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## Genetic parameters of production and reproductive traits in on a farm tested Danish Large White and Landrace swine in Greece

### Summary

Production and reproductive traits in Danish Landrace (LD) and Large White (LW) swine were analysed by restricted maximum likelihood methods to obtain heritabilities as well as genetic and phenotypic correlations. Production traits were: age, backfat thickness (BT), muscle depth (MD) and the ratio BT/MD, adjusted to standard bodyweight of 85 kg. Reproduction traits were: number of pigs born (NB) and number of pigs weaned (NW) per sow and parity. Heritabilities for age, BT, MD and BT/MD were 0.60, 0.44, 0.51 and 0.42 for LD and 0.36, 0.44, 0.37 and 0.45 for LW, respectively. Genetic correlations between age and BT were -0.22 in LD and -0.44 in LW. The genetic correlation between age and MD was close to zero in both breeds. Genetic correlation between BT and MD were -0.36 and -0.25 in LD and LW, respectively. Heritabilities for NB were 0.25 in LD and 0.13 in LW while heritabilities for NW were close to zero in both breeds. Genetic correlation between NB and NW was 0.46 and 0.70 in LD and LW, respectively.

Key Words: heritability, genetic correlations, phenotypic correlations, fattening, reproductive traits, swine, Greece

### Zusammenfassung

Titel der Arbeit: **Genetische Parameter von Produktions- und Reproduktionsmerkmalen bei Schweinen der Rassen Danish Large White und Landrasse untersucht in einem Betrieb in Griechenland**
Heritabilitäten sowie phänotypische und genetische Korrelationen einiger Produktions- und Reproduktionsmerkmale bei Schweinen der Rassen Danish Large White (LW) und Landrasse (LD) wurden mit Restricted Maximum Likelihood Methoden geschätzt. Folgende Produktionsmerkmale wurden untersucht: Alter, Rückenspeckdicke (BT), Muskeldicke (MD) und das BT/MD Verhältnis, korrigiert auf ein konstantes Körpergewicht von 85 kg. Folgende Reproduktionsmerkmale wurden untersucht: Wurfgrösse bei der Geburt (NB) und beim Absetzen (NW). Bei den LD-Schweinen wurden Heritabilitätswerte von 0,60 für das Alter, 0,44 für die BT, 0,51 für die MD und 0,42 für das BT/MD Verhältnis geschätzt. Die entsprechenden Werte bei den LW-Schweinen waren 0,36 für das Alter, 0,44 für die BT, 0,37 für die MD und 0,45 für das BT/MD Verhältnis. Die geschätzte genetische Korrelation zwischen dem Alter und der BT betrug –0,22 bei den LD- und –0,44 bei den LW-Schweinen, während die entsprechende Korrelation zwischen dem Alter und der MD in beiden Rassen nahe Null lag. Die geschätzte genetische Korrelation zwischen der BT und der MD betrug –0,36 bei den LD- und –0,25 bei den LW-Schweinen. Die Heritabilitätswerte für die NB betrug 0,25 bei den LD- und 0,13 bei den LW-Schweinen, während die entsprechenden Werte für die NW bei beiden Rassen gleich Null waren. Zwischen der NB und der NW wurde eine genetische Korrelation von 0,46 bei den LD- und von 0,70 bei den LW-Schweinen ermittelt.

Schlüsselwörter: Heritabilität, genetische Korrelation, phänotypische Korrelation, Produktionsmerkmale, Reproduktionsmerkmale, Schweine, Griechenland

### Introduction

The need of the development of genetic improvement programs for swine in Greece has been widely emphasized by the Ministry of Agriculture early in the 90s in an attempt to improve the efficiency of pig industry. This attempt has been supported by

the Agricultural University of Athens with a number of studies the aim of which was to identify the production and reproductive traits with major economic impact, i.e. to define the breeding objective (LIANOS, 1986; PAPAVASILIOU et al., 1991). In those studies, the economically most important traits identified were: the number of pigs weaned per sow per year, the feed conversion ratio, the daily gain and the proportion of commercial meat cuts. Later on, ROGDAKIS et al. (1994) defined a breeding objective for fattening pigs which comprised the traits: proportion of commercial meat cuts, feed conversion ratio, and age at slaughter. Selection was based on an index including two selection criteria: (i) the weight corrected ratio between back fat thickness and depth of muscle *M. longisimus dorsi* and (ii) the weight corrected age of pigs at measurement. In those studies, however, estimates of genetic parameters of various traits were taken from the literature. Literature estimates cannot necessarily reflect the genetic potential of the breeding stock used, especially when the following are considered: first, the breeding stock is developed by a limited number of breeding animals imported in the farm in 1989 and thus could be subjected to the founder effect. Second, the breeding stock is kept under different production conditions (climate, nutrition regime etc) than in the countries of origin, e.g. Denmark. Reliable and specific population parameter estimates of heritabilities and genetic correlations of production and reproductive traits are essential in predicting breeding values accurately as well as in developing efficient breeding schemes. The method of restricted maximum likelihood (REML) applied to an individual animal model has been the widely used method for estimating variance components in animal populations, mainly because of its ability to account for selection and non-random mating when the complete variance covariance matrix of animal effects is known and used (KENNEDY et al., 1988; IM et al. 1989). The aim of this study is to estimate the genetic parameters for some production and reproductive traits in on a farm tested Landrace and Large White swine using single and multiple trait animal models and to propose efficient selection strategies.

## Material and Methods

### Data

Data regarding production traits were obtained between December 1992 and December 1996 in a breeding unit near Korinth comprising Large White (LW) and Landrace (LD) swine. During this period a total of 1332 LW and 1244 LD boars and gilts were measured for production traits using an ultrasound equipment (ALOKA SSD-500). Pigs were measured on discontinuous time lags. Pigs were housed in pens of about 10 animals and fed ad libitum during the whole test period. The test started at 140 days of age and ended at the age of 180 days. Pigs were weighed and backfat thickness and *M. longisimus dorsi* depth was measured on three points as described by ROGDAKIS et al. (1994). The traits studied were: age on measurement, average backfat thickness (BT: mean of three measurements), average muscle depth (MD: mean of three measurements) and BT/MD ratio. Age, BT, MD and BT/MD were adjusted to 85 kg liveweight using linear regression coefficients obtained by solutions of least squares equations (Table 2). Furthermore, reproductive traits for sows of both

breeds were recorded from August 1989 to October 1995. These traits were: number of pigs born (NB) and number of pigs weaned (NW) per sow and parity. Repeated records per sow were available for both reproductive traits allowing the estimation of repeatabilities. The structure of the data sets analysed is shown in Table 1.

Table 1
Data structure of the production and reproductive traits (Datenstruktur für die Produktions- und Reproduktionsmerkmale)

|  | Landrace | Large White |
|---|---|---|
| Production traits |  |  |
| Number of pigs tested |  |  |
| males | 693 | 631 |
| females | 636 | 609 |
| total | 1329 | 1240 |
| Number of year x sex x seasons effects | 48 | 48 |
| Reproductive traits |  |  |
| Number of records | 1540 | 367 |
| Number of sows | 360 | 115 |
| Average number of records per sow | 4.3 | 3.2 |
| Number of year x seasons effects | 28 | 28 |

Table 2
Regression coefficients and standard errors (in parenthesis) of production traits corrected to 85 kg liveweight; all coefficients are statistically different from zero p ≤ 0.001 (Regressionskoeffizienten und Standardfehler (in Klammern) zur Korrektur der Produktionsmerkmale auf ein konstantes Körpergewicht von 85 kg; alle Koeffizienten sind statistisch signifikant p ≤ 0.001)

| Trait | Landrace Males | Females | Large White Males | Females |
|---|---|---|---|---|
| Age (days) | 1.0699 (0.0257) | 1.1215 (0.0258) | 1.0891 (0.0261) | 1.1135 (0.0268) |
| BT (cm) | 0.0097 (0.00037) | 0.0107 (0.00037) | 0.0090 (0.00038) | 0.0107 (0.00039) |
| MD (cm) | 0.0185 (0.00064) | 0.0205 (0.00064) | 0.0220 (0.00065) | 0.0252 (0.00067) |
| BT/MD | 0.00129 (0.00009) | 0.00143 (0.00009) | 0.00098 (0.00009) | 0.00120 (0.00009) |

BT: Backfat thickness; MD: Muscle depth

## Univariate analysis

Estimates of variance components for all traits studied were obtained using single-trait REML fitting an animal model and using a derivative-free algorithm. The model fitted for age, BT, MD, BT/MD, NB and NW in matrix notation was:

$$y = X\beta + Zu + e$$

where $y$ is the vector of records on pigs or sows, $\beta$ is the vector of fixed effects, $u$ is a vector with elements the additive direct effects and $e$ the vector of residuals. Furthermore, $X$ and $Z$ are the incidence matrices relating records to appropriate fixed and random effects, respectively. It is assumed that $E(y)=X\beta$, $E[u]=E[e]=0$ and $Cov(u,e)=0$.

The assumed variance - covariance matrix of the random effects was as follows:

$$Var(y) = ZAZ'\sigma_a^2 + I\sigma_e^2,$$

where $A$ is the numerator relationship matrix between animals and $I$ an identity matrix of the order of the number of records. Furthermore, $\sigma_a^2$ and $\sigma_e^2$ are the additive gene-

tic and the residual variance, respectively. Fixed effects fitted for fattening traits (age, BT, D and BT/MD) included year, season and sex. The importance of the fixed effects was identified by preliminary least squares analysis of variance of the traits studied. No breed by sex interaction was found to be important. Fixed effects for reproductive traits (NB and NW) included year, season and the parity number as a linear covariable. All pedigree information available was included in the analysis in order to minimize bias due to selection and to increase the accuracy of estimation. The calculations were carried out using the DFREML programs (MEYER, 1993) employing the Simplex procedure to locate the maximum of the log likelihood (L) as described by MEYER (1989). Convergence was considered to have been reached when the variance of function values was less than $10^{-8}$. In all the analyses, a restart was performed in an attempt to ensure that a global maximum had been reached. Repeatability estimates were obtained by fitting an animal model with correlated residuals (MEYER, 1993).

## Bivariate analyses

Bivariate REML analyses were carried out to estimate genetic and phenotypic correlations between production and reproductive traits. Fixed effects for traits considered were as in univariate analyses. The model for the bivariate analysis was as that of univariate with the variance-covariance matrix for y vector of observations defined to include genetic and residual covariances among the traits considered.

## Results

### Breed and sex differences

Means for production traits for the two breeds and for sexes within breeds are presented in Table 3. Males grew faster than females and showed smaller backfat thickness and muscle depths within the two breeds. Furthermore, LD grew faster than LW, were fatter and showed lower muscle depths. As a result, BT/MD ratio was

Table 3
Least squares means, standard errors of means (in parenthesis) and standard deviations (SD) of the production traits for the two breeds (LS-Mittelwerte, Standardfehler (in Klammern) und Standard-abweichungen (SD) der Produktionsmerkmale bei beiden Rassen)

|  | Age (days) | | BT (cm) | | MD (cm) | | BT/MD | |
|---|---|---|---|---|---|---|---|---|
|  | $\hat{\mu}$ | SD | $\hat{\mu}$ | SD | $\hat{\mu}$ | SD | $\hat{\mu}$ | SD |
| Landrace (total) | 158.9* (0.9) | 19.1 | 1.01* (0.01) | 0.26 | 4.44* (0.02) | 0.45 | 0.229* (0.003) | 0.06 |
| Males | 156.6[a] (0.9) | 18.0 | 0.97[a] (0.01) | 0.21 | 4.36[a] (0.02) | 0.44 | 0.224[a] (0.003) | 0.05 |
| Females | 161.3[b] (1.0) | 20.1 | 1.05[b] (0.01) | 0.30 | 4.53[b] (0.02) | 0.44 | 0.233[b] (0.004) | 0.07 |
| Large White (total) | 160.7* (0.9) | 20.1 | 0.98* (0.01) | 0.24 | 4.79* (0.02) | 0.46 | 0.206* (0.003) | 0.05 |
| Males | 159.5[c] (1.0) | 20.3 | 0.91[c] (0.01) | 0.20 | 4.67[c] (0.02) | 0.45 | 0.197[c] (0.003) | 0.05 |
| Females | 161.9[b] (1.0) | 20.0 | 1.05[b] (0.01) | 0.25 | 4.91[d] (0.02) | 0.44 | 0.215[d] (0.004) | 0.04 |

Means with different letters as superscripts are statistically significantly different (p < 0.05)
Breed means are statistically significantly different (p ≤ 0.005)

Table 4
Least squares means, standard errors of means (in parenthesis) and standard deviations (SD) of the reproductive traits for the two breeds (LS-Mittelwerte, Standardfehler (in Klammern) und Standardabweichungen (SD) der Reproduktionsmerkmale bei beiden Rassen)

| | Landrace | | Large White | |
|---|---|---|---|---|
| Trait | $\hat{\mu}$ | SD | $\hat{\mu}$ | SD |
| Number of pigs born | 10.942[a] (0.073) | 2.82 | 11.525[b] (0.152) | 2.92 |
| Number of pigs weaned | 9.363[a] (0.048) | 2.18 | 9.200[a] (0.10) | 2.01 |
| Average age of sows (years) | 2.24[a] (0.02) | 0.96 | 2.20[a] (0.06) | 1.06 |

Means with different letters in superscripts are statistically significantly different (p ≤ .005)

higher in LD than in LW. Means for the reproductive traits are shown in Table 4. LW had bigger litters at birth than LD. No breed difference for litter size at weaning was found. Average age of sows between breeds was not statistically different (p ≤ 0.005). Standard deviations for the production traits age and MD were comparable along breeds and sexes resulting in coefficients of variation in the range of 10-13%. On the contrary, standard deviation of BT was higher resulting in higher coefficients of variation (20-30%) for this trait. The coefficients of variation of BT/MD followed therefore the same pattern. Standard deviations for the reproductive traits were comparable across the two breeds. The resulting coefficients of variation for these traits were in the range of 23-25%.

## Heritabilities

Variance components and heritabilities from univariate analysis for the production traits are shown in Table 5. Age at 85 kg was found more heritable in LD (0.60) than in LW (0.36). Both breeds showed the same heritability for backfat thickness (0.44). On the contrary, muscle depth was found more heritable in LD (0.51) than in LW (0.37). Heritabilities for BT/MD ratio were almost the same in both breeds. Variance components, heritabilities and repeatabilities for the reproductive traits are presented in Table 6. Number of pigs born was found more heritable than number of pigs weaned (NW) in both breeds. Heritabilitiy of NB in LW sows was lower than in LD. Very small estimates (0.03) for heritability were obtained for NW in both breeds. Repeatabilities followed the pattern of heritabilities with estimates for NB and NW of 0.30 and 0.10 in LD and of 0.10 and 0.05, in LW, respectively.

Table 5
Estimates of variance components and heritabilities for production traits in Landrace (LD) and Large White (LW) pigs (Varianzkomponenten- und Heritabilitätsschätzung für die Produktionsmerkmale bei Landrasse und den Large White)

| | $\sigma_a^2$ | | $\sigma_e^2$ | | $\sigma_P^2$ | | $h_a^2$ | |
|---|---|---|---|---|---|---|---|---|
| | LD | LW | LD | LW | LD | LW | LD | LW |
| AGE | 119.0 | 84.5 | 79.7 | 152.8 | 198.7 | 237.5 | 0.60 ± 0.05 | 0.36 ± 0.06 |
| BT | 0.021 | 0.018 | 0.027 | 0.023 | 0.048 | 0.041 | 0.44 ± 0.06 | 0.44 ± 0.07 |
| MD | 0.076 | 0.049 | 0.073 | 0.084 | 0.149 | 0.132 | 0.51 ± 0.06 | 0.37 ± 0.07 |
| BT/MD | 0.0013 | 0.0010 | 0.0018 | 0.0013 | 0.0030 | 0.0023 | 0.42 ± 0.06 | 0.45 ± 0.07 |

$\sigma_a^2$ : additive genetic variance; $\sigma_e^2$ : error variance; $\sigma_P^2$ : phenotypic variance;: $h_a^2$ heritability
BT: Backfat thickness; MD: Muscle depth

Table 6

Estimates of variance components and heritabilities for reproductive traits in Landrace (LD) and Large White (LW) sows (Varianzkomponenten- und Heritabilitätsschätzung für die Reproduktionsmerkmale bei den Landrasse- und Large White-Sauen)

| Trait | NB | | NW | |
|---|---|---|---|---|
| | LD | LW | LD | LW |
| $\sigma_a^2$ | 1.920 | 1.072 | 0.098 | 0.053 |
| $\sigma_{pe}^2$ | 0.422 | 0.912 | 0.246 | 0.108 |
| $\sigma_e^2$ | 5.727 | 7.385 | 2.810 | 3.299 |
| $\sigma_P^2$ | 7.648 | 8.457 | 3.154 | 3.352 |
| $h_a^2$ | $0.25 \pm 0.03$ | $0.13 \pm 0.06$ | $0.03 \pm 0.02$ | $0.02 \pm 0.05$ |
| r | 0.30 | 0.24 | 0.10 | 0.05 |

$\sigma_a^2$ : additive genetic variance; $\sigma_e^2$ : error variance; $\sigma_{pe}^2$ : permanent environmental variance; $\sigma_P^2$ : phenotypic variance; $h_a^2$ : heritability, r: repeatability; NB: number of pigs born per litter; NW: number of pigs weaned per litter

Table 7

Genetic (above diagonal) and phenotypic (below diagonal) correlations of the various production and reproductive traits in Landrace (LD) and Large White (LW) pigs; numbers on the diagonal are average heritability estimates from the bivariate analyses (Genetische (oberhalb der Diagonale) und phänotypische (unterhalb der Diagonale) Korrelationen der Produktions- und Reproduktionsmerkmale bei Landrasse- und Large White-Schweinen; Werte auf der Diagonale sind durchschnittliche Heritabilitätsschätzungen aus der Bivariatanalyse)

| Trait | 1 | | 2 | | 3 | | 4 | |
|---|---|---|---|---|---|---|---|---|
| | LD | LW | LD | LW | LD | LW | LD | LW |
| Production | | | | | | | | |
| 1. AGE | (0.54) | (0.39) | -0.22 ±0.08 | -0.44 ±0.08 | -0.03 ±0.06 | -0.05 ±0.09 | -0.16 ±0.09 | -0.40 ±0.08 |
| 2. BT | -0.10 | -0.19 | (0.40) | (0.48) | -0.36 ±0.07 | -0.25 ±0.08 | | |
| 3. MD | -0.02 | -0.02 | -0.17 | -0.12 | (0.55) | (0.40) | | |
| 4. BT/MD | -0.08 | -0.18 | | | | | (0.40) | (0.48) |
| Reproductive | | | | | | | | |
| 1. NB | (0.27) | (0.15) | 0.46 ±0.11 | 0.70 ±0.35 | | | | |
| 2. NW | 0.89 | 0.67 | (0.03) | (0) | | | | |

BT: Backfat thickness; MD: Muscle depth; NB: number of pigs born per litter; NW: number of pigs weaned per litter

## Correlations

Table 7 summarizes the phenotypic and genetic correlations between the production and reproductive traits. Correlations between BT and MD with BT/MD are not presented, because the single traits are autocorrelated to their ratio. Age at 85 kg was found negatively genetically correlated to all other production traits. This negative correlation was more evident in LW than in LD for the traits age - BT and age - BT/MD. Genetic correlation between age and MD was found negative and close to zero. Backfat thickness was found genetically negatively correlated to MD in both breeds. This correlation was higher in LD than in LW. Phenotypic correlations between traits were generally smaller than the respective genetic correlations in both breeds. A high genetic correlation was obtained between NB and NW in both breeds.

On the contrary to production traits, phenotypic correlations for reproductive traits were higher than the genetic correlations.

## Discussion

### Breed and sex differences

The present results show a significant breed and sex effect on production traits. Landrace pigs grew faster, were fatter and showed smaller muscle depths than LW. The result about the age is not in agreement with other literature references where LW are generally reported to grow faster than Landrace pigs (GU et al., 1989, FERRAZ and JOHNSON, 1993; BIDANEL et al., 1994; DUCOS and BIDANEL, 1996). Furthermore, LD pigs are reported to be leaner (GU et al., 1989) or fatter at standardized liveweight (FERRAZ and JOHNSON, 1993; BIDANEL and DUCOS, 1996; DUCOS and BIDANEL, 1996) as in the present study. Since the animals of the present study were kept under the same environmental conditions the observed differences may reflect strain differences of the breeds used. Comparison of the two breeds for the reproductive performance showed a higher number of pigs born in LW sows than in LD. No difference between the two breeds for number of pigs weaned was observed. Bigger litter sizes at birth for LW sows are also reported in the literature (FERRAZ and JOHNSON, 1993; DUCOS and BIDANEL, 1996). On the contrary, ROEHE and KENNEDY (1995) found no difference for litter size at birth and at weaning between Yorkshire and LD sows.

### Heritabilities

Heritabilities for the production traits were high, ranging from 0.37 to 0.60. Reported heritabilities for these traits are in the range of 0.21 to 0.59 for LD and 0.21 to 0.53 for LW (KENNEDY et al., 1985; SAVOIE and MINVIELLE, 1988; GU et al., 1989; KAPLON et al., 1991; HOVENIER et al., 1992; LO et al., 1992; BRYNER et al., 1992; BIDANEL et al., 1994; LI and KENNEDY, 1994; DUCOS and BIDANEL, 1996; BRANDT and TAEUBERT, 1998). Selection on production traits has proved to be efficient in both breeds. HUDSON and KENNEDY (1985) and KENNEDY et al. (1986) reported a genetic change of age to 90 kg in Canadian populations in the range from -0.25 to -0.44 days per year. FERRAZ and JOHNSON (1993) estimated a genetic trend of -0.063 mm per year for backfat thickness. KENNEDY et al. (1996) found that the annual genetic trends over the years 1976 to 1993 for 4 breeds (LD, LW, Duroc and Hampshire) and 4 regions in Canada were -1.44% and -0.36% for the mean in fat depth and in age at 100 kg, respectively.

Heritability of NB was found higher in LD than in LW sows. The value estimated in LD (0.25) is out of the range (0.02 to 0.18) reported from KAPLON et al. (1991), FERRAZ and JOHNSON (1993), SEE et al. (1993), ROEHE and KENNEDY (1995) and from DUCOS and BIDANEL (1996). On the contrary, values close to zero (0.03) were obtained for the heritabilities of NW in both breeds. These values are also out of the range (0.06 to 0.08) which is reported in the literature for heritability of NW (KAPLON et al., 1991; ROEHE and KENNEDY, 1995). This result indicates that selection for reproductive performance should concentrate on NB. Selection on this

trait has also proved to be efficient in the literature. FERRAZ and JOHNSON (1993) estimated a genetic trend of 0.012 pigs per year for litter size at birth.

## Correlations

Genetic correlations between some production traits were found negative in both breeds. The highest values were obtained between age and BT in LW (-0.44) and between BT and MD in LD (-0.36). Negative genetic correlations between age and BT are reported widely in the literature in the magnitude of -0.05 to -0.54 in both breeds (JEFFRIES and PETERSON, 1982; KENNEDY et al., 1985; SAVOIE and MINVIELLE, 1988; KAPLON et al., 1991; HOFER et al., 1992; LO et al., 1992; BIDANEL et al., 1994; LI and KENNEDY, 1994). Negative genetic correlations between BT and MD are found also by LO et al. (1992). Furthermore, backfat thickness is reported to be highly correlated (-0.52 to -0.99) to premium cuts in proportion to carcass weight (SCHWOERER et al., 1980; BLUM et al., 1984; BERESKIN and STEELE, 1988). Also muscle area of *longissimus dorsi* is reported to be correlated (0.80) with commercial meat cuts (BERESKIN and STEELE, 1988). High correlations of backfat thickness and (or) of the *M. longissimus dorsi* area with commercial meat cuts imply their potential use as selection criteria for genetically improving commercial meat cuts. The latter is a trait with major economic impact for the Greek pig industry (PAPAVASILIOU et al., 1991).

Genetic correlations between the reproductive traits NB and NW were found high (0.46 to 0.70) in this study. Since heritability of NW was close to zero but that of NB was relatively high, selection on NB will result in an increase of the NW as a correlated response. Number of pigs weaned is a trait with great commercial importance for Greek pig industry (PAPAVASILIOU et al., 1991).

High genetic correlations between those traits are also reported in the literature. ROEHE and KENNEDY (1995) found a genetic correlation between NB and NW of 0.65 in LW and of 0.82 in LD sows. KAPLON et al. (1991) reported genetic and phenotypic correlation for litter size at birth and litter size at 21 days of 0.91 and 0.88, respectively.

The estimation of reliable genetic correlations between production and reproductive traits was not feasible in the present study due to lack of adequate number of records for both production and reproductive traits. However, the analysis of a pooled data set (of both breeds) obtained by limited number of records for both production and reproductive traits showed very small (0.05 to 0.20) and divergent (favorable or unfavorable) genetic correlations between production and reproductive traits. The hypothesis of no genetic correlation between production and reproductive traits has been repeatedly supported in the literature (HALEY et al., 1988; RYDHMER et al., 1995; DUCOS and BIDANEL, 1996). There is some evidence, however, that traits like ovulation rate, number of embryos and embryo survival at 30 days of gestation be low but favorably correlated with litter weight at birth, with average daily gain between 30 and 85 kg and average backfat thickness (BIDANEL et al., 1996). HALEY and LEE (1992) have also reported high and positive genetic correlation between ovulation and litter weight at birth. The use of such traits as selection criteria, however, cannot be always envisaged under farm conditions. On the contrary, weight traits like

litter weight at birth or at weaning could easily and at low costs be measured. In a divergent selection experiment for lean growth capacity in a population of LW pigs, KERR and CAMERON (1996) found that the genetic correlations of litter weight at birth and at weaning with daily food intake were positive and relatively high (0.42 to 0.50). The corresponding correlations with backfat thickness were, however, not significantly different from zero.

Selection strategy

The high heritabilities obtained for the production traits in the present study, ensured that the imported breeding stock which was used for the establishment of the herd originated from genetically diverse animals. Therefore, selection for leaner, fast growing pigs is expected to be efficient in both breeds. Besides the demand of the market for leaner pork at low prices, increasing attention is paid by both producers and consumers to meat quality aspects, i.e. meat color, water binding capacity, pH and intramuscular fat content, as well. Moderate to high heritabilities for meat quality traits are often reported in the literature (CAMERON, 1990; LO et al., 1992; HOVENIER et al., 1992) so selection on those traits is expected to be efficient. Alternatively, improved pork meat quality could be attained if those traits were correlated to other, easy to measure, traits. HOVENIER et al. (1992) reported favorable genetic correlations between liveweight gain and meat quality traits and unfavorable genetic correlations between meat quality traits and backfat thickness and lean meat content. Slightly unfavorable genetic correlations between pH and age or between pH and BT are also reported in the literature (JOHANSSON, 1987; BIDANEL et al., 1994). Furthermore, CAMERON (1990) and LO et al. (1992) have found unfavorable genetic correlations between muscle depth and (or) backfat thickness with intramuscular fat content and water holding capacity. Eventually, selection for faster growing and leaner pigs is expected to lower meat quality resulting in pork meat less juicy, tender and with less flavor. Selection for more efficient pigs should therefore include aspects of meat quality as well. This implies the need of the inclusion of one, at least, meat quality trait, for instance pH and (or) intramuscular fat content, as a selection criterion, as well. Alternatively, meat quality could be retained unchanged by the use of restriction selection indices.

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Buchbesprechung

## Deutsche Holsteins - Die Geschichte einer Zucht -

B. MÜGGE, W. E. LUTZ, H. SÜDBECK, S. ZELFEL

1. Auflage, 147 Seiten, 51 Tabellen, 37 Farb- und 87 Schwarz-Weiß Fotos, Verlag Eugen Ulmer, Stuttgart, 1999, ISBN-Nr. 3-8001-4538-3, 78,- DM

In dem faszinierenden Buch wird die Entwicklung einer Rasse in nahezu 125 Jahren von sehr kompetenten Autoren übersichtlich dargestellt. In unserer schnelllebigen Zeit ist es besonders wichtig, dass die Entwicklungsschritte dieser erfolgreichen Rinderrasse festgehalten und dargestellt werden. Dies ist gleichzeitig eine besondere Ehre für diejenigen, die sich tatkräftig und überzeugend für diese Rasse engagierten. Die Abhandlung der Thematik erfolgt in fünf Kapiteln. Im ersten Kapitel werden die Anfänge einer systematischen Züchtung für Milchrinder in Deutschland von 1850 bis zum 1. Weltkrieg übersichtlich dargestellt. Gerade die junge Generation kann die historische Entwicklung von den Landschlägen hin zu den regionalen Zuchtrichtungen gut nachvollziehen.

Das zweite Kapitel veranschaulicht sehr eindrucksvoll die Konsolidierung der Rassen und den Zusammenbruch am Ende des 2. Weltkrieges, d.h. den Zeitabschnitt von 1919 bis 1945.

In diesem Zeitraum entwickelten sich leistungsfähige Zuchtverbände und Persönlichkeiten, wie Adolf Köppe (Ostfriesland) und Jakob Peters (Ostpreußen), bestimmten die Ausrichtung auf Leistung und Vermarktung.

Nach dem zweiten Weltkrieg begann der Aufbau einer stark geschrumpften Schwarzbuntpopulation, die, insbesondere durch den Verlust der hervorragenden ostdeutschen Zuchtgebiete, einen mühsamen Weg bis 1960 beschritt. Von 1960 bis zur Wende (Kap. 4) entwickelten sich zwei unterschiedliche Schwarzbuntzuchten in Deutschland. Während die DDR sich voll auf Kreuzungszucht konzentrierte und das Schwarzbunte Milchrind (SMR) für die Großbetriebe züchtete, setzte das Zuchtprogramm in der Bundesrepublik auf eine Verdrängungszucht mit Holstein-Friesian aus Nordamerika. Die Zeit von „Pabst Ideal" begann in Deutschland und unterstützt durch die Förderung von H. Wilhelm Schaumann wurde die wissenschaftliche Begleitung der Einkreuzung möglich.

Das letzte Kapitel beschreibt die Entwicklung nach der Wiedervereinigung. Neue Organisationen bilden Zuchteinheiten, die über Ländergrenzen hinweg arbeiten und damit den zukünftigen Entwicklungen eines globalisierten Marktes gewachsen sein werden.

Das interessante und gut aufgemachte Buch ist eine sehr gelungene Darstellung der Entwicklung der Milchviehzucht in Deutschland. Es ist ein Standardwerk für jeden engagierten Züchter. Die interessante Dokumentation der Zuchtgeschichte am Beispiel der Deutschen Holstein zeigt die Möglichkeiten der Auswirkung von additiven Geneffekten durch die Verdrängungszucht, doch ob die Reinzucht die Zuchtmethode bei der Weiterentwicklung der Rinderzucht bleiben wird, bleibt abzuwarten.

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