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Modelling of Body Mass Increase and Feed Conversion Ratio in Chickens ROSS 208

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Abstract

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The fattening efficiency evaluation in broilers, expressed in the European Efficiency Factor (EEF index) requires the information on mortality rate, body mass and feed conversion ratio reached at the age of their delivery to slaughter. This requirement is met by the use of the deterministic simulation model BIOM N 2001. In contrast to the contemporary widely used models of growth that describe the body mass growth as a function of time, the BIOM N 2001 model is based on the conversion of metabolizable feed energy into the gross energy deposited in the tissues of a growing warm-blooded animal. The results, obtained in an experiment with broiler chickens ROSS 208, demonstrate the formal compatibility of this new methodical approach with the classical growth function of Gompertz. The advantage of this new method is its compatibility with variables, generally used at well performing farms in the course of the fattening period, i.e. good agreement between the calculated values and those measured in an experiment, namely the amount of feed consumed under the measured climatic conditions of the breeding hall, the body mass of broilers (females – 2 374 g, males – 2 696 g), their age at slaughter maturity, and the feed conversion ratio. Taking into account the actual mortality of the flock it is easy to calculate the EEF index and to use the BIOM N 2001 model for the solution of prognostic or diagnostic tasks.

Broiler chickens, deterministic model, body mass, feeding

The classical approach to simulation of body mass growth by means of the Gompertz's function frequently used in the growth evaluation of broiler chickens (e.g. Rogers et al. 1987; Hurwitz and Talpaz 1997) describes the experimental growth curve as a function of time. Likewise Emmans (1997) derives the expected feed consumption in the growing organism from the time course of the Gompertz function.

The new approach in a simulation of body mass growth based on the conversion of metabolizable energy consumed in the feed, into mass and gross energy of proteins, lipids and carbohydrates deposited in the growing body was published by Novák L. (1996), Novák L. and Zeman (1997). The influence of air temperature, humidity and ventilation rate in the stable on the available net energy for production, compatible with parameters currently found in well performing farms was presented recently (Novák, P. et al. 2000). This knowledge was now incorporated into the series of the growth models BIOM and BIOM N 2001, published by Novák L. (2000, 2003).

The aim of this paper is to demonstrate the validity of the BIOM N 2001 model in simulation of body mass growth and feed conversion ratio data, with results of the carefully carried experiment on broiler chickens.

Materials and Methods

The growth experiment with broiler chickens ROSS 208 was carried out at the Research Institute for Animal Production Praha-Uhříněves. The experimental groups were kept separated by sex in pens (1.5·× 3 m) of 50

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birds each. Consumption of standardized feed mixtures BR1, BR2, BR3 fed from day 1, 11 and 35 of age, respectively, was recorded. The laboratory-controlled content of metabolizable energy was in BR1 11.89 MJ/kg, in BR2 12.04 MJ/kg and in BR3 12.76 MJ/kg. Temperature and air humidity in the hall was measured and controlled automatically day and night, and maintained within the range of values corresponding to the zone of thermoneutrality of growing chickens. Their feed consumption and body mass were measured at weekly intervals.

Body mass growth and feed conversion ratio in the growth model BIOM N 2001 is simulated by the mathematical sequence with variable differences of the daily body mass increases. The basic input parameters are: the initial body mass Gi for i = 0, and the genetic body mass limit GLi, in [kg] represents the value of live body mass reached by the individual with sexually and physically developed body. The daily body mass increase ΔGi, is defined in [kg/d]. The unit used for the time interval (Δt) in these calculations is one day (d).

$$\mathbf{G_{i+1} = G_i + \Delta G_i \,.\, \Delta t} \quad [\text{ kg }] \tag{1}$$
$$\mathbf{\Delta G_i = (0.18.IFI - 0.3.STX - 0.3).G^{3/4}.\, [0.225.(1\text{-}G/GLi)+0.027.G/GLi]} \quad [\text{kg/d}] \tag{2}$$

The calculation of daily feed intake DFI [kg/d], and total feed intake TFI [kg] is regulated by the dimensionless Index of Feed Intake (IFI). The values of this index move between 0 < IFI < 5.5. The actual value of IFI index represent the ratio of daily metabolizable energy intake in the feed consumed to the actual value of basal metabolism (see equation 3). The index STX indicates the relative increase of the basal metabolic rate needed for compensation of the impact of various stress factors, they do increase the value of the maintenance metabolism. Under the optimal conditions, the value of STX index is close to zero (Novák P. et al. 2000). The relation between the IFI index and the daily feed intake (DFI) is described by equation (3).

$$\mathbf{DFI = 0.3.IFI.\, G^{3/4} / SMEF / UTL / DMF} \quad [\text{kg/d}] \tag{3}$$
$$\mathbf{TFIi{+}1 = TFIi + DFIi \,.\, \Delta t} \quad [\text{kg}] \tag{4}$$

SMEF – Specific Metabolizable Energy content in the Feed [MJ/kg],
UTL – index of the consumed feed utilisation [kg/kg],
DMF – Dry Matter content in the Feed [kg/kg].

With the aim to compare the course of the growth curve simulated by the BIOM N 2001 model with some of the classical growth functions, the simultaneous of experimental data was done by the Gompertz function (see equation 5).

$$\mathbf{G_t = GLi \,.\, exp(-B.exp(-\, a.t))} \quad [\text{kg}] \tag{5}$$

B and (a) are the Gompertz exponents,
(t) is the age of chickens expressed in days.

Results

The age-dependent body mass growth and feed conversion ratio (FCR) are presented in Fig. 1 for female and in Fig. 3 for male broiler chickens.

The individual average body mass in females (n = 50; mortality 4%) reached 2 374 g by day 42 of age (ranging from 1 970 g to 2 760 g). At the age of 63 d the average body mass in the female group was 3 806 g, ranging from 3 200 g to 4 670 g.

In the experimental group of males (n = 50; mortality 0%), a higher average body mass was 2 696 g by day 42 d of age, ranging from 2 100 g to 3 290 g. In this group, the males reached an average body mass of 4 373 g on day 63 of age, ranging from 2 900 g to 5 370 g. Differences between the minimum and maximum body mass in the female and the male chicken groups did reach more than twofold value of the standard deviation on both sides around the average value.

The solid lines in Figs 1 and 3 indicate the compatibility of body mass growth and feed conversion ratio simulated by the BIOM N 2001. It is evident that they do correspond with the experimental values within the corridor outlined by the 10% distance around the average values. The course of the Gompertz curve is marked with dashed lines.

The corresponding simulation of developments of the EEF index for females is shown in Fig. 2, and for males in Fig. 4. The calculation of EEF index for both sexes indicates the better fit for the data of the BIOM N 2001 model than for the Gompertz function.

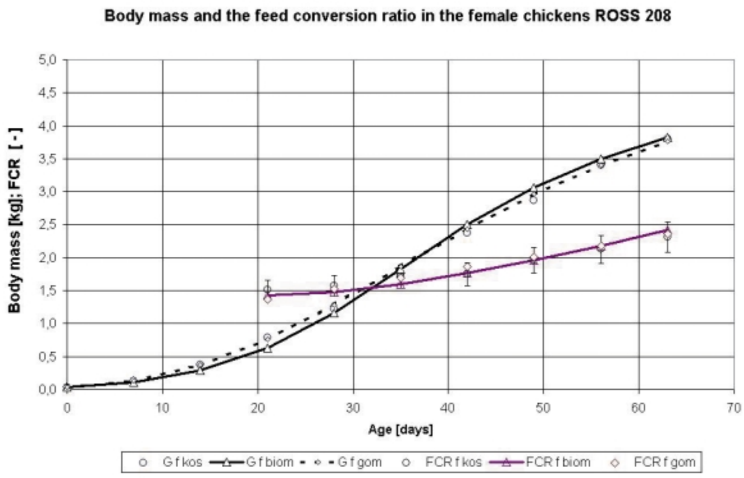

Fig. 1. Body mass and the FCR in female chickens. Gf kos- female chickens experimental data
Gf biom- female chickens body mass values calculated by the BIOM N 2001 method
Gf gom- female chickens body mass values calculated by the Gompertz method
FCR- feed conversion ratio calculated from experimental data
FCR f biom- feed conversion ratio calculated from BIOM N 2001 data
FCR f gom- feed conversion ratio calculated from Gompertz body mass data

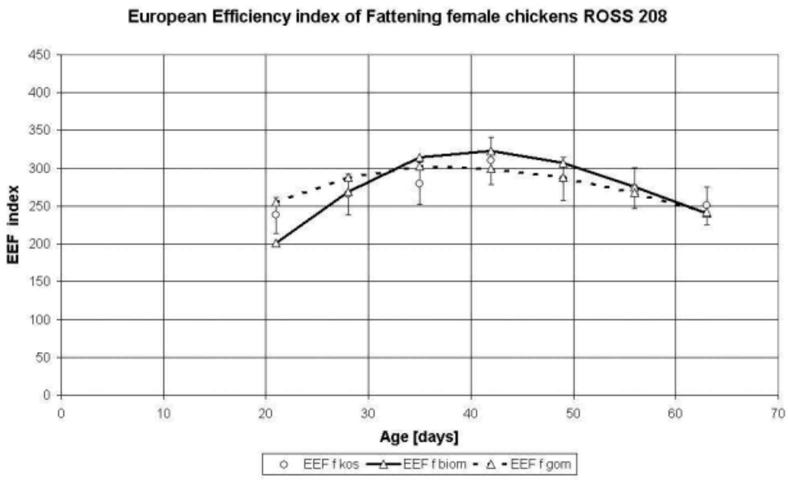

Fig. 2. Body mass and the feed conversion ratio in male chickens.
Gm kos- male chickens experimental data
Gm biom- male chickens body mass values calculated by the BIOM N 2001 method
Gm gom- male chickens body mass values calculated by the Gompertz method
FCR m kos- male chickens feed conversion calculated from experimental data
FCR m biom- male chickens feed conversion calculated from BIOM N 2001 data
FCR m gom- male chickens feed conversion calculated from Gompertz body mass data

Discussion

The values of the body mass growth curve in the BIOM N 2001 model are generated on the biophysical principle that defines the net energy value for production by using the IFI (index of feed intake that determines the intake of metabolizable energy) and the STX (index

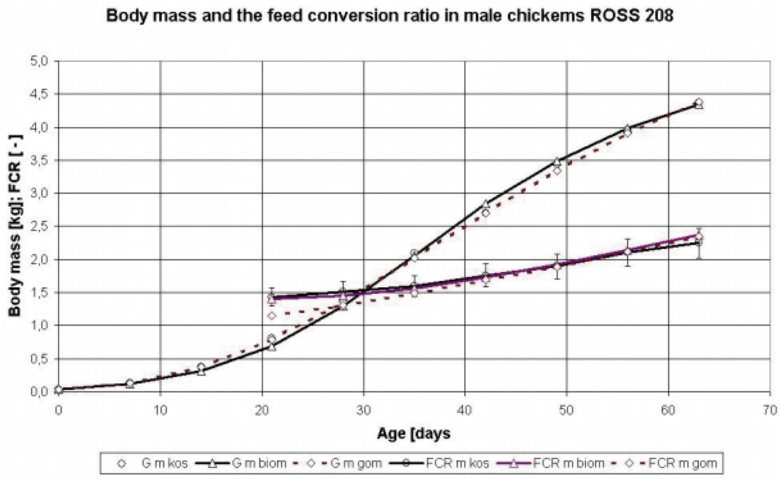

Fig. 3. European index of Fattening Efficiency in female chickens
EEF f kos - values of the EEF index estimated from the experimental data
EEF f biom- values of the EEF index estimated from the BIOM N data
EEF f gom -values of the EEF index estimated from the Gompertz data

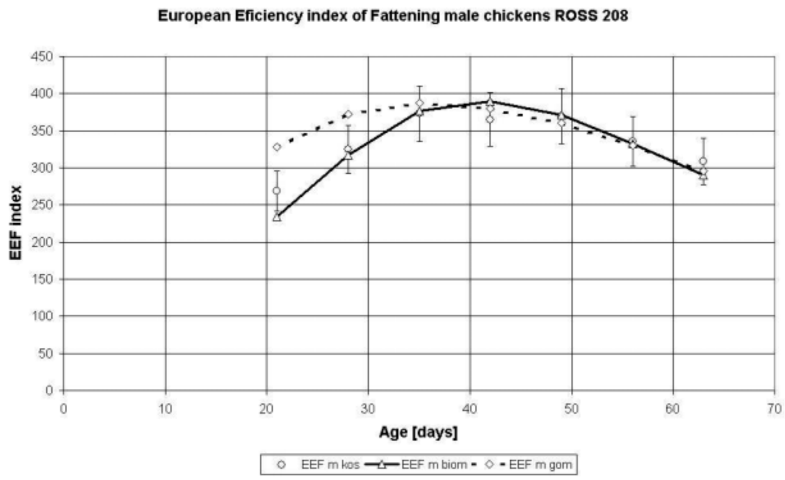

Fig. 4. European index of Fattening Efficiency in male chickens
EEF m kos - values of the EEF index estimated from the experimental data
EEF m biom- values of the EEF index estimated from the BIOM N data
EEF m gom -values of the EEF index estimated from the Gompertz data

of the stress factors that increase the value of maintenance requirement). The STX index quantitatively reflects the influence of temperature, humidity and air movement in the breeding hall and the quality of the maintenance care paid to the chickens (Novák P. et al. 2000).

Simultaneous evaluation of the experimental values by Gompertz growth function yielded the growth curve compatible with the curve simulated by the BIOM N 2001 model. We compared our results with those published by Hurwitz and Talpaz (1997) for Cobb chickens with the Gli = 4949 ± 124 g, and LaBelle with the Gli = 3146 ± 104 g.

The Gompertz exponents (a) found for Cobb chickens were a = 0.0377 ± 0.0008; for LaBelle chickens a = 0.038 ± 0.0115. In our experiment the values for female chickens were Gli = 4900 g with a = 0.0466. In male chickens the Gli = 6000 g, was a = 0.0444. We do agree with Hurwitz and Talpaz (1997) in that the Gompertz function copes in a flexible and precise manner with the minimum deviation of the experimental body mass growth data. At the same time it should be added that the Gompertz function sensibly reacts also to changes in the genetically limited body mass Gli. However, the Gompertz function, despite the effort of Emmans (1997) does not simulate directly the total feed consumption. Based on the coincidence of the body mass growth we did succeed, by means of the BIOM N 2001 model, to import the calculation of food consumption into the data of Gompertz function.

The values of the constant in the equations of the BIOM N 2001 model are derived for a virtual organism and are based on the common biological knowledge. This includes basal metabolic value of the obligatory thermostatic heat production expressed by the allometric formula (basal metabolism (BM) derived by Kleiber, $BM = 0.3.G^{3/4}$; MJ/d) (Kleiber 1961). Sex differences are represented by different values of genetically limited body mass GLi; kg. The model of virtual organism considers the lipid-free body mass to be composed of 20% dry matter and of 80% water. The dry matter consists of 20% minerals and 80% protein dry matter. The proportion of fat in the empty body of this virtual organism depends on the actual values of body mass maturity (G/GLi), on the state of feeding and the presence of stress factors expressed by the values of indexes IFI and STX. The amount of synthesized lipids is generated from the amount of net energy for production that remains after the needs for protein synthesis are met.

In conclusion, the developed approach for simulation of body mass growth and feed conversion ratio by the BIOM N 2001 function has been proved compatible with real data obtained in the experiment with female and male chickens ROSS 208. The simulation of body mass growth, feed conversion ratio and the age of the chicken slaughter maturity enable together with the data on mortality to express the changing value of the EEF index as shown in Figs 2 and 4. The structure of the presented BIOM N 2001 function enables a direct evaluation of food consumption and food conversion ratio as affected by various stress factors. Therefore a better fit of the experimental EEF values for the BIOM N 2001 model is reached. This methodology may be successfully used for the solution of diagnostic or prognostic tasks in the evaluation and control of feeding efficiency and its consequence for the economy.

Simulace zvyšování růstu hmotnosti a konverze krmiva u kuřat ROSS 208

Evropský index hodnocení efektivity výkrmu brojlerů (EEF index) vyžaduje znalost procenta úhynů, hmotnost těla a konverzi krmiva, dosaženou v době ukončení výkrmu. Tyto ukazatele jsou v práci využity v deterministickém modelu růstu Biom N 2001. Na rozdíl od současných metod modelování růstu, které provádějí výpočet růstu hmotnosti jako funkci času, model Biom N 2001 je založen na principu konverze metabolizovatelné energie přijaté v krmivu na energii uloženou do tkání rostoucího organismu. Výsledky, dosažené v pokusech na brojlerových kuřatech ROSS 208 ukazují formální soulad tohoto nového metodologického přístupu s výsledky klasické růstové funkce Gompertzovy. Výhodou použití této metody je její kompatibilita s ukazateli, běžně sledovanými v dobře vedených chovech v průběhu výkrmu brojlerů, a to souhlas mezi vypočtenými a v experimentu naměřenými hodnotami: množství spotřebovaného krmiva v měřených klimatických podmínkách chovné haly, hmotnosti brojlerů, jejich stáří v době porážkové zralosti a konverze krmiva. Při současné znalosti aktuální hodnoty mortality hejna, je možné na základě těchto dat počítat index EEF a využít tak model Biom N 2001 pro řešení prognostických i diagnostických úkolů.

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