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ALLOMETRIC GROWTH OF TISSUES IN PIG HAMS

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Original scientific paper

SUMMARY

The aim of this study was to investigate the influence of MHS genotype on growth and development of muscle and fatty tissue in pig hams. The investigation was performed on 72 barrows divided into 4 groups according to genotype (NN and Nn) and feeding regime (standard and intensive). The data for analyses were collected by MRT imaging; the coefficients of allometric growth were calculated using simple allometric function. The allometric growth coefficients of muscle and fatty tissue showed that muscle tissue grow proportionally with the increase of live weight (b≈1), while fatty tissue grow faster compared to the live weight increase (b>1). The differences in allometric growth coefficients calculated for muscle and fatty tissues in the hams of investigated pigs were not statistically significant between the feeding groups and between the genotypes either (P>0.05).

Key-words: pigs, growth, MHS-genotype, MRT-imaging, allometry

INTRODUCTION

The growth of animals results from many biological processes. The genotype of an animal determines the maximal level to which these processes can carry on, while environment affects the degree of expression of this genetic potential. Understanding the relation between genotype and environment is of crucial importance for setting up the strategies and models which can yield in the expression of maximal growth potential. In past decades, many different mathematical models were used and developed for the purpose of domestic animal growth description, aiming to make reliable predictions and assumptions. The allometric growth analysis relies on the assumption that the proportions of an animal are determined by the overall weight. This understanding of growth is also known as differential or relative growth as it refers to growth of different tissues and the changing composition of the animal's body. One of the models often used in the description of these events is allometric function. Term differential or allometric growth means changing in the proportion of individual organs and body parts as they increase in size; it describes part-to-body relationship. Organs of the body and tissues grow in different intensity; as a consequence of differential growth, marked differences in the shape and composition of the body occur (Walstra and De Greef, 1995; Schinckel and Einstein, 1995). Fortin et al. (1983), on the basis of allometric analysis, concluded that growth coefficients for muscle, fat and bones show general pattern. Bones, which have lower growth coefficient, represent an early maturing tissue; muscles have allometric coefficient close to unity, meaning that they grow proportionally with the increase in total body weight; while fat, having allometric coefficient of growth higher than unity, is a late maturing tissue. Although sometimes criticised by some authors, e.g. Evans and Kempster (1979), allometric function is often used in the growth and development studies of individual tissues or organs due to its stable linear solutions and a straightforward biological interpretation.

MATERIAL AND METHODS

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This study was carried out on 72 barrows divided into four groups according to genotype (MHS) and feeding regime (BHZP standard and *ad libitum*). The pigs were 4 line crossbreds with a Piétrain (Pi) x Hampshire (Ha) sire and Large White (LW) x German Landrace (GL) dam, which represent standard fattener types of the German Hybrid Pig Breeding Program (BHZP=Bundes Hybrid Zucht Programm). The MHS genetic status of the pigs was determined by DNA – test, using polymerase chain reaction (PCR) and restriction fragment length polymorphism (RFLP) methods. On the basis of such genotyping, piglets were grouped in two genotypes: MHS-gene carrier (heterozygous, Nn) and MHS negative piglets (homozygous, NN).
During the experiment barrows were kept in single pens under the controlled microclimatic conditions, but two different feeding regimes. Standard feeding regime (group 1) represented current BHZP recommendations used in pig production. The intensive regime (group 2) was experimental, designed to support the full genetic potential of growth (unrestricted feeding system). The pigs from group 1 were fed *ad libitum* in the first period of fattening; during the finishing period they were fed restricted diets. The second group of pigs were fed *ad libitum* during the entire fattening period.
The data needed for growth analysis were obtained by the use of a MR tomograph in the process of MRI (magnetic resonance imaging). The MRI scanner had field strength of 1.5 Tesla, made by BRUKER Biospin GmbH, model Medspec BMT 15/100. Before the scanning, the pigs were sedated by applying Ursotamin at the doses of approximately 40 mg/kg live weight. The duration of the whole scanning procedure was approximately 1.5 hour per pig. MRT measurements were performed at 4 week intervals, starting at the age of 10 weeks up to the final live weight of approximately 120 kg. During the scanning a set of parallel slices (transverse orientation) was acquired. One sequence measurement contains 50 to 60 slices covering the entire body of the pig. The distance between the slices depended on the size of an animal, varying from 16 to 32 mm. By scanning the ham, a set of 9-12 images were acquired depending on the age and size of the pig (Figure 2). The images obtained were edited on the screen for statistical analysis. All partial cross section areas which were of no interest (e.g. bones, organs, background) were manually eradicated at a Silicon Graphics Workstation using an IDL program package (IDL Research Systems Inc., 1994). The remaining set of pixels were subjected to cluster analysis by the SAS statistic software package (SAS Institute Inc., 1989) which discriminates lean from fat areas on the MR image.

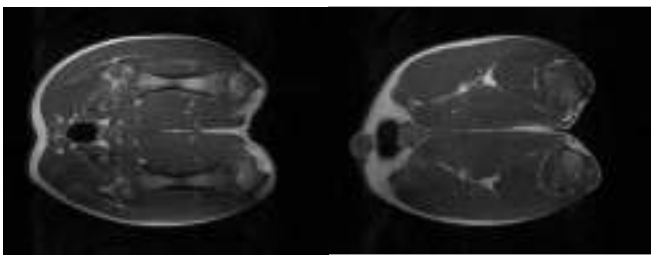

Figure 1. MR image of the transversal slice of the pig ham

Growth analysis
A simple allometric function was used for the depiction of differential growth of muscle and fatty tissue. This model describes a part-to-whole relationship and has the following form:

$$\log Y = \log a + b * \log X$$

where:
Y - the weight of tissue or a main part,
X - the weight of body or of a main part (in case that the growth of a particular tissue within this part is of concern),
a - intercept on y axis,
b - the allometric growth coefficient (slope)

Statistical analysis was performed by statistical package SAS software (SAS, Inst. Inc., 2000) and STATISTICA for Windows 6.0 (StatSoft, Inc. 1996.). Graphs and charts presented in this study were created using STATISTICA for Windows 6.0 and Microsoft Excel 97 (Microsoft Corporation, 1997) packages. The differences between groups were tested by two way ANOVA analysis from the SAS

6.12 GLM procedure. Differences between MHS genotypes within two feeding regimes and between two feeding regimes regardless the genotype were tested by LSD-test of STATISTICA for Windows 6.0 program package (StatSoft, Inc. 1996).

RESULTS AND DISCUSSION

Simple monophasic allometric function was used for the description of differential growth of muscle and fatty tissue in the ham of pigs. Allometric growth coefficients calculated for relative growth of muscle and fatty tissue volumes in the hams of investigated pigs are presented in Table 1. These results point out that muscle tissue grew proportionally with the increase in live weight of pigs ($b \approx 1$) while fatty tissue showed late maturing nature growing faster in relation to live weight of pigs ($b > 1$). Presented results are in agreement with the study of Kastelic (1997) who found that fatty tissue in hams of pigs grew significantly faster than their body weight. Similar results were obtained in the studies of Brandl (1988) and Fisher et al. (2003). Schinckel (2001) reported allometric growth coefficients which were different depending on the measurement, namely 0.776 for muscle tissue and 1.37 for total fatty tissue. Authors stated that it is possible to very accurately predict the contents of individual tissues in the pig carcasses by allometric model, but also that the prediction of fatty tissue growth is more precise than it is the case for muscle tissue.

Table 1. Allometric coefficients (b), standard error (SE_b) and coefficient of determination (R^2) for muscle and fatty tissue in the hams of pigs by feeding system and genotype

Tissue	Standard feeding			Intensive feeding		
	b	SE_b	R^2	b	SE_b	R^2
	NN + Nn			**NN + Nn**		
Muscle	1.03010	0.01433	0.97469	0.98391	0.01446	0.97266
Fatty	1.21818	0.02344	0.95272	1.29305	0.02946	0.93678
	NN			**NN**		
Muscle	1.02778	0.02135	0.97229	0.95453	0.01995	0.97032
Fatty	1.21240	0.03438	0.94587	1.33080	0.03754	0.94724
	Nn			**Nn**		
Muscle	1.03363	0.01916	0.97781	1.01886	0.01987	0.97842
Fatty	1.22431	0.03240	0.95581	1.25241	0.04643	0.92617

In the study differences between the growth of muscle and fatty tissues in the hams of pigs were not significant. This was approved by the results of Roehe et al. (2003) who started that; if the intensity of muscle and fat growth increase at the same manner, then the proportion do not change, though both tissues grow faster. Differential growth of muscle and fatty tissue in the hams of pigs under conditions of standard feeding is presented in Figure 2; while Figure 3 shows growth of these tissues under intensive feeding regime. In the experiment of Kušec et al. (2007), growth of fatty tissue in the whole body of investigated pigs was influenced by the feeding regime since the differences between allometric coefficients calculated for two feeding groups were statistically significant. The fact that intensive feeding results in significant differences in fat deposition in total body of the pigs and not in the hams, direct the investigation of fat distribution in other body parts of pigs.

Regarding the genetic status of investigated pigs in this study, no statistically significant differences in allometric growth coefficients were found. The curves depicting the allometric growth of muscle and fatty tissue evaluated for the MHS homozygous negative pigs (NN) and MHS heterozygous carriers (Nn) are presented in Figures 4 and 5, respectively. Investigating the influence of MHS-genotype on growth of total muscle and fatty tissue content Kušec (2007) also has not reported any significant differences between the NN and Nn genotypes.

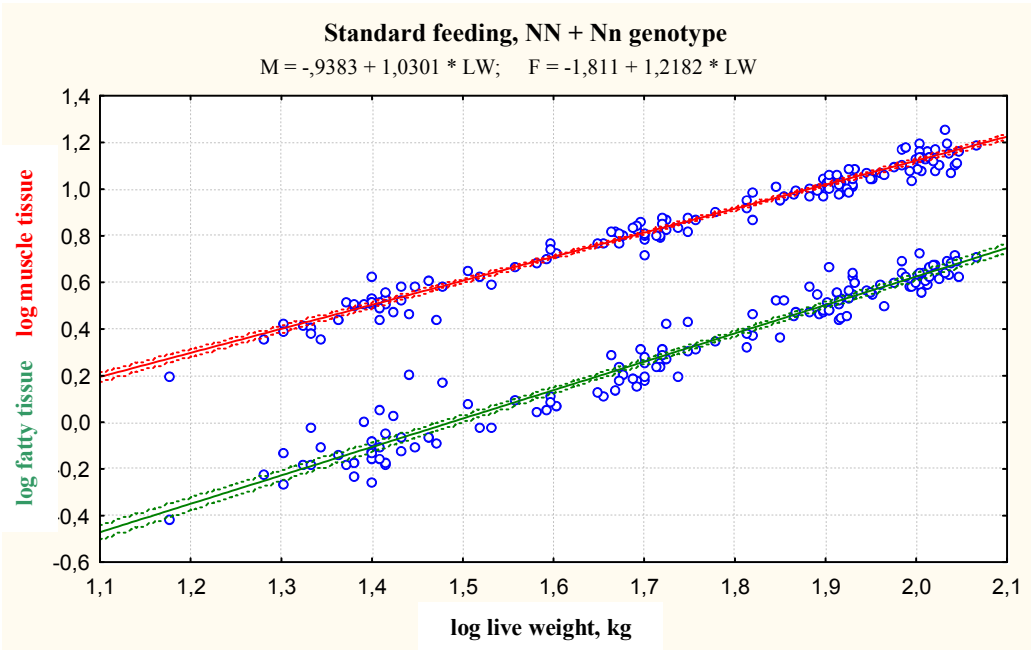

Figure 2. Differential growth of muscle and fatty tissue in the hams of pigs under conditions of standard feeding

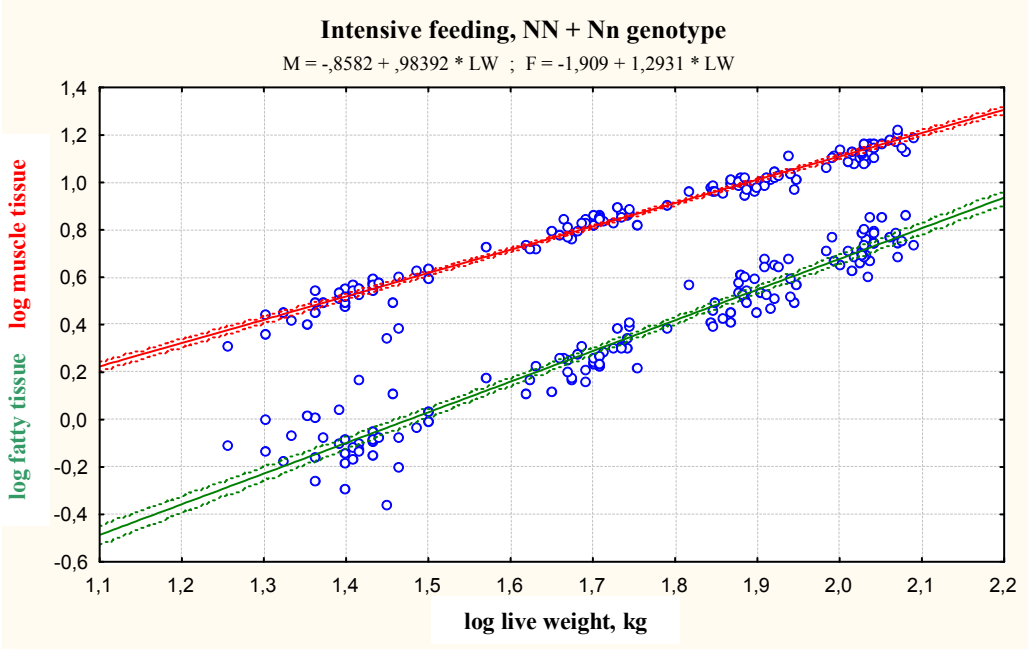

Figure 3. Differential growth of muscle and fatty tissue in the hams of pigs under conditions of intensive feeding

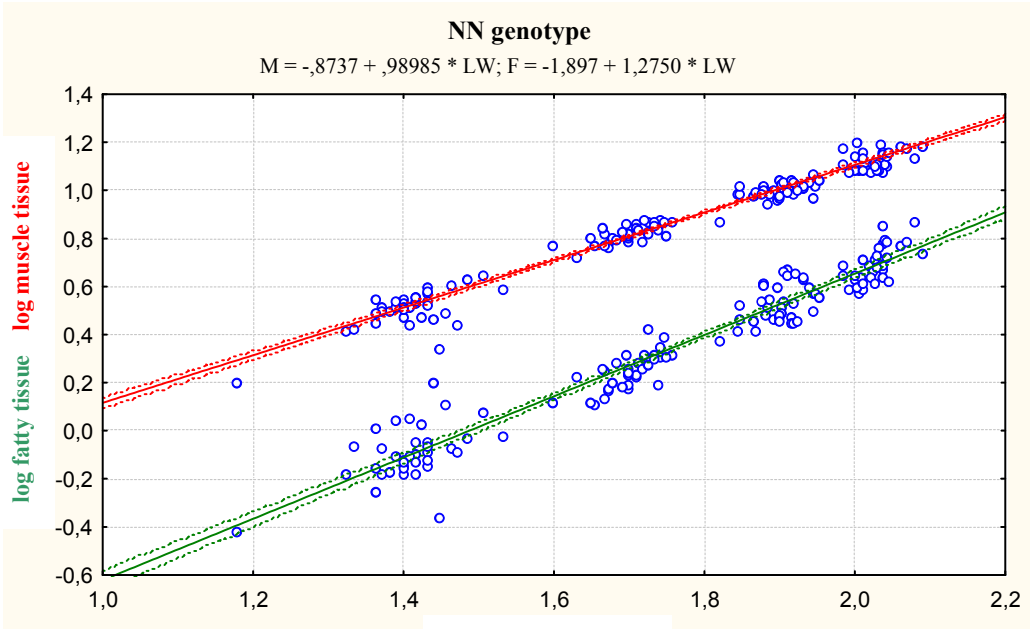

Figure 4. Differential growth of muscle and fatty tissue in the hams of the homozygous negative pigs (NN)

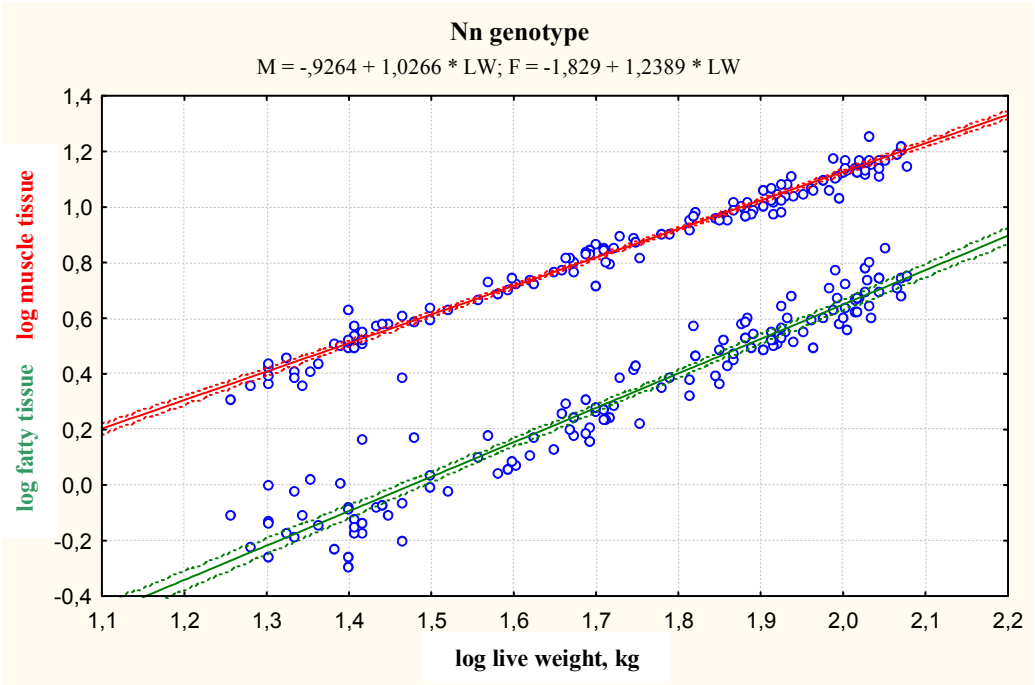

Figure 5. Differential growth of muscle fatty tissue in the hams of heterozygous carrier pigs (Nn)

The results presented here indicate that different feeding levels and MHS status of the pigs have no significant influence on the muscle and fatty tissue growth coefficients in the hams of pigs. Contrary to coefficients of allometry, the feeding intensity has effect on the fatty tissue content in the hams of pigs in certain periods of fattening (Margeta et al., 2007).

CONCLUSION

On the basis of presented results, it can be concluded that muscle tissue of the pig ham grows proportionally with the increase in live weight of the pig (b≈1). Fatty tissue of the pig hams, however, grows faster related to the live weight of pigs (b>1). The differences in allometric coefficients of muscle and fatty tissue growth in the hams between the feeding groups and genotypes of pigs were not statistically significant. The investigation of fat distribution in other body parts of pigs is needed in order to clarify the differences in total fat deposition between the pig groups fed standard and intensive (*ad libitum*) diets.

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