations (above diagonal) for milk, fat and protein yield and fat and protein percentage in first (1st)and higher lactations

	Milk kg (1st)	Fat kg (1st)	Protein kg (1st)	Fat-% (1st)	Protein -% (1st)	Milk kg	Fat kg	Protein kg	Fat-%	Protein -%
Milk kg (1st)	0.36	0.87	0.91	-0.51	-0.23	0.86	0.67	0.79	-0.31	-0.21
Fat kg (1st)		0.24	0.94	-0.07	0.12	0.70	0.78	0.83	0.06	0.67
Protein kg (1st)			0.36	-0.28	0.18	0.69	0.62	0.83	-0.18	0.62
Fat-% (1st)				0.42	0.61	-0.44	0.08	-0.12	0.87	0.68
Protein-% (1st)					0.63	-0.42	-0.12	-0.03	0.44	0.85
Milk kg						0.27	0.81	0.87	-0.28	-0.34
Fat kg							0.26	0.88	0.32	0.07
Protein kg								0.26	0.04	0.16
Fat-%									0.45	0.66
Protein-%										0.53

Discussion

Herd*Year*Season significantly affected all milk production traits as reported in basically all studies dealing with environmental effects in milk producing livestock. Additionally, age at first lambing in first lactations contributed significantly to the variation of yield traits while lactation number and age within lactation number in higher lactations also showed an effect on protein content. In first lactations, the positive effect of age on yield traits most likely reflects increased nutrient requirements for growth. The same may be applied on second lactations. However, the contribution of increasing age within higher lactation numbers to reduced milk performance is probably due to an accelerated aging process. Lambing interval to the next lactation was included to account for different stage of parity and thus nutrient requirements for fetal growth. The East Friesian milk sheep is a seasonal breed with the main lambing season in January and February. Hence ewes should be in roughly equal stages of parity. However, lambings also occur in most other months, so major differences may be observed for single ewes und thus justify the effect's inclusion in parameter estimation models.

As a considerable part of the income in dairy sheep derives from lamb meat (Carta and Ugarte, 2003), a high selection pressure is also on fertility traits. Due to higher lamb losses in triples upwards, especially in alpine regions, twins are the desired birth type in most breeds. However, in dairy sheep ewes are usually at least partly housed, perinatal observation is easier and lambs are weaned earlier, hence higher litter sizes are also acceptable. The East Friesian milk sheep thus has the highest percentage of multiples in Austrian sheep (Fuerst-Waltl, 2005, unpublished results). The investigation of effects of birth type on milk yield is therefore of great interest. Results for birth type at lambing were in accordance with many other studies in Laxta and Churra sheep breeds (e.g. Gabiña et al., 1993; Carriedo et al., 1995; Fuertes et al., 1998; Othmane et al., 2002) but also dairy goats (Rabasco et al., 1993). The authors reported an increase of milk yield with higher litter size while milk contents decreased or were not affected. In a study dealing with East Friesian milk sheep, litter size only significantly affected milk and protein yield while no significant effect was found for fat yield and milk contents (Horstick, 2001). Higher milk yield partly reflects the stimulus of lambs during the suckling period. For this analysis no information about duration of suckling period was available. However, in another study in Alpine goats (Browning et al., 1995) evidence was found that not only suckling stimulus is responsible for the effect of litter size. Milk yield increased with litter size although kids were separated from goats immediately after birth. Thus the hormonal status, modified by multiples, may also play a major role (Gall, 2001). Ewes born as multiples themselves seemed to be inferior to single born ewes with respect to milk production. A reason therefore may be found in smaller birth weights in multiples and thus delayed growth compared to singles. Losses of lambs during and shortly after birth contributed to reduced milk and protein yield and fat percentage in higher lactations. Beside the already mentioned suckling stimulus, decreased performance may also be related to problems associated with dystocia.

Estimated heritabilities for yield traits and milk contents are moderate to high and in accordance to earlier published values e.g. for 220-day-lactational records in Lacaune (Barillet and Boichard, 1987). In the East Friesian milk sheep genetic parameters were estimated for test-day records only (Hamann et al., 2004) and ranged from 0.09 for fat percentage to 0.20 for protein percentage. Apart from reduced heritabilities due to the use of test-day records, the authors argue that low heritabilities were caused by field data with rather varying environmental conditions. Estimated genetic correlations between yield traits were highly positive as reported in other studies (e.g. Barillet and Boichard, 1987; Hamann et al., 2004). Negative genetic correlations between milk yield and milk contents are in accordance to the findings of Barillet and Boichard (1987) in Lacaune and Othmane et al. (2002) in Churra while Hamann et al. (2004) reported a positive genetic correlation to fat percentage in East Friesian milk sheep.

Heritabilities, genetic correlations and repeatabilities found in this study indicate that sufficient breeding progress may be achieved by using a lactational model. Litter size could be included in a multitrait model in future works. Additionally, somatic cell score and its relationship to other traits should also be analysed.

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