Bulgarian Journal of Agricultural Science, 21 (No 3) 2015, 687-692
Agricultural Academy

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

V. VIDOVIĆ[1], D. LUKAČ[1], V. VIŠNJIĆ[2], A. STOISAVLJEVIĆ[2] and M. STUPAR[1]
[1]*University of Novi Sad, Faculty of Agriculture, Department of Animal Sciences, Serbia*
[2] *Carnex Ltd. Meat Industry, Vrbas, Serbia*

Abstract

VIDOVIĆ, V., D. LUKAČ, V. VIŠNJIĆ, A. STOISAVLJEVIĆ and M. STUPAR, 2015. Effect of different selection criteria for litter size, growth performance and carcass traits improvement of the pigs in Serbia. *Bulg. J. Agric. Sci*., 21: 687–692

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

E-mail: vidovic.vitomir@gmail.com

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;

μ - 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

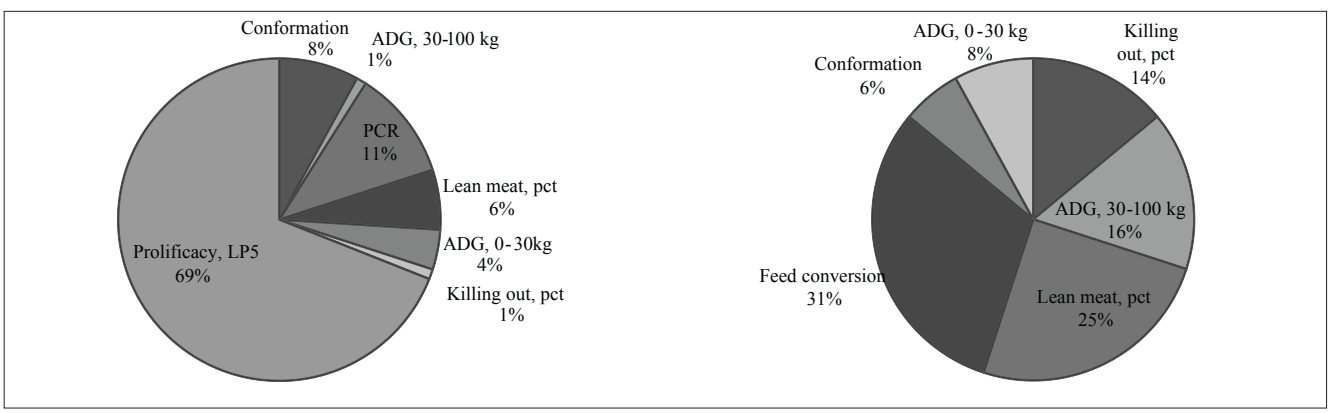
Results and Discussion

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

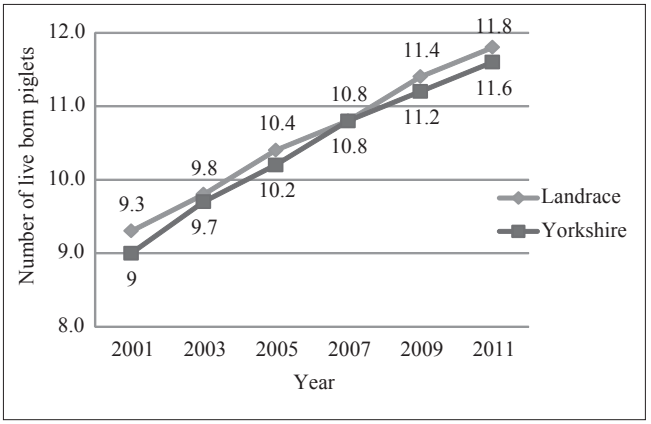
Table 1
Breed structure and number of pig carcasses analyzed

Breed	Sire	Dam	Progeny	No. of carcasses
Landrace	11	80	196	36
Yorkshire	12	74	182	36
Duroc	10	66	102	36
Pietrain	10	62	80	36



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.



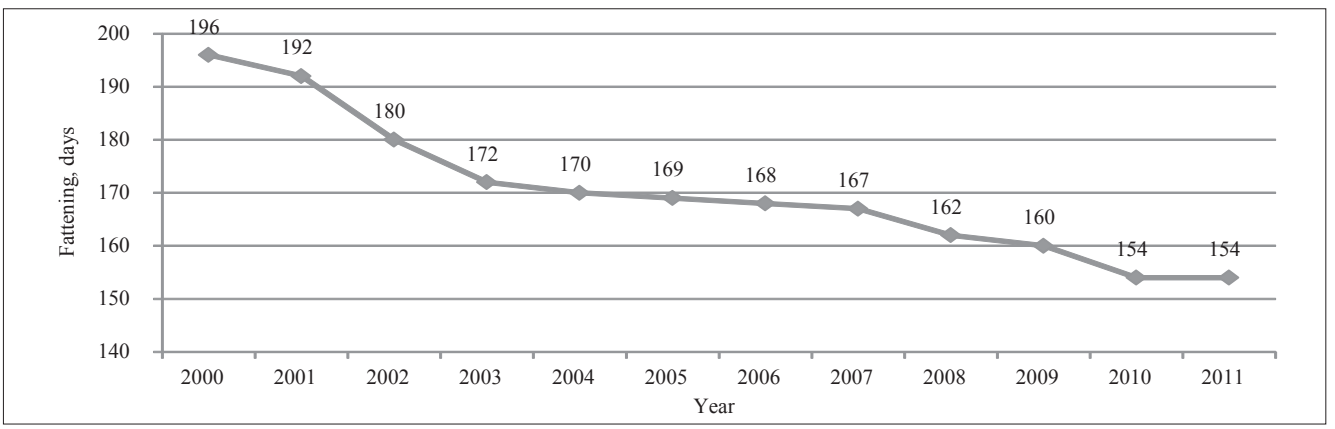
Graph. 2. Effect of selection on litter size at first farrowing of Landrace and Yorkshire

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

Traits	Y + L			D + P		
	h^2	Sh^2	SD	h^2	Sh^2	SD
Alive born	0.09	0.06	3.1	0.11	0.12	3.8
Alive at day fifth	0.11	0.07	2.1	0.11	0.12	3.1
Growth rate,g	0.28	0.12	64.0	0.31	0.16	87.0
Days of fattening	0.30	0.17	23.0	0.33	0.19	34.0
Feed conversion,g	0.34	0.18	46.0	0.33	0.21	64.0
Meat content, %	0.43	0.09	5.6	0.44	0.18	7.9
Protein rate, %	0.21	0.15	2.9	0.23	0.19	3.8

h^2 - heritability; Sh^2 - standard error of heritability; SD - standard deviation.

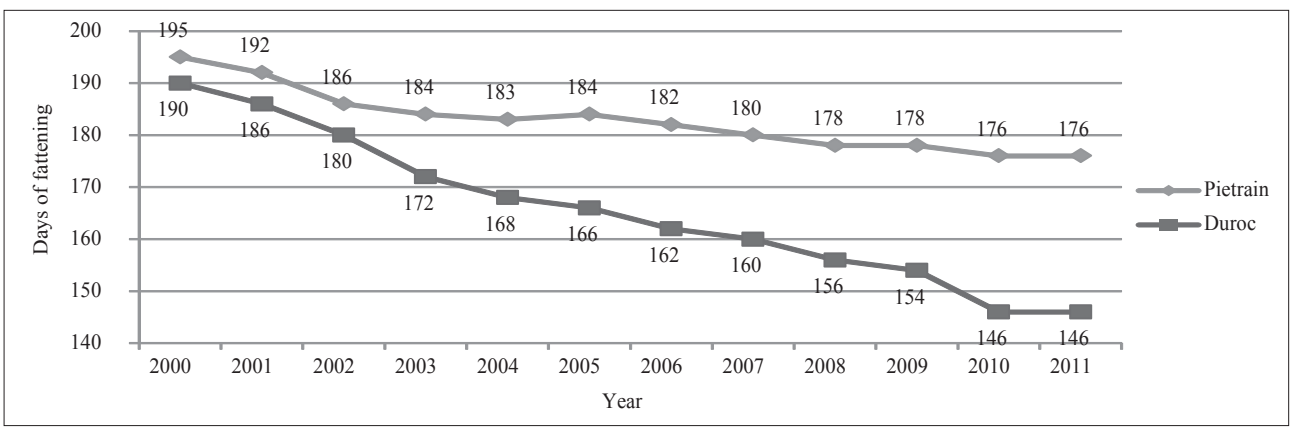


Graph. 3. Effect of selection on age at slaughter (indirectly on growth) and feed conversion for Landrace, Yorkshire and Duroc

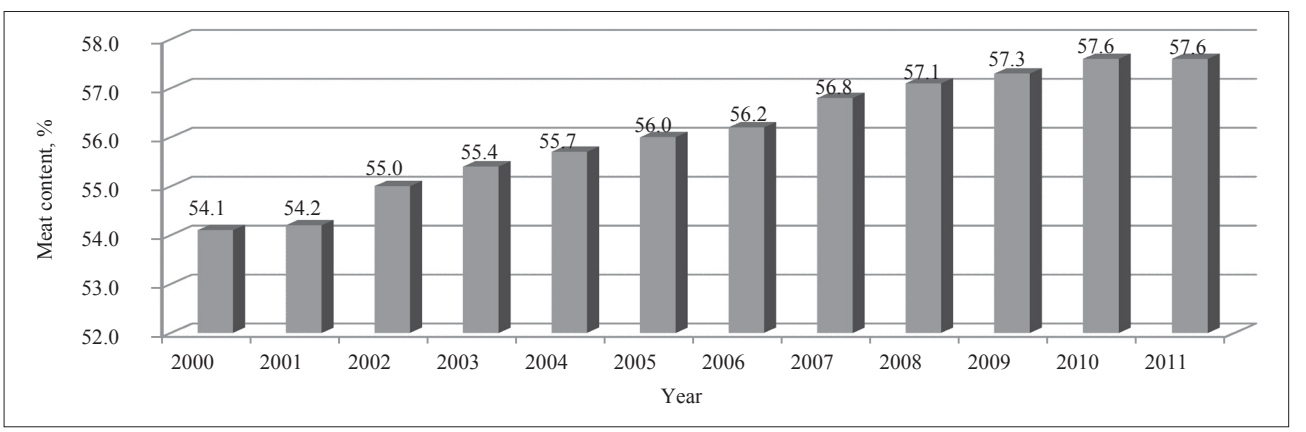
criteria for these most economically important traits were well defined. Selection intensity was controlled by producing the number of semen doses per jump. In the case of feed conversion, the improvement observed over the 11 years of the study was 90 kg per head. However, the fastest and greatest improvement was seen during the first five years. Since feed conversion and feed efficiency is a trait of average heredit-ability, 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 haves 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 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).

Carcase 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

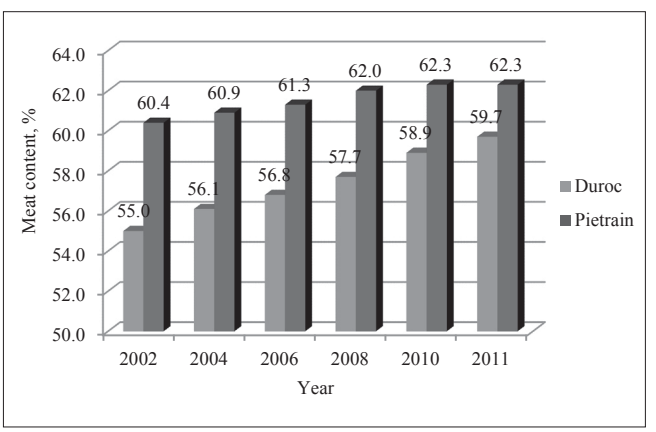


Graph. 5. Effect of selection for percentage of meat content in carcasses of Landrace and Yorkshire pigs

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, carcase meat content had increased among all pig breeds (Graphs 5 and 6).

For the post-F_1 pig generations in the study (i.e. the last eight generations of selection), the effect of the selection criteria 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 F_1 generation during breeding, selection criteria were naturally concentrated more on fertility traits. Additionally, the realized increase in carcase 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 significantly more than Duroc, even they selected using same criteria (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 Landrace, 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. The effects of selection for meat content of Duroc and Pietrain

Graph 6 shows differences in carcase meat content between 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), Bergsma 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, 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. The level of protein, one of the most important parameters 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 influence fat quality such as fatty acid composition, though it seems that a three-way crossbred pig has intermediate values 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 generation. The feeding regime and management of gilts and sows was changed to previous one. This change has significant influence 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 criteria 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 keeping this pig breed, with greater cost and less profit.

Also carcase 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

Research was financially supported by the Ministry of Science and Technological Development, Republic of Serbia, project TR31032. Also, these results are part of the project No 114-451-3464/2013-01, which is financially supported by the Provincial Secretariat for Science and Technological Development, Autonomous Province of Vojvodina, Republic of Serbia.

References

Bergsma, R., E. Kanis, M. W. A. Varstegen and E. F. Knol, 2010. Genetic Correlations between Lactation Performance and Growing – Finishing Traits in Pigs. **Proceeding of the Ninth WCGALP**, Leipzig 41.

Chen, P., T. J. Baas, J. W. Mabry, K. J. Koehler and J. C. M. Dekkers, 2003. Genetic parameters and trends for litter traits in US Yorkshire, Duroc, Hampshire, and Landrace pigs. *Journal of Animal Science*, **81**: 46–53.

Chen, P., T. J. Baas, J. W. Mabry, J. C. M. Dekkers and K. J. Koehler, 2002. Genetic parameters and trends for lean growth rate and its components in U.S. Yorkshire, Duroc, Hampshire, and Landrace pigs. *Journal of Animal Science*, **80**: 2062–2070.

Edwards, D. B., R. J. Tempelman and R. O. Bates, 2006. Evaluation of Duroc- vs. Pietrain-sired pigs for growth and composition. *Journal af Anim Science*, **84**: 266-275.

Edwards, D. B., R. O. Bates and W. N. Osburn, 2003. Evaluation of Duroc- vs Pietrain-sired pigs for carcass and meat quality measures. *Journal of Animal Science*, **81**: 1895–1899.

Hanenberg, E., E. F. Knol and J. W. M. Merks, 2001. Estimates of genetic parameters for reproduction traits at different parities in Dutch Landrace pigs. *Livestock Production Science*, **69**: 179–186.

Lukač, D., V. Vidović, Lj. Štrbac, D. Punoš, V. Višnjić and M. Stupar, 2013. Phenotypic and genotypic analysis of carcass quality traits in pigs. *Veterinarski glasnik*, **64** (3-4), (in press).

Lukač, D., V. Vidović, Lj. Štrbac, D. Punoš and M. Stupar, 2012. The influence of breed and sex on tissue distribution in pig carcasses. *6th Central European Congress on Food*, Novi Sad,23-26 May, 1670-1674.

Latorre, M. A., P. Medel, A. Fuentetaja, R. Lázaro and G. G. Mateos, 2003. Effect of gender, terminal sire line and age at slaughter on performance, carcass characteristics and meat quality of heavy pigs. *Animal Science*, **77**: 33-45.

Nguyen, N. H. and C. P. Mcphee, 2005. Genetic parameters and responses of performance and body composition traits in pigs selected for high and low growth rate on a fixed ration over a set time. *Genetics Selection Evolution*, **37**: 199–213.

Nielsen, B., 2004. LG5 – new goal for litter size. Dan Avl Magasinet, pp. 19–20.

Petry, D. B. and K. Johnson, 2004. Responses to 19 generations of litter size selection in the Nebraska Index line. I. Reproductive responses estimated in pure line and crossbred litters. *Journal of Animal Science*, **82**: 1000–1006.

Rosendo, A., T. Druet, J. Gogué, L.Canario and J. P. Bidanel, 2007. Correlated responses for litter traits to six generations of selection for ovulation rate or prenatal survival in French Large White pigs. *Journal of Animal Science*, **85**: 1615-1624.

Rydhmer, L., 2000. Genetics of sow reproduction, including puberty, oestrus, pregnancy, farrowing and lactation. *Livestock Production Science*, **66**: 1–12.

Serenius, T., M. L. Sevon-Aimonen, A. Kause, E. A. Mantysaari and A. Maki-Tanila, 2003. Selection potential of different prolificacy traits in the Finnish Landrace and Large White populations. *Acta Agriculturae Scandinavica Section A*, **54**: 36–43.

Solanes, F. X., K. Grandinson, L. Rydhmer, S. Stern, K. Andersson and N. Lundeheim, 2004. Direct and maternal influences on the early growth, fattening performance, and carcass traits of pigs. *Livestock Production Science*, **88**:199–212.

Suzuki, K., T. Shibata, H. Kadowaki, H. Abe and T. Toyoshima, 2003. Meat quality comparison of Berkshire, Duroc and crossbred pigs sired by Berkshire and Duroc. *Meat Science*, **64**: 35–42.

Su, G., M. S. Lund and D. Sorensen, 2007. Selection for litter size at day five to improve litter size at weaning and piglet survival rate. *Journal of Animal Science*, **85**: 1385-1392

Vidović, V., D. Lukač, Lj. Štrbac, D. Punoš, M. Stupar, 2011a. Genetic trends using different criteria of selection on specialized breeds in pigs. *Biotechnology in Animal Husbandry,* **27:** 1779-1786.

Vidović, V., S. Trivunović, D. Punoš, Lj. Štrbac, D. Lukač and M. Stupar, 2011b. Selection efficiency on bones and meat yield in pigs. *Biotechnology in Animal Husbandry*, **27**: 1787-1792.

Vidović, V. and D. Lukač, 2010. Animal genetics. *Faculty of Agriculture*, Novi Sad, 361 pp.

Vidović., V., 2009. Principles and methods of breeding animals. *Faculty of Agriculture*, Novi Sad, 348 pp.

Vidović, V., D. Lukač, Lj. Štrbac, D. Punoš and M. Stupar, 2012. Effect of differnt selection criteria on growth traits and carcass quality in pigs. **Proceedings of the** 6th CEFood, Novi Sad, pp. 1660-1665.

Quinton, V. M., J. W. Wilton, J. A. Robinson and P. K. Mathur, 2006. Economic weights for sow productivity traits in nucleus pig populations. *Livestock Science*, **99**: 69-77.

Wolf, J., E. Žáková and E. Groeneveld, 2005. Genetic parameters for a joint genetic evaluation of production and reproduction traits in pigs. *Czech Journal of Animal Science*, **50**: 96–103.

Wolf, J. and M.Wolfová, 2012. Effect of service sire on litter size traits in Czech Large White and Landrace pigs. *Czech Journal of Animal Science*, **57** (5): 220–230.

Received July, 23, 2014; accepted for printing January, 20, 2015.