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PIG IMPROVEMENT SCHEMES FOR LARGE STATE FARMS IN SLOVENIA

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1. INTRODUCTION

Selection programs have to take into account the specifics of the production system of each country. The pig-production in Slovenia, one of the Yugoslav republics which lies in the western part of the country, is characterised by large state farms where production is evenly distributed throughout the year. A large number of animals reared at each farm and unified rearing conditions within each farm represent a special advantage for selection work. These farms were established in 1959. In 1974 the new selection program which has been used since then was put into practice. The effectiveness of this selection program is estimated in this paper.

2. SELECTION PROGRAM FOR PIGS IN SLOVENIA

2.1. Bases of the selection program

In 1985 there were 630,000 pigs in Slovenia. The majority (65%) were reared by private breeders and the remainder (35%) by eight state farms. Each farm keeps between 1,500 to 5,500 breeding sows and 20,000 to 100,000 animals are fattened yearly.

In the years 1966-1973 various crossbreedings were intensively studied in Slovenia with the following breeds: Swedish Landrace, Large White, German Landrace, Pietrain, and Slovenian local breed - "Krškopoljska". Among sixteen crossbreeds tested the three-breed cross named 12 x 55 showed the best results and was therefore in 1974 chosen as the basis for the future selection work. At the same time the selection work was reorganised, structured and distributed among different farms and private farms as follows:

a) Selection (two farms):
   - selection and testing pure breeds A, B, C
   - production of breeding gilts A
   - production of breeding boars B, C
   - production of breeding gilts AB (line 12)

b) Reproduction (one farm):
   - selection and production of breeding gilts AB (line 12)

c) Production (other farms and private breeders):
   - production of piglets (AB x C)
   - fattening of crosses (ABC)

2.2. The course of selection and its criteria

Breeds A, B, and C are selected in pure breed. The main emphasis of the selection is laid on boars for artificial insemination. The selection criteria for separate breeds are different. Breeds A (Swedish Landrace) and B (Large White) must have outstanding reproduction and fattening traits, and breed C (German Landrace or Duroc or Pietrain) must have outstanding fattening and
slaughter traits. The procedure for estimating the breeding value and testing the animals is the same, only the criteria of selection are different.

2.2.1. Selection according to fertility

Practically fertility is not included in selection. Although the criteria are established they are low and often not taken into account. Offsprings of old sows can be selected for breed if the sow's average number of liveborn piglets is 10 (breeds A and B) or 9 (breed C). If the animal is distinguished in other traits, fertility is not taken into account in selection, even if it is lower.

Table 1: Fertility of sows on the selection farm Ihan in the years 1980-1984 (Kovač et al. 1985)*

<table>
<thead>
<tr>
<th>Year</th>
<th>Gilts</th>
<th>Oldsow</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of litters farrowing (days)</td>
<td>No. of liveborn piglets</td>
<td>No. of litters interval (days)</td>
</tr>
<tr>
<td>1980</td>
<td>2.911</td>
<td>375,8</td>
<td>5.074</td>
</tr>
<tr>
<td>1981</td>
<td>2.507</td>
<td>381,5</td>
<td>7.377</td>
</tr>
<tr>
<td>1982</td>
<td>2.655</td>
<td>370,7</td>
<td>7.852</td>
</tr>
<tr>
<td>1983</td>
<td>2.513</td>
<td>362,7</td>
<td>7.627</td>
</tr>
<tr>
<td>1984</td>
<td>2.291</td>
<td>362,9</td>
<td>8.339</td>
</tr>
</tbody>
</table>

*Farrowings of all sows on the selection farm Ihan in the period from 1.1.1980 to 31.12.1984 are taken into account.

2.2.2. Testing of boars

Test stations for testing of boars are on both selection farms. The basic characteristics of testing are:
- type of test: performance test
- animals: purebreed boars
- period of testing: 30-100 kg
- housing: individual
- feeding: ad libitum
- feed: one feed mixture with 14.3% of crude protein
- water: ad libitum
- measurements:
  - weighings at 30, 60 and 100 kg
  - quantity of feed
  - backfat thickness by ultrasound
- index
  \[ I = 462 + 0.45x_1 - 1.74x_2 - 2.04x_3 \]
  \[ x_1 \] - duration of fattening from 30-100 kg (days)
  \[ x_2 \] - total feed consumption from 30-100 kg (kg)
  \[ x_3 \] - backfat thickness - ultrasound (mm)
- selections:
  - at the beginning of the test
  - at 60 kg
  - at 100 kg

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a) Selection at the beginning of the test (28-31 kg)

In order to shorten the generation interval it is important to get progeny of the selected boars as soon as possible. Young boars are mated with gilts or primiparous sows and usually two best growing males are taken from litter for testing. These animals must be without exterior and hereditary defects.

b) Selection at 60 kg

There is no special index for the estimation of breeding value at 60 kg. The criteria of selection are deviation of the traits (daily gain from 30-60 kg, feed conversion for 1 kg gain from 30 to 60 kg) from the moving average for the last three weeks. The breed’s characteristics of growth are also taken into account. Young boars growing slowly and those with high feed conversion as well as boars with different exterior defects (anomalies of legs, genitals, hooves, teats, etc.) are culled, which means that 35-45 % of the animals are culled.

c) Selection at the end of testing (100 kg)

At the end of testing the index estimating the aggregate genotype is calculated for each boar. Selection at 100 kg takes into account:

- difference between breeds: comparative value of index on the basis of annual deviation of separate breeds from not weighed average of all breeds
- seasonal effects: the moving four weeks average of comparative values of index
- criteria of selection: intensity of selection is determined by the needs for replacement boars according to breeds.

The final culling is performed after the exterior of selected boars is examined. Table 2 shows the distribution of boars by categories of the selection at 100 kg.

Table 2: Distribution of boars by categories of the selection at 100 kg in the years 1976-1984 (Salehar et al. 1985)

<table>
<thead>
<tr>
<th>Categories of selection (%)</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slaughter</td>
<td>57,9</td>
</tr>
<tr>
<td>Breed</td>
<td></td>
</tr>
<tr>
<td>- Boars for natural mating</td>
<td>31,1</td>
</tr>
<tr>
<td>- Boars for AI</td>
<td>-</td>
</tr>
<tr>
<td>- Elite boars for selection farm</td>
<td>10,8</td>
</tr>
</tbody>
</table>

Intensity of the selection of elite boars differs between breeds and has been reduced since 1980 because of the increased production on the selection farm. After the final selection is done the culled boars are slaughtered, and carcass traits are measured.

2.2.3. Selection of breeding gilts

Breeding gilts must be offsprings of elite boars. At the age of 6-7 months they are weighed after exterior selection and the backfat thickness is measured by ultrasound. About 60 % of the animals are selected for reproduction.
3. EVALUATION OF GENETIC IMPROVEMENT

3.1. Material

For the evaluation of the genetic improvement the data of the boars tested on the selection farm Ihan between 1975 and 1984 were used. Pigs of Swedish Landrace, German Landrace and Large White breeds were tested according to the procedure described in chapter 2.2.2. The number of sires and boars at the beginning and at the end of test is presented in Table 3.

Table 3: Number of sires and boars at the beginning and at the end of the test

<table>
<thead>
<tr>
<th>Breed</th>
<th>No. of sires</th>
<th>No. of boars at the beginning of the test</th>
<th>No. of boars at the end of the test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swedish Landrace</td>
<td>186</td>
<td>4,784</td>
<td>2,635</td>
</tr>
<tr>
<td>Large White</td>
<td>107</td>
<td>1,110</td>
<td>595</td>
</tr>
<tr>
<td>German Landrace</td>
<td>160</td>
<td>3,322</td>
<td>2,171</td>
</tr>
</tbody>
</table>

Genetic improvement was evaluated for the following traits:
- duration of fattening from 30 to 100 kg
- feed conversion from 30 to 100 kg
- backfat thickness - ultrasound
- index

3.2. Methods of evaluation of genetic improvement

Genetic improvement (ΔG) for each trait was estimated by regression of the progeny value on time within sires \( b_{x''}(t), t \):

\[
\Delta G = - 24 \cdot b_{x''}(t), t \\

x''(t) - observed value of the progeny \\
t - time since the first progeny of each sire was penned (in months)
\]

In the calculation of this regression individual data were used since the number of progenies for different sires was different and unevenly distributed in time.

The data used for estimating genetic improvement were corrected by the following procedure:

a) Correction for year, season and other systematic effects is done as described in the chapter 2.2.2.c.

b) Correction for the selection at 60 kg on the traits measured at 100 kg

Selection is performed in two stages: at 60 and 100 kg. Selection at 60 kg affects the distribution of trait values at 100 kg and therefore the sample at 100 kg is not at random. The most important criterion of selection at 60 kg is feed conversion from 30 to 60 kg. Therefore the traits at 100 kg \( x' \) were corrected by regression of the traits on feed conversion from 30 to 60 kg \( b_{x'}, z \) and by calculated selection differential for this trait for each separate monthly group within sires \( (SD_z) \):

\[
x'' = x' - b_{x'}, z \cdot SD_z
\]
The regression coefficients for the duration of fattening from 30 to 100 kg, feed conversion in the same period and index (Table 4) are statistically significant, while they are small and statistically insignificant for backfat thickness.

Table 4: Regression coefficients of different traits at 100 kg on feed conversion from 30 to 60 kg

<table>
<thead>
<tr>
<th>No. of boars</th>
<th>Swedish Landrace</th>
<th>Large White</th>
<th>German Landrace</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of fattening 30-100 kg (days)</td>
<td>7,09 ± 2,30**</td>
<td>7,44 ± 3,56*</td>
<td>8,37 ± 2,21**</td>
</tr>
<tr>
<td>Feed conversion 30-100 kg (kg)</td>
<td>0,42 ± 0,07**</td>
<td>0,31 ± 0,10**</td>
<td>0,39 ± 0,06**</td>
</tr>
<tr>
<td>Backfat thickness (mm)</td>
<td>-0,67 ± 0,85</td>
<td>-0,58 ± 1,44</td>
<td>-0,18 ± 0,85</td>
</tr>
<tr>
<td>Index</td>
<td>-47,9 ± 7,10**</td>
<td>-37,8 ± 11,1**</td>
<td>-35,8 ± 7,14**</td>
</tr>
</tbody>
</table>

** p < 0,01
* p < 0,05

3.3. Results

The phenotypic values for the traits at 100 kg are shown on graphs in Appendix 1.

3.3.1. Evaluation of genetic and phenotypic change for the duration of fattening from 30 to 100 kg

Table 5: Evaluation of annual genetic and phenotypic change for the duration of fattening from 30 to 100 kg

<table>
<thead>
<tr>
<th>Breed</th>
<th>Evaluation of genetic change per year (days)</th>
<th>Evaluation of phenotypic change per year (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swedish Landrace</td>
<td>0,71 ± 0,78</td>
<td>-0,71 ± 0,23**</td>
</tr>
<tr>
<td>Large White</td>
<td>-2,22 ± 1,08*</td>
<td>-0,62 ± 0,38</td>
</tr>
<tr>
<td>German Landrace</td>
<td>0,41 ± 0,60</td>
<td>-0,44 ± 0,16**</td>
</tr>
</tbody>
</table>

Evaluation of genetic improvement for the duration of fattening (Table 5) is significant only with the Large White breed (-2,22 days a year), while with the Swedish Landrace and German Landrace breeds (0,71 and 0,41 days) it is not significant.

3.3.2. Evaluation of genetic and phenotypic change for feed conversion from 30 to 100 kg

The evaluation of genetic improvement for feed conversion from 30 to 100 kg is significant with all three breeds and amounts to -54 g with Swedish Landrace, -89 g with Large White and -61 g with German Landrace. The trend is expected, since the greatest economic weight with the selection at 100 kg is given to this trait, and this trait is also the most important criterion for the selection at 60 kg. With all three breeds the values are higher than
the evaluations for phenotypic change (Table 6).

Table 6: Evaluation of annual genetic and phenotypic change for feed conversion from 30 to 100 kg

<table>
<thead>
<tr>
<th>Breed</th>
<th>Evaluation of genetic change per year (g)</th>
<th>Evaluation of phenotypic change per year (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swedish Landrace</td>
<td>-54 ± 24 *</td>
<td>-39 ± 7 **</td>
</tr>
<tr>
<td>Large White</td>
<td>-89 ± 30 **</td>
<td>-33 ± 9 **</td>
</tr>
<tr>
<td>German Landrace</td>
<td>-61 ± 18 **</td>
<td>-28 ± 5 **</td>
</tr>
</tbody>
</table>

3.3.3. Evaluation of genetic and phenotypic change for backfat thickness measured by ultrasound at the weight of 100 kg

Table 7: Evaluation of annual genetic and phenotypic change for backfat thickness - ultrasound

<table>
<thead>
<tr>
<th>Breed</th>
<th>Evaluation of genetic change per year (mm)</th>
<th>Evaluation of phenotypic change per year (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swedish Landrace</td>
<td>-0,76 ± 0,25 **</td>
<td>-0,85 ± 0,10 **</td>
</tr>
<tr>
<td>Large White</td>
<td>0,12 ± 0,36</td>
<td>-1,11 ± 0,17 **</td>
</tr>
<tr>
<td>German Landrace</td>
<td>-0,35 ± 0,21</td>
<td>-0,72 ± 0,10 **</td>
</tr>
</tbody>
</table>

The evaluation of genetic improvement with the Swedish Landrace breed is -0,76mm and with German Landrace -0,35mm a year. With Large White the evaluation of genetic improvement shows a undesired trend. A significant evaluation was obtained only with the Swedish Landrace breed.

3.3.4. Evaluation of genetic and phenotypic change for the index

Table 8: Evaluation of annual genetic and phenotypic change for the index

<table>
<thead>
<tr>
<th>Breed</th>
<th>Evaluation of genetic change per year</th>
<th>Evaluation of phenotypic change per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swedish Landrace</td>
<td>8,13 ± 2,63 **</td>
<td>6,15 ± 0,70 **</td>
</tr>
<tr>
<td>Large White</td>
<td>8,92 ± 3,32 **</td>
<td>5,99 ± 0,99 **</td>
</tr>
<tr>
<td>German Landrace</td>
<td>6,40 ± 2,01 **</td>
<td>4,59 ± 0,65 **</td>
</tr>
</tbody>
</table>

The evaluation of genetic improvement for the index is significant with all three breeds and is higher than the phenotypic evaluations.

4. DISCUSSION

Livestock improvement strategies even planned for longer periods are many times changed in the course of the time to achieve larger genetic gain with lower costs. The selection intensity is also modified frequently so that the actual number of selected animals can match the required number of breeding animals.

In the presented work the within sire regression of the progenies' performance on time was used to estimate genetic gain for traits studied. This method requires the fulfilment of two basic assumptions: (1) the tested progenies of
a sire are sampled at random from each litter and (2) the genetic gain is linear with time. Both assumptions are not completely fulfilled for the data used in our analysis.

Since 1975 the selection intensity has decreased due to increased demand for boars as the production has been enlarged. The change of the selection intensity has not been the same for all three purebreeds considered. During the last 10 years also the parameters used to compute the index have been modified, moving average as the comparing value has been introduced, gilts selection for daily gain and backfat thickness has been employed and imported boars have been included in base population to prevent inbreeding. In each generation a more or less intensive selection has taken place at three different stages (1) at the beginning of the testing period (piglets from each litter are not sampled at random) (2) at the average weight of 60 kg and (3) at the end of testing period (at the average weight of 100 kg). The criteria for the selection at the first two stages are not precisely defined and selection intensity is rather low. In spite of low selection intensity at the first two stages the progenies of a sire which are taken into the test and remain in the test till the completion do not represent a random sample. Only the partial correction of the data for the selection done at the second stage is possible.

Due to the method used the genetic change was estimated only from the data of one sex. However the change in the phenotypic value from one generation to another is caused by the change of the environment and genetic change achieved in both sexes. As the result of the breeding scheme which has been applied the genetic gain in females lags one generation behind that in males. This must be taken into account when comparing genetic and phenotypic changes. It must be also notified that the number of sires used in the analysis was rather small, particularly with Large White and that the progenies of a sire were concentrated in time (average period in which progenies of one boar were tested was 9,72 months).

In that respect the estimated genetic gain for different traits shows various level of bias. Genetic change for index is probably the most unbiased of all traits considered. It differs significantly from zero for all three purebreeds and is in the agreement with the phenotypic change. From our results the conclusion can be drawn that the selection for index was less effective with German Landrace and that the genetic change achieved with males was higher than the phenotypic change in the whole population. Estimated genetic change for backfat thickness is in agreement with the phenotypic trend with Swedish Landrace and German Landrace but not with Large White. For feed conversion genetic gain is significantly different from zero for all three breeds and larger than phenotypic change. Genetic gain for this traits is probably overestimated, since it is hard to believe to get such a large gain in the real life.

In conclusion we can say that the breeding strategy employed has been effective. Estimated values for the genetic gain are in good agreement with the phenotypic change for index which is a composite trait and for backfat thickness, a trait with the high heritability. The agreement between the genetic gain and phenotypic change is reasonable for feed conversion which highly effects the value of index even the genetic gain for this trait is probably overestimated. Because the daily gain has low influence on index and is very much effected by environment the agreement between genetic gain and phenotypic change is rather low for this trait.

Similar discrepancies between phenotypic change and genetic gain estimated by
within sire regression of progenies performance on time can be found in the results of other authors (Puff (1976), Hudson et al. (1985), Standal (1979)). Concentration of progenies of a sire in time and sampling of progenies which is not done at random are the main reasons for such discrepancies when the field data or testing results are used. The problem of estimating genetic gain objectively can be solved by keeping frozen sperm for several years and estimating genetic gain from the difference of the performance of the progenies of the old and young boars.

5. CONCLUSIONS

In the paper the system of pig breeding on large state farms in Slovenia is presented. The testing and selection methods used for evaluating and selecting boars are described. Genetic gain achieved for different traits in the last 10 years was estimated separately for each of the three purebreeds.

Estimated genetic and phenotypic (in brackets) change per year for Swedish Landrace was 0.71 days (-0.71), -54 g (-39), -0.76 mm (-0.85), 8.13 (6.15) for fattening period (from 30-100 kg), feed conversion (from 30-100 kg), backfat thickness and index respectively. The same values for Large White were -2.22 days (-0.62), -89 g (-33), 0.12 mm (-1.11), 8.92 (5.99) and 0.41 days (-0.44), -61 g (-28), -0.35 mm (-0.72), 6.40 (4.59) for German Landrace.

Estimated genetic change for feed conversion and index are significantly different from zero with all purebreeds. In addition with Large White the same is true also for the duration of fattening and with Swedish Landrace for backfat thickness.

Genetic gain is estimated with less bias for traits with higher heritability or traits which highly effect index. Test station data are generally not well suited as data for estimating genetic change due to concentration of progenies of a sire in a time and sampling the progenies which is not done at random. The problem of estimating genetic gain objectively can be solved by keeping frozen sperm for several years and estimating genetic gain from the difference of the performance of the progenies of the old and young boars.

6. ACKNOWLEDGEMENT

We wish to express our warmest thanks to Mr. Jurij Pohar, M.Sc. for his help and advices in data processing as well as for the revision of this paper.

7. LITERATURE


STANDAL, N. 1979. Genetic change in the Norwegian Landrace pig population. A. Agri. Scand. 29, 139-144.

8. APPENDIX 1

Graph 1: Duration of fattening from 30-100 kg

Graph 2: Feed conversion from 30-100 kg

Graph 3: Backfat thickness (ultrasound)

Graph 4: Index of breeding value