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# GROWTH CHARACTERISTICS OF HYBRID PIG PREDICTED BY MEANS OF ASYMMETRIC S-CURVE

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## SUMMARY

***The present study was performed on 24 pigs distributed over two MHS-genotypes (NN, Nn) and two feeding regimes (intensive, restrictive). These pigs were investigated as the last of four trials in the experiment carried out by Kušec et al. (2005). The data on muscle and fatty tissue volumes were obtained by means of Magnetic Resonance Imaging (MRI). For the growth depiction and for the predictions of live weight as well as of muscle and fat tissue, four models developed by Kušec et al. (2007) were used. These models were set up on the basis of the general form of asymmetric S-function. This function seemed to fit well to the data collected in the present study; but the inaccuracy of the models appeared to increase with age. At the age of 124 days, the estimated values of live weight, muscle and fat volumes were close to the actual values measured in the group of intensively fed pigs; in the group of restrictively fed pigs live weight and muscle volume were underestimated while the volume of fat was overestimated. At the time of the last MR imaging (154 days of age), live weight and muscle volume was to some extent overestimated in the pigs fed intensively and underestimated in those fed restrictively. The volume of fatty tissue was estimated with favourable accuracy in all investigated groups of pigs. For further predictions, two approaches were used. In the first approach to predict individual live weights, at the age of 124 days, the predictions were fairly accurate for most of the pigs, falling in the range within one week; 4 of them being estimated falsely by more than ±7 days. Generally, when expressed as absolute value, the average misestimate was ~4 days in all groups, except for the restrictively fed MHS-gene carrier pigs which were estimated with 6 days difference on the average. At the age of 154 days, the predictions were to some extent less accurate; 7 pigs (in total) were incorrectly predicted by more than a week. The prediction accuracy was lower in the intensively fed pigs, ~6 days on the average; in the restrictive group of pigs, misestimates of live weight predictions were on the average ~4 and ~5 days for NN and Nn genotypes, respectively. Finally, in the second approach, the time that particular group of pigs would need to achieve a predetermined live weight of 100 kg was calculated. The closest prediction was achieved in the group of intensively fed MHS-homozygous negative pigs (4 days) while other groups were estimated with 6 days divergence from the actual age at 100 kg live weight. It was concluded that the predictions made by means of asymmetric S-function were fair enough for a pig producer to make a fattening plan or some other important decisions, e.g. in selection on growth traits.***

***Key words: pigs, growth, non-linear models, prediction***

## INTRODUCTION

Many mathematical models are used in order to describe the growth of domestic animals in the attempt to predict optimal slaughter time/weight or the development of body parts or tissues. Logistic function, Richard's function, various forms of generalised logistic functions is widely used in animal science; their use in production of pigs of different categories and genotypes are given by Pfeiffer et al. (1984). These functions have a characteristic S-shape, often called "sigmoid" or S-curve. The

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knowledge of the parameters in a model should enable the prediction of the live weights of an animal or their tissues, organs etc. in the future. For example, Kuhn et al. (1985) showed that the Gompertz function can be used in the prediction of muscle, fat and bone growth of pigs from birth until 245 days of life in three different feeding regimes. The same function was used in the determination of optimum slaughter age for pigs kept under feeding regimes which differed in energy content (Kuhn et al., 1987). The aim of the mentioned study was to maximize the utilisation of growth potential of meat i.e. to avoid the excessive deposition of fat in the pig carcasses. The asymmetric S-function being form of generalised logistic equation with a variable inflection point, proved to be appropriate for description of live weight growth of boars during the fattening period as presented by Kralik et al. (1993). By means of this function the authors found that boars with higher average daily gain reach the point of inflection (maximum daily gain rate) at an earlier age. Subsequently, their phase of progressive growth lasts relatively shorter than in animals with lower average daily gain. Knowledge of the function parameters allowed good prediction of the time animals needed to obtain a predetermined live weight (100 kg). The authors also concluded that the proposed model made possible the selection of animals according to the growth capacity of each individual. The same function was also used in analyses of phenotypic expression and growth characteristics of gilts from three different breeds (Kralik et al., 1999). The authors found that German Landrace (GL) gilts were characterised by faster growth and that they appeared to be an earlier maturing production type of pigs compared to the other two breeds of gilts (Swedish Landrace and SLxGL crossbreds). The described model enabled the selection of gilts regarding the growth capacity of individual animals.

MR imaging, along with other non-invasive techniques, is known to be appropriate for the estimation of muscle and fat tissue in pigs (Kolstad, 2001; Tholen et al., 2003; Baulain et al., 2004; Collewet et al., 2005; Monziols et al., 2006). Using this tool Kušec et al. (2007) acquired data in order to apply asymmetric S-function in the description of live weight, muscle tissue and fat growth patterns of German hybrid pigs. They found coefficients for constructing the S-curve that could depict the growth pattern of MHS negative (NN) and MHS gene carrier (Nn) pigs from two different feeding regimes. Authors pointed out that it will be tempting to test the ability of asymmetric S-function in the prediction of growth characteristics of other pigs, assuming that they are of the same genotype and reared under the same conditions. Therefore, the aim of this study is to use the S-function in order to examine the accuracy of predictions made by this model on the fattening pigs of different MHS-genotypes (NN and Nn) kept in intensive and restrictive feeding systems.

## MATERIAL AND METHODS

### *Animals used and experimental design*

The pigs from present study (n=24; 6 in each group) were investigated as the last of four trials in the experiment carried out by Kušec et al. (2005). In this experiment, 96 barrows were tested on fattening traits and no influence of the trial was observed, except for the feed intake in the finishing phase between the first and second trial. The barrows were 4-way-crosses with a Piétrain x Hampshire sire and a Large White x German Landrace dam, representing a common German hybrid pig used for fattening. The pigs were divided according to MHS-genotype (NN and Nn) and feeding regime (intensive and restrictive). The intensive regime was designed to supply the nutrients generously in order to support the full growth potential. In this group, pigs were fed *ad libitum* which represented unrestricted feeding system. The pigs from restricted feeding group were fed diets designed according to the recommendations of the Federal Hybrid Pig Breeding Programme (BHZP). The experimental design is shown in Table 1.

**Table 1. Animal distribution over MHS-genotype and feeding regime**
*Tablica 1. Raspodjela životinja u skupine prema MHS genotipu i sustavu hranidbe*

| Genotype – *Genotip* | NN | Nn |
|---|---|---|
| Restrictive feeding – *Restriktivna hranidba* | 6 | 6 |
| Intensive feeding – *Intenzivna hranidba* | 6 | 6 |

***MR imaging***

The data of muscle and fat tissue volumes were obtained by meansof magnetic resonance imaging (MRI). MRI measurements were performed at 4 week intervals, starting at the age of 10 weeks up to the final live weight of approximately 120 kg. The volumes of muscle and fat tissue were calculated by the mathematical method known as Cavalieri principle. This is the basis for the volume estimation as frequently used today (Roberts et al., 1993; Baulain and Henning, 2001).

***Growth analysis***

The basis for the pig growth analysis in the present study is a natural law found by Nelder (1961) and Lewandowski (1974):

$$\frac{dy}{dt} = cy(t) * (1 - (\frac{y(t)}{A})^{\gamma}, \; c > 0, \; \gamma > 0 \qquad (1)$$

which says that the weight gain of an organism in a certain moment is proportional to the weight of the organism at that moment *y(t)* and the biological potential at this moment *(A-y(t))*, where *A* is the chosen maximum weight of the species in question; where the two factors have a different intensity of action on the weight gain at different time intervals. The A value from this study was set up to be 220 kg and 160 kg for intensive and restricted group, respectively. These live weights are clearly not the biological maximum weights of pigs, but the present study was limited not only by the commercial conditions but also due to the size of the tomograph (at most 120 kg live weight). More detail on maximum weight of pigs as used for this kind of analysis was discussed by Kušec et al. (2007).
For the depiction of live weight growth as well as the growth of muscle and fat tissue, four models were applied to the specific experimental group. These models were developed by Kušec et al. (2007) on the basis of general form of asymmetric S-function:

$$f(t) = \frac{A}{(1 + be^{-c\gamma t})^{1/\gamma}} \qquad (2)$$

The parameters of the models for pigs of different MHS genotype kept in two feeding regimes are presented in Table 2.

**Table 2. Model parameters used to depict the growth of live weight, muscle and fat tissue for investigated pigs (Kušec et al., 2007)**
*Tablica 2. Parametri modela za opisivanje rasta žive mase, mišićnog i masnog tkiva istraživanih svinja (Kušec i sur., 2007.)*

| | Parameters *Parametri* | Intensive - *Intenzivna* | | Restrictive - *Restriktivna* | |
|---|---|---|---|---|---|
| | | NN | Nn | NN | Nn |
| Live weight *Živa težina* | b | 0.054 | 0.057 | 0.058 | 0.057 |
| | c | 1.382 | 1.394 | 1.686 | 1.643 |
| Muscle tissue *Mišićno tkivo* | b | 0.069 | 0.081 | 0.071 | 0.070 |
| | c | 1.711 | 1.834 | 1.728 | 1.693 |
| Fat tissue *Masno tkivo* | b | 0.081 | 0.081 | 0.067 | 0.065 |
| | c | 1.414 | 1.363 | 1.349 | 1.312 |

On the basis of those models, predictions of live weights were performed by two approaches; the first one was a direct estimation for each individual pig and the second one was on the group basis.

**The first approach**

Knowing the parameters of the asymmetric S-function (c and $\gamma$) for a certain population enables direct solving of a differential equation for some given initial condition. This means that it is possible to predict the future live weight of an animal by knowing its live weight at a certain moment. The method of discretisation for the initial condition $y(t_0)=y_0$ (the first weight taken for an individual animal) yields the solution:

$$Y_{n+1}-y_n=h*c*y_n*(1-(y_n/A)^{\gamma});\ h=1, \qquad (3)$$

where $y_n$ is the live weight of an animal at the time n, $y_{n+1}$ is the predicted successive live weight at the time n+1, c is the parameter of the S-function, $\gamma$ is the coefficient of asymmetry (0.01) and h is constant.

**Second approach**

The asymmetric S-function can be mathematically rearranged to yield the equation for prediction of time the pigs would need to achieve certain predetermined live weight:

$$T=\frac{1}{c}*\gamma \ln b*((\frac{A}{W})^{\gamma}-1)^{-1}\ , \qquad (4)$$

where T is time, b and c are growth curve parameters, $\gamma$ is the coefficient of asymmetry and W is the chosen predetermined live weight.

**Statistical analysis**

Data obtained in this study were analysed by the factorial ANOVA procedure of SAS program package (Version 9.1; SAS Inst. Inc., 2003). The differences between the investigated groups were tested by LSD method. Growth model was developed using STATISTICA for Windows 7.1 (StatSoft, Inc. 2006). Predictions were calculated by spreadsheet calculator Microsoft Excel for XP (Microsoft Corporation, 2002) package.

## RESULTS AND DISCUSSION

In the present study, live weight, muscle and fat tissue volumes of hybrid pigs differing in MHS-genotype and feeding regime were measured repeatedly during the growth period. The results are presented in Table 3.

**Table 3. Real (means and standard deviations) and predicted values (in brackets) of live weights (LW), muscle (M) and fat (F) of investigated pigs at the time of MR imaging**

*Tablica 3. Prave (aritmetičke sredine i standardne devijacije) i procijenjene vrijednosti (u zagradi) živih masa (LW) , mišićnog (M) i masnog tkiva (F) istraživanih svinja u trenutku posljednjeg MRT mjerenja*

| Age - Dob (days - *dana*) | Measurement *Mjerenje* | Intensive - *Intenzivna* | | Restrictive - *Restriktivna* | |
|---|---|---|---|---|---|
| | | NN | Nn | NN | Nn |
| 68 | LW (kg) | 26.58$^a$±3.99 (27.27) | 24.08$^a$±4.71 (24.75)) | 29.83$^b$±1.89 (25.76) | 26.25$^a$±4.10 (25.21) |
| | M ($dm^3$) | 10.82$^a$±1.66 (8.89) | 9.95$^a$±2.17 (7.51) | 12.56$^b$±0.89 (8.57) | 10.96$^a$±1.77 (8.40) |
| | F ($dm^3$) | 3.20$^a$±0.75 (3.28) | 2.91$^a$±0.62 (2.93) | 3.93$^b$±0.62 (5.07) | 3.23$^a$±0.80 (5.01) |
| 96 | LW (kg) | 53.75±7.47 (53.03) | 48.25±8.22 (49.88) | 55.83±2.50 (51.2) | 52.17±6.15 (49.64) |
| | M ($dm^3$) | 21.18$^a$±2.78 (19.91) | 19.52$^b$±4.07 (18.81) | 23.90$^a$±1.01 (19.59) | 22.85$^a$±3.51 (19.08) |
| | F ($dm^3$) | 9.33±2.00 (8.83) | 8.24±2.20 (7.93) | 8.76±1.06 (11.50) | 8.26± 1.30 (11.19) |

| | | | | | |
|---|---|---|---|---|---|
| 124 | LW (kg) | $81.92^{a}\pm8.32$ (83.53) | $76.58^{b}\pm7.05$ (80.38) | $86.08^{a}\pm3.48$ (78.32) | $82.92^{a}\pm5.94$ (76.31) |
| | M ($dm^3$) | $32.96^{a}\pm4.07$ (32.92) | $31.66^{a}\pm3.88$ (32.71) | $37.56^{b}\pm1.38$ (32.72) | $36.14^{b}\pm4.30$ (31.92) |
| | F ($dm^3$) | 17.60±3.26 (17.29) | 16.53±3.18 (15.75) | 16.35±1.24 (14.15) | 15.70±1.81 (13.99) |
| 154 | LW (kg) | 111.83±10.13 (115.92) | 107.33±5.74 (113.26) | 109.08±4.48 (103.94) | 106.33±4.16 (101.72) |
| | M ($dm^3$) | $44.37^{a}\pm4.11$ (45.78) | $44.04^{a}\pm4.12$ (46.43) | $48.82^{b}\pm2.42$ (45.72) | $47.68^{a}\pm4.47$ (44.82) |
| | F ($dm^3$) | $29.20^{a}\pm5.22$ (27.98) | $26.79^{a}\pm4.32$ (25.92) | $21.17^{b}\pm2.03$ (21.80) | $21.17^{b}\pm1.91$ (21.14) |

Values within rows with different superscripts differ at $p<0.05$

It shows significant differences between the compared groups by the age of the pigs at the date of MR imaging. It can be seen that at the first measurement, MHS-homozygous negative (NN) pigs from restrictively fed group had significantly higher live weights, muscle and fat tissue volumes ($p<0.05$). At the age of 96 days, the only difference recorded was that of a lower muscle volume in intensively fed MHS-gene carriers (Nn) compared to other three variants ($p<0.05$). The same group of pigs had the lowest live weights at the age of 124 days, while MHS-negative pigs fed restrictively showed the highest muscle volumes ($p<0.05$). There were no evident differences between the groups in fat tissue volumes. At the time of the last tomography imaging (154 days of age), there were no significant differences in live weight, but the group of restrictively fed MHS-negative pigs had the highest muscle tissue volume ($p<0.05$) and both genotypes from intensively fed pigs had significantly more fatty tissue than the pigs of the both genotypes fed restrictively ($p<0.05$).

The values in the brackets from Table 3 refer to the live weights, muscle and fat volumes of pigs from the present trial, estimated by the general form of asymmetric S-function (2), using the parameters given in Table 2. These estimations are calculated on the group basis for a particular age. Although the estimated values resemble those that were actually measured, it seems that the inaccuracy of these predictions increases with age. Moreover, the measured growth traits of the intensively fed pigs from the present study were to some extent lower than expected; in the case of restrictively fed pigs these values were higher than expected on the basis of previous study (Kušec et al. 2007). This could be due the smaller number of pigs per group in the present study compared to that of the previous one which was performed on 68 pigs (approximately 24 pigs per group). Nevertheless, the most apparent were the differences between real and predicted live weights and muscle volumes of pigs under investigation at the age of 124 and 154 days. More precisely, at the age of 124 days the predicted values of live weight, muscle and fat volumes were close to the actual values measured in the intensively fed group of pigs, but in the group of restrictively fed pigs the values of live weight and muscle volume were obviously underestimated; the volume of fat was overestimated. At the time of the last MR imaging of the animals (154 days of age), live weight and muscle volume was to some extent overestimated in the pigs fed intensively and underestimated in those fed restrictively. The volume of fatty tissue in all investigated groups of pigs was predicted with favourable accuracy.

Using the asymmetric S-function, Kušec et al. (2007) proposed the optimal time and live weight for slaughtering pigs by feeding regimes and genotypes identical as in the present study. Unfortunately, this estimation could not be proven in the present investigation since at those live weights the pigs were too large to fit the tube of NMR tomography device. Nonetheless, the prediction power of the model was examined for live weights of the pigs that were recorded at last two MRI examinations. To complete such task, two approaches were used. The first approach was based on the predictions performed for each individual animal and the second approach was group based. In this approach, the parameters of the asymmetric S-function from Table 2 were used for direct solving of a differential equation (3) for a given initial condition. In this case the initial condition was the first weight taken for each individual pig. Using respective parameters mentioned above, the pigs from the investigated groups were individually evaluated in order to predict live weight at the age of 124 and 154 days.

Since individual weights of pigs at mentioned ages were recorded, the estimated time needed to reach them could be calculated. Subtraction of the age of pigs at particular weighing (124 and 154 days) from the age predicted in described manner obtained the accuracy of the model presented in Tables 4 and 5.

**Table 4. Individual live weights at 124 days of age and the differences between that age and the predicted one by the respective model**

*Tablica 4. Individualne žive mase u dobi od 124 dana i razlike između te dobi i dobi izračunate pomoću pripadajućeg modela*

| Nr. of the animal *Broj životinja* | Intensive – *Intenzivna* | | | | Restricted - *Restriktivna* | | | |
|---|---|---|---|---|---|---|---|---|
| | NN | | Nn | | NN | | Nn | |
| | LW (kg) | Age Δ (days) | LW (kg) | Age Δ (days) | LW (kg) | Age Δ (days) | LW (kg) | Age Δ (days) |
| 1 | 67.5 | -8 | 66 | -8 | 86 | 6 | 80 | 5 |
| 2 | 78.5 | 2 | 79 | -1 | 81.5 | 2 | 88 | 13 |
| 3 | 86 | -2 | 81.5 | -4 | 88.5 | 2 | 74.5 | 3 |
| 4 | 84.5 | 1 | 83 | -3 | 86.5 | 7 | 79 | 4 |
| 5 | 92 | 7 | 69.5 | -4 | 91 | 6 | 89.5 | 9 |
| 6 | 83 | -4 | 80.5 | -6 | 83 | 2 | 86.5 | 3 |

From Table 4 it can be seen that at 124 days of age, in most of the pigs the prediction was fairly accurate falling in the range within one week; 4 of them being estimated falsely by more than ±7 days. The most precise predictions were accomplished in the intensively fed homozygous negative (Nn) pigs. For one of them the model was inaccurate by only 1 day; for two of them the estimation was false by two days. In general, when expressed as absolute value, the average misestimate was ~4 days in all groups, except for the restrictively fed MHS-gene carrier (Nn) pigs which were estimated with 6 days difference on average.

**Table 5. Individual live weights at 154 days of age and the differences between that age and the predicted one by the respective model**

*Tablica 5. Individualne žive mase u dobi od 154 dana i razlike između te dobi i dobi izračunate pomoću pripadajućeg modela*

| Nr. of the animal *Broj životinja* | Intensive – *Intenzivna* | | | | Restricted - *Restriktivna* | | | |
|---|---|---|---|---|---|---|---|---|
| | NN | | Nn | | NN | | Nn | |
| | LW (kg) | Age Δ (days) | LW (kg) | Age Δ (days) | LW (kg) | Age Δ (days) | LW (kg) | Age Δ (days) |
| 1 | 95 | -13 | 100.5 | -7 | 108 | 3 | 103.5 | 3 |
| 2 | 107 | -2 | 109 | -4 | 103 | -2 | 108.5 | 10 |
| 3 | 116 | -4 | 117 | -2 | 113 | 4 | 102 | 5 |
| 4 | 119 | 3 | 109 | -9 | 111.5 | 8 | 102.5 | 2 |
| 5 | 123.5 | 6 | 104 | -3 | 114 | 6 | 111.5 | 8 |
| 6 | 110.5 | -8 | 104.5 | -15 | 105 | -2 | 110 | 3 |

At the age of 154 days, as shown in Table 5, the predictions were to some extent less accurate because 7 pigs were incorrectly predicted by more than a week. Nevertheless, MHS-homozygous negative (NN) pigs fed under restrictive feeding regime were predicted with the highest accuracy, having only one pig estimated with more than a week error. Intensively fed MHS-gene carrier (Nn) pigs were predicted with the lowest correctness; one pig from this group was predicted falsely by more than 2 weeks. The prediction accuracy was lower in the intensively fed pigs, ~6 days on the average; in the restrictive group of pigs, misestimates of live weight predictions were on the average ~4 and ~5 days for NN and Nn genotypes, respectively.

In the second approach, the duration of desired fattening period, i.e. the time that a particular group of pigs would need to achieve a certain predetermined live weight, was calculated. For this purpose the asymmetric S-function was mathematically rearranged to obtain equation 4. When parameters from Table 2 were interpolated into the equation, the data on the investigated groups of pigs were evaluated for a live weight of 100 kg. The results of those predictions, namely the accuracy of predicted time that pigs needed to achieve 100 kg live weight, are presented in Table 6.

**Table 6. The accuracy of prediction of the time in days that investigated pigs needed to achieve live weight of 100 kg**
*Tablica 6. Točnost procjene vremena (u danima) kojeg su istraživane svinje trebale za dostizanje žive mase od 100 kg*

| Pokazatelj – *Indicator* | Intensive – *Intenzivna* | | Restrictive - *Restriktivna* | |
|---|---|---|---|---|
| | NN | Nn | Nn | Nn |
| Mean age at 100 kg<br>*Srednja dob pri 100 kg* | 143 | 148 | 143 | 146 |
| Predicted age at 100 kg<br>*Procijenjena dob pri 100 kg* | 139 | 142 | 149 | 152 |
| Difference – *Razlika* | 4 | 6 | -6 | -6 |

It can be seen that the closest prediction was achieved in the group of intensively fed MHS-homozygous (NN) negative pigs (4 days) while other groups were estimated with 6 days divergence from the actual age at 100 kg live weight. However, all of the predictions are falling within the range of one week accuracy which can be considered as fairly well.

## CONCLUSION

The results of the present study show that the growth characteristics of investigated pigs were well described by the asymmetric S-function. The data on live weight, muscle and fat volumes fitted well with the points on the S-curve when previously published coefficients were applied. Inaccuracies in the predictions from the present study seem to have increased with age; they were most apparent at the age of 154 days, i.e. at the time of the last MR imaging of the animals.

The overall accuracy of the live weight prediction by asymmetric S-function at the age of 124 days was found to be fairly well, while at the age of 154 days, the predictions were to some extent less accurate. The predictions of the time that particular group of pigs needed to achieve predetermined live weight of 100 kg was fairly accurate as well. However, the fact that all of the misestimates fall within one week interval on the average shows that model could be functional in pig production.

Having this in mind, it can be concluded that the predictions made by means of asymmetric S-function were fair enough for a pig producer to make a fattening plan or some other important decisions. For example, such results could be used in selection on growth characteristics. This is the practical consequence of the present investigation on the application of mathematical models in the area of animal growth.

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## OSOBINE RASTA HIBRIDNIH SVINJA PREDVIĐENE POMOĆU ASIMETRIČNE S-KRIVULJE

### SAŽETAK

***Istraživanja prikazana u ovome radu izvršena su na 24 hibridne svinje raspodijeljene prema genotipu (NN i Nn) i sustavu hranidbe (intenzivna i restriktivna). Te su svinje ispitivane u posljednjem od četiri ponavljanja u istraživanjima koje su proveli Kušec i sur. (2005). Podaci o volumenu mišićnoga i masnoga tkiva dobiveni su primjenom magnetno-rezonantne tomografije (MRT). Za opisivanje rasta i za procjenu živih masa, mišićnoga i masnoga tkiva korištena su četiri modela, koje su ustanovili Kušec i sur. (2007.) primjenom asimetrične S-funkcije. Dobivene S-krivulje nisu previše odstupale od podataka prikupljenim u ovom istraživanju, ali je uočeno da se nepreciznost modela pojačava s dobi životinja. U dobi od 124 dana, procijenjene vrijednosti žive mase, mišićnoga i masnoga tkiva bile su blizu vrijednostima izmjerenim u skupini intenzivno hranjenih svinja; u skupini restriktivne hranidbe žive su mase i volumeni mišića bili podcijenjeni, dok je volumen masnoga tkiva bio precijenjen. U trenutku posljednjega MRT mjerenja (dob od 154 dana), živa masa i mišićno tkivo bili su precijenjeni u intenzivno hranjenih svinja, a podcijenjeni u skupini restriktivne hranidbe. Volumen masnog tkiva bio je procijenjen sa zadovoljavajućom točnošću u svih istraživanih skupina svinja. Za daljnja predviđanja koristila su se dva pristupa. U prvome pristupu predviđale su se individualne žive mase u dobi od 124 dana, a prognozirane vrijednosti bile su u rasponu od tjedan dana, osim u 4 slučaja, što se može smatrati prilično točnim. Općenito, prosječna pogreška u prognozi bila je četiri dana u svim skupinama, osim u skupini restriktivno hranjenih svinja, nositelja MHS-gena (Nn), u kojih je***

***pogreška prognoze iznosila 6 dana u prosjeku. U dobi od 154 dana, predviđanja su bila ponešto slabija; u 7 svinja (od ukupnoga broja) pogreška u prognozi iznosila je više od tjedan dana. Točnost prognoze bila je slabija u intenzivno hranjenih svinja (prosječna pogreška ~6 dana), dok je u restriktivnoj skupini prosječna pogreška za NN i Nn genotipove iznosila ~4, odnosno ~5 dana. Na kraju, primjenjujući drugi pristup, izračunalo se vrijeme koje bi skupina svinja trebala za porast do 100 kg. Najbliže predviđanje postiglo se u skupini intenzivno hranjenih MHS-homozigotno negativnih svinja (4 dana), dok je u ostalim skupinama odstupanje bilo 6 dana od dobi, pri kojoj je zaista dostignuta živa masa od 100 kg. Zaključeno je da se asimetrična S-funkcija može poslužiti u praksi za planiranje tova ili za donošenje neke druge važne odluke, na primjer u selekciji na svojstva rasta.***

***Ključne riječi: svinje, rast, nelinearni modeli, prognoza***

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