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# Genetic parameters of direct and ratio traits from field and station tests of pigs

## Abstract

Genetic parameters of several growth and carcass traits were estimated for the Hungarian Large White (HLW) and Hungarian Landrace (HL) pig breeds. The objective of the analysis was to compare the direct (days on station test, consumed feed, valuable cuts and age) and ratio/composite (net daily gain, feed conversion, proportion of valuable cuts, lean meat percentage and average daily gain and meat quality score) traits, which were collected in the course of station and field tests. The analysis was based on the national database (1997-2003) using univariate and bivariate animal models. Estimated heritabilities for station test traits ranged between 0.34-0.69 (except for meat quality score, where the heritability was low (0.10, 0.15 for HLW and HL, respectively) and exceeded that of the field test traits (0.18-0.23). Relative importance of random litter effects was low for the station test traits (0.01-0.29) but moderate for the field test traits (0.20-0.48). The unfavourable genetic correlation between lean meat percentage and meat quality score (-0.28, -0.44 for HLW and LW, respectively) is worth mentioning. In both performance tests the direct and ratio test counterparts showed similar heritabilities and their genetic correlation were close to unity (0.74-0.95). Based on these results selection on either the direct or on the ratio traits would possibly result similar selection response.

Key words: swine, genetic parameters, direct traits, ratio traits, fattening traits, slaughtering traits

## Zusammenfassung

Titel der Arbeit: **Genetische Parameter von direkten und indirekten Produktionsmerkmalen beim Schwein unter Stations- und Feldprüfungsbedingungen**

Bei den Rassen Ungarisches Edelschwein (HLW) und Ungarische Landrasse (HL) wurden genetische Parameter für mehrere Mast- und Schlachtleistungsmerkmale geschätzt. Das Ziel der Analyse war ein Vergleich der direkten (Anzahl der Masttage, Futterverbrauch in der Mastperiode, Masse der wertvollen Teilstücke und Anzahl der Lebenstage) und indirekten (Netto-Lebenstagzunahme, Futterverwertung in der Mastperiode, Anteil wertvoller Teilstücke, Muskelfleischanteil, Lebenstagzunahme, Punktzahl der Fleischqualität) Produktions-merkmale, ermittelt in Feld- und Stationsprüfung. Für die Analyse standen ungarische Daten aus den Jahren 1997 bis 2003 zur Verfügung, die mit Hilfe von univariaten und bivariaten Tiermodellen ausgewertet wurden. Die Heritabilitätswerte für Mast- und Schlachtleistungsmerkmale lagen bei der Stationsprüfung zwischen 0,34-0,69 (ausgenommen die Punktzahl der Fleischqualität, mit $h^2$-Werten zwischen 0,10 und 0,15 in beiden Rassen). Diese Werte übertrafen die in der Feldprüfung geschätzten Heritabilitäten (0,18-0,23).

Bei den Merkmalen der Stationsprüfung war die Bedeutung des zufälligen Wurfeffekts niedriger (0,01-0,29) als in der Feldprüfung (0,20-0,48). Erwähnenswert ist die ungünstige genetische Korrelation zwischen dem Muskelfleischanteil und der Fleischqualitätspunktzahl (-0,28 und -0,44) in beiden Schweinerassen. Für Feld- und Stationsprüfung wurden für direkte und indirekte Leistungsmerkmale ähnliche Heritabilitäten gefunden und die genetische Korrelation zwischen letzteren war sehr hoch (0,74-0,95). Die Ergebnisse legen nahe, dass in der Selektion bei direkten bzw. indirekten Merkmalen ein vergleichbarer Zuchtfortschritt zu erreichen ist.

Schlüsselwörter: Schweine, genetische Parameter, direkte Merkmale, indirekte Produktionseigenschaften, Mastmerkmale, Schlachtmerkmale

## Introduction

Meat production, more specifically pork production continuously aims to satisfy the consumers' demands. Although these demands are likely to change over long periods, during the last two decades the consumers primarily showed preference for lean meat. Producing lean pork cannot be easily realized as a 70kg swine carcass may contain 25-35% fat. Beside other factors (such as restricted feeding) the solutions for reducing fat include genetic selection, and once genetic improvement is attained it is permanent. Genetic selection may target several traits to be improved. In Hungary selection in pig breeding is based on data from field and station tests respectively (CSATÓ et al., 2002). The evaluated traits can be sorted into two groups where the first group contains traits that can be directly measured while the second group consists of traits that can be calculated using the measurements of at least two directly measured traits. The selection response for any trait is partly dependent on the traits' heritability moreover if the selection procedure targets more traits at the same time the genetic correlations among the traits also have to be taken into account. The objective of the present study was to estimate the genetic parameters of all the measured and calculated traits using the data of Hungarian pig populations measured in the course of various (field and station) tests. Thus from the estimated heritabilities and genetic correlations it can be determined if the direct or the indirect traits show more advantageous features on which selection should be based.

## Material and Methods

The genetic analysis was conducted on the data collected by the National Institute for Agricultural Quality Control of Hungary between 1997 – 2003, in the course of the field and station tests respectively. The analysed genotypes were the Hungarian Large White (HLW) and the Hungarian Landrace (HL) breeds.

### Field test (own performance test)

In the field test ultrasonic (SONOMARK 100) fat depth measurements were taken from boars and gilts between 80 and 110kg between the 3rd and 4th lumbar vertebrae (8cm laterally from the spinal cord), between the 3rd and 4th ribs (6cm laterally from the spinal cord) and the loin muscle area between the 3rd and 4th ribs (6cm laterally from the spinal cord). Using these measurements lean meat percentage (LMP) can be calculated. Age (AGE) and body weight (with an accuracy of 1 kg) of the animals were recorded at the same time from which their average daily gain (ADG) was also calculated. All healthy animals in a litter are tested on the farm except for those sent to the station. Gilts are kept in groups up to 25 pigs while boars are raised in smaller groups up to 15 on an *ad libitum* feeding regime.

### Station test (progeny test)

For the purpose of the station test a castrate and a female from the same litter are sent to the station between the age of 65-77 days (random selection is assured). Body weight of the animals at the age of 65 days should be at least 17 kg but not greater than 32 kg. After some preliminary adaptation period the test begins at the age of 80 days (body weight at this age is at least 23 kg) and ends with reaching the final weight of 105 kg. Animals are fed *ad libitum* and penned individually. Days of test (DOT), total amount of feed consumed during the test (FEED) and valuable cuts (VC) (neck, shoulder, loin and ham) are directly measured from which net daily gain (NDG), feed conversion ratio (FCR) proportion of valuable cuts (VC%) could be calculated. Meat quality score (MQ) was also recorded that was calculated according to GROENEVELD et al. (1996). Moreover body weight is measured at the beginning and at the end of the test with an accuracy of 1 kg. Number of measurements for the examined genotypes are presented in table 1.

Table 1
Number of measurements for the Hungarian Large White, Hungarian Landrace breeds (Anzahl Datensätze für die Rassen Ungarisches Edelschwein und Ungarische Landrasse)

| Genotype[1] | Field test[2] | Station test[3] |
|---|---|---|
| Hungarian Large White[4] | 111006 | 8168 |
| Hungarian Landrace[5] | 55703 | 3391 |

[1]Rasse; [2]Feldprüfung; [3]Stationsprüfung; [4]Ungarisches Edelschwein; [5]Ungarische Landrasse

## Statistical analysis

In the statistical analysis authors adapted the linear models developed by GROENEVELD et al. (1996) for the same genotypes (table 2). Applying these models heritabilities of the individual traits and their genetic correlations were estimated. The method used to obtain the (co)variance components was the appropriate variation of the animal model using the PEST (for data coding) (GROENEVELD, 1990) and VCE-5 (KOVAC and GROENEVELD, 2003) softwares (under LINUX) based on the BLUP and REML methods.

Table 2
The considered factors for the examined traits (Die berücksichtigten Effekte in den Modellen)

| Factor[1] | Type | AGE[1] | LMP[3] | ADG[4] | DOT[5] | FEED[6] | VC[7] | NDG[8] | FCR[9] | VC%[10] | MQ[11] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| weight[12] | C | x | x | - | x | x | x | x | x | x | x |
| herd[13] | F | x | x | x | x | x | x | x | x | x | x |
| sex[14] | F | x | x | x | x | x | x | x | x | x | x |
| Year-month[15] | F | x | x | x | x | x | x | x | x | x | x |
| station[16] | F | - | - | - | x | x | x | x | x | x | x |
| litter[17] | R | x | x | x | x | x | x | x | x | x | x |
| animal[18] | A | x | x | x | x | x | x | x | x | x | x |

[1]Effekt; [2]Alter; [3]Muskelfleischanteil; [4]Lebenstagzunahme; [5]Masttage; [6]Futterverbrauch [7]Masse wertvoller Teilstücke; [8]Netto-Lebenstagzunahme; [9]Futterverwertung; [10]Anteil wertvoller Teilstücke; [11]Fleischqualitätspunktzahl; [12]Körpergewicht (Kovariable); [13]Betrieb (Fixer Effekt); [14]Geschlecht (Fixer Effekt); [15]Jahr-Monat (Fixer Effekt); [16]Station (Fixer Effekt); [17]Wurfeffekt (Zufälliger Effekt); [18]Tier (Additiv genetischer Effekt)

The heritability estimates of AGE, LMP, ADG, DOT, FEED, VC, NDG, FCR, VC%, MQ were obtained by using the following univariate linear model:

$$\boldsymbol{y = Xb + Za + e}$$

**y** = vector of observations, **b** = vector of fixed effects, **a** = vector of random animal effects, **e** = vector of random residual effects, **X** and **Z** are incidence matrices relating records to fixed and random animal effects, respectively.

Expected values of **a** and **e** were E(**a**) = E(**e**) = 0. The variance-covariance structure assumed to be V(**a**) = $A\sigma^2_a$, V(**e**) = $I\sigma^2_e$, and cov(**a,e**) = Cov(**e,a**) = 0, where A is the numerator relationship matrix. Also cov(**y,a**) = $ZAI\sigma^2_a$.

Genetic correlations were estimated among AGE, LMP, DOT, FEED, VC, MQ, among ADG, NDG, FCR, VC% and between AGE-ADG, DOT-NDG, FEED-FCR and VC-VC%. Due to the size of the datasets and the relatively low computing capacity heritabilities and genetic correlations could only be estimated using univariate and bivariate models, respectively.

## Results and Discussion

Estimated heritabilities for the field and station test traits are presented in table 3. Station test heritabilities exceeded that of the field test traits except meat quality score where low heritability estimates were found. In Hungary meat quality score is calculated from several parameters (pH1, pH2, meat colour, subjective score) from which the subjective score is probably prone to error and may result incorrect scores (GROENEVELD et al., 1996). It has to be noted that separate heritability estimates of meat quality score parameters were low or moderately low (0.10-0.30) as reported by KNAPP et al. (1997); LO et al. (1992); HOVENIER et al. (1992). These findings suggest that though meat quality is internationally considered an important trait to be improved by genetic selection its definition may not be optimal. Valuable cuts and proportion of valuable cuts both showed moderately high heritabilities and were in accordance with the reported estimates of others (GROENEVELD et al., 1998; GROENEVELD and PESCOVICOVA, 1999; WOLF et al., 2001; SCHULZE et al., 2001; FISCHER et al., 2002). The other traits measured in the station test (DOT, FEED, NDG, FCR) showed moderate heritabilities and were similar to the findings of CHEN et al. (2002); DUCOS et al. (1992); ZHANG et al. (2000) for DOT; GROENEVELD et al. (1996) for FEED; but were higher than reported by HERMESCH et al. (2000), HOFER et al., (1992) and MRODE and KENNEDY (1993) for NDG, FCR.

Table 3
Heritability estimates of the field and station test traits (standard errors of estimates are given in brackets) (Die Heritabilitätswerte der Merkmale in der Feld- und Stationsprüfung (Standardabweichung in Klammern)

| | Hungarian Large White[1] | Hungarian Landrace[2] |
|---|---|---|
| Age[3] | 0.23 (0.01) | 0.23 (0.01) |
| Lean meat percentage[4] | 0.23 (0.02) | 0.28 (0.02) |
| Average daily gain[5] | 0.20 (0.01) | 0.18 (0.02) |
| Days of test[6] | 0.34 (0.01) | 0.35 (0.03) |
| Consumed feed[7] | 0.37 (0.02) | 0.48 (0.04) |
| Valuable cuts[8] | 0.54 (0.02) | 0.65 (0.04) |
| Net daily gain[9] | 0.36 (0.01) | 0.35 (0.04) |
| Feed conversion ratio[10] | 0.37 (0.02) | 0.35 (0.04) |
| Proportion of valuable cuts[11] | 0.54 (0.02) | 0.69 (0.03) |
| Meat quality score[12] | 0.10 (0.02) | 0.15 (0.04) |

[1]Ungarisches Edelschwein; [2]Ungarische Landrasse; [3]Alter [4]Muskelfleischanteil; [5]Lebenstagzunahme; [6]Masttage; [7]Futterverbrauch; [8]Masse wertvoller Teilstücke; [9]Netto-Lebenstagzunahme; [10]Futterverwertung; [11]Anteil wertvoller Teilstücke; [12]Fleischqualitätspunktzahl

From the field test traits AGE and ADG showed low heritabilities and were in good agreement with the findings of other authors (GROENEVELD et al., 1998; HOVENIER et al., 1992; PESCOVICOVA et al., 1999; THOLEN et al., 1998; THOLEN et al., 2001). LMP also showed low heritability but the received values were perhaps lower than expected as other authors reported moderately high heritability estimates (SONESSON et al., 1998; 0.41; KNAPP et al., 1997; 0.40-0.53; HOVENIER et al., 1992; 0.63) for the same trait. The results may be caused by imprecise ultrasonic scanning. Precision might be improved if the operators’ code would be included in the applied models.

Estimated random litter effects (common environment effect of the sow) for the field and station test traits are presented in table 4. The relative importance of this effect was less in the station test than in the field test traits. VC, VC%, FCR and MQ showed negligible random litter effects but the size of this effect for DOT, FEED and NDG were also low or moderately low similarly to DUCOS et al. (1992); HOFER et al. (1992) GROENEVELD et al. (1998); GROENEVELD and PESCOVICOVA (1999); ZHANG et al. (2000); CHEN et al. (2002). On the contrary in the field test traits the relative importance of random litter effect was either reached (LMP) or exceeded (AGE) that of the additive genetic effect. BERESKIN (1987) reported similar finding for AGE but for LMP low random litter effects were published by KNAPP et al. (1997) and GROENEVELD et al. (1998).

Table 4
Relative importance of random litter effects (proportion of the total variance) of the field and station test traits (standard errors of estimates are given in brackets) (Zufällige Wurfeffekte der Produktionsmerkmale in der Feld- und Stationsprüfung (Standardabweichung in Klammern)

| | Hungarian Large White[1] | Hungarian Landrace[2] |
|---|---|---|
| Age[3] | 0.48 (0.01) | 0.46 (0.01) |
| Lean meat percentage[4] | 0.20 (0.01) | 0.25 (0.01) |
| Average daily gain[5] | 0.29 (0.01) | 0.33 (0.01) |
| Days of test[6] | 0.11 (0.01) | 0.14 (0.04) |
| Consumed feed[7] | 0.29 (0.01) | 0.22 (0.05) |
| Valuable cuts[8] | 0.05 (0.01) | 0.01 (0.05) |
| Net daily gain[9] | 0.21 (0.01) | 0.23 (0.04) |
| Feed conversion ratio[10] | 0.05 (0.01) | 0.02 (0.04) |
| Proportion of valuable cuts[11] | 0.04 (0.01) | 0.01 (0.04) |
| Meat quality score[12] | 0.07 (0.01) | 0.08 (0.04) |

[1]Ungarisches Edelschwein; [2]Ungarische Landrasse; [3]Alter; [4]Muskelfleischanteil; [5]Lebenstagzunahme; [6]Masttage; [7]Futterverbrauch; [8]Masse wertvoller Teilstücke; [9]Netto-Lebenstagzunahme; [10]Futterverwertung; [11]Anteil wertvoller Teilstücke; [12]Fleischqualitätspunktzahl

The genetic correlation coefficients for the Hungarian Large White and Hungarian Landrace breeds and are presented separately for the direct traits (tables 5-6), ratio traits (tables 7-8) and between the direct and ratio trait equivalents (table 9).

Table 5
Estimated genetic correlation coefficients of the direct (field and station) traits in the Hungarian Large White breed (standard errors of estimates are given in brackets) (Genetische Korrelationen zwischen direkten Merkmalen (in Stations- und Feldprüfung) beim Ungarischen Edelschwein)

| DOT[2] | VC[3] | MQ[4] | AGE[5] | LMP[6] | |
|---|---|---|---|---|---|
| 0.62 (0.02) | 0.00 (0.03) | -0.06 (0.13) | 0.68 (0.02) | 0.03 (0.03) | FEED[1] |
| | -0.38 (0.03) | -0.29 (0.11) | 0.51 (0.03) | -0.06 (0.04) | DOT[2] |
| | | 0.18 (0.20) | 0.02 (0.04) | 0.34 (0.04) | VC[3] |
| | | | -0.02 (0.10) | **-0.28 (0.11)** | MQ[4] |
| | | | | 0.04 (0.04) | AGE[5] |
| | | | | | LMP[6] |

[1]Futterverbrauch; [2]Masttage; [3]Masse wertvoller Teilstücke; [4]Fleischqualitätspunktzahl; [5]Alter; [6]Muskelfleischanteil

Table 6
Estimated genetic correlation coefficients of the direct (field and station) traits in the Hungarian Landrace breed (standard errors of estimates are given in brackets) (Genetische Korrelationen zwischen direkten Merkmalen (in Stations- und Feldprüfung) bei der Ungarischen Landrasse))

| DOT[2] | VC[3] | MQ[4] | AGE[5] | LMP[6] | |
|---|---|---|---|---|---|
| 0.79 (0.04) | -0.03 (0.05) | 0.09 (0.14) | 0.64 (0.04) | -0.07 (0.05) | FEED[1] |
| | -0.22 (0.05) | 0.12 (0.15) | 0.54 (0.05) | -0.08 (0.06) | DOT[2] |
| | | -0.35 (0.14) | 0.07 (0.04) | 0.40 (0.05) | VC[3] |
| | | | -0.19 (0.13) | **-0.44 (0.14)** | MQ[4] |
| | | | | 0.10 (0.04) | AGE[5] |
| | | | | | LMP[6] |

[1]Futterverbrauch; [2]Masttage; [3]Masse wertvoller Teilstücke; [4]Fleischqualitätspunktzahl; [5]Alter; [6]Muskelfleischanteil

From the results the moderately high and negative genetic correlation between MQ and LMP has to be emphasised. The received association is unfavourable as the selection on LMP decreases MQ. The existence of this unfavourable genetic correlation was justified by other authors (BIEDERMANN et al. 2000; BIZELIS et al., 2000; THOLEN et al., 2001).

Table 7
Estimated genetic correlation coefficients of the ratio (field and station) traits in the Hungarian Large White breed (standard errors of estimates are given in brackets) (Genetische Korrelationen zwischen indirekten Merkmalen (in Stations- und Feldprüfung) beim Ungarischen Edelschwein)

| | FCR[2] | VC%[3] | ADG[4] | |
|---|---|---|---|---|
| | -0.40 (0.03) | 0.09 (0.03) | 0.60 (0.02) | NDG[1] |
| | | -0.47 (0.04) | -0.25 (0.03) | FCR[2] |
| | | | 0.10 (0.03) | VC%[3] |
| | | | | ADG[4] |

[1]Netto-Lebenstagzunahme; [2]Futterverwertung; [3]Anteil wertvoller Teilstücke; [4]Lebenstagzunahme

Table 8
Estimated genetic correlation coefficients of the ratio (field and station) traits in the Hungarian Landarce breed (standard errors of estimates are given in brackets) (Genetische Korrelationen zwischen indirekten Merkmalen (in Stations- und Feldprüfung) bei der Ungarischen Landrasse)

| | FCR[2] | VC%[3] | ADG[4] | |
|---|---|---|---|---|
| | -0.39 (0.06) | 0.12 (0.07) | 0.66 (0.05) | NDG[1] |
| | | -0.40 (0.06) | -0.19 (0.04) | FCR[2] |
| | | | 0.00 (0.05) | VC%[3] |
| | | | | ADG[4] |

[1]Netto-Lebenstagzunahme; [2]Futterverwertung; [3]Anteil wertvoller Teilstücke; [4]Lebenstagzunahme

Table 9
Estimated genetic correlation coefficients between the direct and ratio trait equivalents in the Hungarian Large White and Hungarian Landrace breeds (standard errors of estimates are given in brackets) (Genetische Korrelationen zwischen den direkten und indirekten Merkmalen bei den Rassen von Ungarischem Edelschwein und Ungarischer Landrasse (Standardabweichung in Klammern))

| DOT[4]-NDG[5] | FEED[6]-FCR[7] | VC[8]-VC%[9] | AGE[10]-ADG[11] | Genotype[1] |
|---|---|---|---|---|
| -0.92 (0.01) | 0.86 (0.01) | 0.89 (0.01) | -0.79 (0.01) | Large White[2] |
| -0.95 (0.01) | 0.83 (0.03) | 0.90 (0.01) | -0.74 (0.01) | Landrace[3] |

[1]Rasse; [2]Ungarisches Edelschwein; [3]Ungarische Landrasse; [4]Masttage; [5]Netto-Lebenstagzunahme; [6]Futterverbrauch; [7]Futterverwertung; [8]Masse wertvoller Teilstücke; [9]Anteil wertvoller Teilstücke; [10]Alter; [11]Lebenstagzunahme

Based on the estimated heritabilities and random litter effects, station test traits had higher heritabilities than field test traits, where measuring discipline and care might be increased. The moderately large and negative genetic correlation between lean meat percentage and meat quality score is unfavourable as the current selection on the former traits decreases the latter traits' performance. The direct and ratio trait equivalents showed high genetic correlations moreover their heritability and random litter estimates were basically the same. Therefore the selection response is not expected to be different for the direct or the ratio traits.

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