EFFECT OF DIFFERENT SELECTION CRITERIA FOR LITTER SIZE, GROWTH PERFORMANCE AND CARCASS TRAITS IMPROVEMENT OF THE PIGS IN SERBIA

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Abstract


Four pig breeds, Landrace and Yorkshire (as dam lines) and Duroc and Pietrain (as terminal, sire lines) were studied on commercial farms during 2000 - 2011. Altogether, 13584 litters with a total of 154344 progeny of both sexes, from 43 boars and 4824 sows were analyzed. Also, analysis of genetic change study included 426 sows of Duroc and 247 Pietrain, totally 2557 litters and 22760 piglets then, in each breed of 14 boars, total 28. The difference between the number of live born piglets and piglets alive on the day fifth was significant, which means that future feeding regimens of sows must be optimized. The selection efficiency of number of live born piglets was on average 0.25 per generation. Even different size of heritability the genetic variation of analyzed traits was similar from the beginning to the last selected generation. Carcase quality was analyzed for 144 pigs of different weights and sex. The average weight of animals at the end of the fattening period was 103 kg ± 2.6 kg. Weight of bone was not significantly different between Landrace, Yorkshire and Duroc pigs, while bones in Pietrain pigs were much lighter. This indicates the slower growth of Pietrain pigs, which required an extra fattening period of 24 to 32 days compared to the other breeds. When just growth was compared, Pietrain pig growth was significantly less compared with their peers of other breeds. Even that, selection gain was significant to all breeds. At Landrace and Yorkshire selection improved gain for 42 days. Significantly slower was on Duroc, only 19 days and highest at Pietrain, 44 days. At the end of the study, the content of meat in the carcasses was, on average, 57.6% in Landrace and Yorkshire pigs and 59.7% in Duroc pigs (this was not significantly different). Pietrain carcasses contained 62.3% meat, which was significantly more than in the other breeds. After 11 years of breeding according to the chosen selection criteria, intramuscular fat content in the final carcasses was: 0.8% in Pietrain, 2.6% in Duroc, 2.0% in Landrace and 1.8% in Yorkshire pigs.

Key words: pigs, selection criteria, litter size, growth, quality carcass

Introduction

In pig production, the most important traits from a monetary point of view can be as follows: number of weaned piglets per sow per year; feed conversion; growth; meat content in carcass; and protein and fat content in meat. To provide an optimal selection effect for each of them, it is important to determine the genetic correlation between them, and the size of each factor’s heritability as well. Litter size traits generally are lowly heritable (Hanenberg et al., 2001; Chen et al., 2003; Wolf et al., 2005; Wolf and Wolfová, 2012). Therefore, using additional information in genetic evaluations may be beneficial for increasing the precision of predicted breeding values. According to well-established knowledge of the negative genetic correlation between fertility or milk yield and meat content in pig carcasses, it is necessary to develop different selection criteria, or better yet, specialized pig breeds (Vidović and Lukač, 2010; Vidović, 2009).

Since the purpose of selection effects in the current study was real on-farm pig production, two groups of pig breeds
were studied: 1) fertility and milking breeds – Landrace and Yorkshire and 2) terminal sire breeds – Duroc and Pietrain. Selection criteria were different for terminal sire breeds (Duroc and Pietrain) compared to Landrace and Yorkshire where selection concentrated on litter size and milk yield. Trends were predicted according to current literature sources, according to the selection criteria, farm, year and season, as well as farm management effects. The current research analyzed the chosen selection effects during 11 years of pig selection on commercial farms.

Material and Methods

The study was conducted on four commercial farms during 2000 to 2011. Four pig breeds, Landrace (L) and Yorkshire (Y) as dam lines (total used 13584 litters with 154344 progeny of both sexes, produced from 43 boars and 4824 sows) and terminal sire lines (included 426 sows of duroc (D) and 247 pietrain (P), totally 2557 litters and 22760 piglets then, in each breed of 14 boars, total 28). The selection criteria used are shown in Graph 1. The average live weight at slaughter of all animals was 103 kg ± 2.6 kg (Table 1 and Graph 1).

The following Mixed Model Equation, Least Square (MMELS) model was used to analyze influences of Farm, Year and Season (FYS) then Breed as fixed effects and Sire as a random effect.

\[
Y_{ijkl} = \mu + FYS_i + B_{ij} + S_{ijk} + E_{ijkl}
\]

where:

- \(Y_{ijkl}\) - Number of observations hierarchically distributed;
- \(\mu\) - General mean of observations;
- \(FYS_i\) - Fixed effect of farm, year and season;
- \(B_{ij}\) - Fixed effect of different breeds;
- \(S_{ijk}\) - Random sire effect;
- \(E_{ijkl}\) - Residual

Results and Discussion

Heritability was estimated for litter size, growth, feed conversion, and carcase than meat traits (Table 2). Even though the heritability estimates were statistically significantly different, the standard deviations showed similar trends. The standard deviation values points to new selection possibilities to improve the chosen hereditable traits.

**Litter size.** Totally different selection criteria were used for the specialized pig breeds, as clearly, litter size was not of selection interest for Duroc and Pietrain pigs. So, litter size at first farrowing was analyzed among Landrace and Yorkshire pigs only. Litter sizes in both Landrace and Yorkshire

### Table 1

<table>
<thead>
<tr>
<th>Breed</th>
<th>Sire</th>
<th>Dam</th>
<th>Progeny</th>
<th>No. of carcasses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landrace</td>
<td>11</td>
<td>80</td>
<td>196</td>
<td>36</td>
</tr>
<tr>
<td>Yorkshire</td>
<td>12</td>
<td>74</td>
<td>182</td>
<td>36</td>
</tr>
<tr>
<td>Duroc</td>
<td>10</td>
<td>66</td>
<td>102</td>
<td>36</td>
</tr>
<tr>
<td>Pietrain</td>
<td>10</td>
<td>62</td>
<td>80</td>
<td>36</td>
</tr>
</tbody>
</table>

Graph. 1. Selection criteria used for dam line breeds: Landrace and Yorkshire (left) and terminal sire breeds: Duroc and Pietrain (right)
pig breeds increased during the study, and were similar both at the beginning and end of the study (Graph 2). In addition, the rate of litter size increase observed during the study was similar for both Landrace and Yorkshire pigs. However, after 11 generations of selection, the increase in litter size observed was a little less than expected. Similar results were reported by Vidović et al. (2011a), Su et al. (2007), Rosendo et al. (2007), Quinton et al. (2006), Petry et al. (2004) and Serenius et al. (2003). Selection for litter size since 1992 has led to a total response of 3.8 and 3.0 piglets per litter in Danish Landrace and Danish Yorkshire, respectively (Nielsen, 2004). The inbreeding coefficient obtained in the current study was almost zero. Limiting factors were probably the FYS effects and the feeding regime of the sows. Clearly, the feeding regime could be redefined in the future, which may result in further improvements in litter size. The variation observed at the end of the study indicates the potential for on-going selection progress to improve litter sizes.

**Fattening days and feed conversion.** Selection for feed conversion and age at slaughter (Graphs 3 and 4) produced the predicted decreasing trends. This shows that the selection

### Table 2
**Heritability, standard error and standard deviation of examined traits**

<table>
<thead>
<tr>
<th>Traits</th>
<th>Y + L</th>
<th>D + P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>h²</td>
<td>Sh²</td>
</tr>
<tr>
<td>Alive born</td>
<td>0.09</td>
<td>0.06</td>
</tr>
<tr>
<td>Alive at day fifth</td>
<td>0.11</td>
<td>0.07</td>
</tr>
<tr>
<td>Growth rate, g</td>
<td>0.28</td>
<td>0.12</td>
</tr>
<tr>
<td>Days of fattening</td>
<td>0.30</td>
<td>0.17</td>
</tr>
<tr>
<td>Feed conversion, g</td>
<td>0.34</td>
<td>0.18</td>
</tr>
<tr>
<td>Meat content, %</td>
<td>0.43</td>
<td>0.09</td>
</tr>
<tr>
<td>Protein rate, %</td>
<td>0.21</td>
<td>0.15</td>
</tr>
</tbody>
</table>

h² - heritability; Sh² - standard error of heritability; SD - standard deviation.
criteria for these most economically important traits were well defined. Selection intensity was controlled by producing the number of semen doses per jump. In the case of feed conversion, the improvement observed over the 11 years of the study was 90 kg per head. However, the fastest and greatest improvement was seen during the first five years. Since feed conversion and feed efficiency is a trait of average hereditability, it should be possible to continue with the selection effect, i.e. to further decrease feed conversion, then increase feed efficiency and thus reduce cost and increase profit per kg of live weight gain. The feeding regime and management of gilts and sows was changed, improved according to new knowledge, to previous one. This change has significant influence on genetic potential of both, gilts and sows. Similar trends have been shown by Bergsma et al. (2010), Quinton et al. (2006), Rydhmer (2000), Chen et al. (2002).

There were no selection differences between Landrace, Yorkshire and Duroc pigs, so their grouped data are shown in Graph 4. At the end of the study, these pig breeds required on average 154 days to grow to slaughter weight, compared with the 196 days required at the start of the study. This was a decrease of 42 days over the 11 years of the study. Economically, this was an improvement of about € 20 per pig. Pietrain pigs, while also improved, experienced significantly less daily weight gain and were consequently a greater age at slaughter compared to the three other breeds. Comparisons of age and feed conversion between Duroc and Pietrain pigs are presented in Graph 5. Duroc pigs required 32 fewer days to achieve commercial slaughter weight, and consumed 88 kg less feed while doing so. This reduced quantity of Duroc feed translated into a € 19 cost reduction compared to the cost of the feed for Pietrain pigs. These results are similar to Edwards et al. (2006), Solanes et al. (2004), Latorre et al. (2003).

**Carcass quality.** In the case of the well-known and currently-observed negative genetic correlations between milk yield and carcase meat content, breeders have to optimize selection criteria and use specialized sire and dam lines in their breeding programs. In the current study, pig breeds were di-

Graph. 4. Differences in age at slaughter between Duroc and Pietrain pigs

Graph. 5. Effect of selection for percentage of meat content in carcasses of Landrace and Yorkshire pigs
vided into two groups selected according to totally different
criteria; Landrace and Yorkshire were dam lines, while the
terminal sire lines were Duroc and Pietain. After 11 years of
selection, carcass meat content had increased among all pig
breeds (Graphs 5 and 6).

For the post-F₁ pig generations in the study (i.e. the last
eight generations of selection), the effect of the selection cri-
teria on meat content in Landrace and Yorkshire pigs was not
statistically different, even though optimal increases were
achieved (Graph 5). Since these pig breeds are treated as dam
lines to provide a heterosis effect in the F₁ generation dur-
ing breeding, selection criteria were naturally concentrated
more on fertility traits. Additionally, the realized increase in
carcass meat content was very close to the predicted one. At
the end of the study, the content of meat in the carcasses was,
on average, 57.6% in Landrace and Yorkshire pigs (Graph 5),
and 59.7% in Duroc pigs (this was not significantly different).
Pietrain carcasses contained 62.3% meat, which was signifi-
cantly more than Duroc, even they selected using same crite-
ria (Graph 6). Finally, in spite of the increased meat content,
the potential breeding animals, Landrace and Yorkshire had
deposited back fat of between 16- 20 mm at slaughter age.
This is significant, since later on, these animals, if they are
going to be parents, must have some fat reserves to produce
progeny.

Bone density did not differ significantly between Lan-
drace, Yorkshire and Duroc pigs. In contrast, Pietrain bones
were significantly lighter. This demonstrates the lower
growth in this breed compared to the other breeds, and the
fact that they required 24 to 32 days longer feeding to reach
slaughter weight. When just growth was compared, Pietrain
pig growth was significantly less compared with their peers
of other breeds.

Graph 6 shows differences in carcase meat content be-
tween Duroc and Pietrain pigs, even though these breeds were
subjected to the same selection criteria. The only differences
were at the beginning of start trial. The differences of 3.4%
greater meat content or 2.5 kg meat per carcass (1% of meat
= 0.8 kg of meat), translated into about € 8 greater profit from
Pietrain carcasses compared to Duroc carcasses at the end of
the study. In total, however, Duroc pigs produced about € 14
more profit than Pietrain pigs when their more efficient feed
conversion and much shorter fattening period were taken into
account as well. Similar conclusions were produced by Lukač
et al. (2013), Lukač et al. (2012), Vidović et al. (2011b), Bergs-
ma et al. (2010), Edwards et al. (2003), Nguyen et al. (2005),
Latorre et al. (2003).

The selection effects in meat content, %: - Duroc:  4, 7
- Pietrain: 1, 9

Meat quality. At the end of the study, after 11 years of
breeding according to the chosen selection criteria, intra-
muscular fat content in the final carcasses was: 0.8% in Pi-
etrain, 2.6% in Duroc, 2.0% in Landrace and 1.8% in York-
shire pigs. The level of protein, one of the most important pa-
rameters of meat quality, was the lowest in Pietrain (20.1%),
and was 21.8%, 22.5% and 22.9% respectively in Landrace,
Yorkshire and Duroc. The terminal sire can strongly influ-
ence fat quality such as fatty acid composition, though it
seems that a three-way crossbred pig has intermediate val-
ues of parents for carcass and meat quality traits (Suzuki et
al., 2003).

Conclusion

The selection criteria for the chosen traits were close to
optimal. Clearly genetically inherited traits were improved
for each of the pig breeds. Litter size increased with time,
with approximately 0.25 more live born piglets per genera-
tion. The feeding regime and management of gilts and sows
was changed to previous one. This change has significant in-
fluence on genetic potential of gilts and sows.

At the end of the study, Landrace, Yorkshire and Duroc pig
breeds required, on average, 42 days less to grow to slaughter
weight, compared with the number of days they required at
the start of the study. Selection of pigs according to the cri-
teria of live weight gain and age at slaughter improved these
characteristics amongst Landrace, Yorkshire and Duroc pigs,
but no differences were seen between them at the end of the
study. Pietrain pigs, while also improved over the course of
the study, experienced significantly less daily weight gain
and were consequently a greater age at slaughter compared to
three other breeds. This impacted on the economics of keep-
ing this pig breed, with greater cost and less profit.
Also carcass meat content was able to be improved by selection. Selection efficiency was higher for Duroc pigs compared with Pietrain pigs. Pietrain pigs produced carcasses with 3.4% more meat than Duroc carcasses but the much longer period of fattening resulted in overall reduced profits. Intramuscular fat was much lower in Pietrain carcasses (0.8%) compared to Duroc pig carcasses (2.6%). This resulted in a negative effect on Pietrain pig meat quality.

Acknowledgments

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