

GROWTH OF SELECTED BONES AND MUSCLE GROUPS IN BROILER CHICKENS DURING REARING PERIOD

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Abstract. The aim of this study was to determine an increase in the length of skeletal bones and muscle groups in broiler pullets during the rearing period. The research material consisted of the Ross 308 broiler pullets. The analysis included keel bone, leg bones (tarsometatarsus, femur and tibia), wing bones (humerus and ulna) as well as breast, thigh, drumstick muscles and wing muscles located along humerus and ulna. Day-old chicks weighed 36.5 g on average and during the whole rearing period, i.e. until 6 weeks of age increased their body weight to 2229.2 g. From 1 to 42 days of age, the weight of wing muscles increased from 0.91 to 429.9 g, that of thigh muscles changed from 1.95 to 218.0 g and that of drumstick muscles increased from 1.27 to 140.7 g. At that time, the weight of wing muscles increased from 0.74 to 38.9 g. In day-old chicks, the lengths of tarsometatarsus, tibia, femur, ulna and humerus were 25.6 mm, 32.0 mm, 24.7 mm, 17.5 mm and 17.0 mm, respectively. The respective values for 6-week-old birds were 81.7 mm, 105.8 mm, 78.5 mm, 73.9 mm and 77.8 mm. A different growth rate of the analysed traits as well as a clear decrease in this rate with increasing age of birds were found. For most analysed traits, the rate of increase in muscle weight was three times higher than that in the length of individual skeletal bones. At that time, the keel length increased from 20.4 to 132.6 mm. Positive significant and highly significant relationships were found between most analysed traits such as: body weight of chickens and the weight of their breast and leg muscles.

Keywords: age, bones, broiler pullets, muscles

INTRODUCTION

In recent years, the flocks of the Ross 308, Cobb 500, Hubbard F-15 and Hubbard Flex sets have been reared most frequently in our country. The research performed on these birds concerned mainly the evaluation of basic production indices [Koreleski and Świątkiewicz 2000; Górski et al. 2002; Janocha et al. 2008]. However, few experiments were conducted in the field of evaluation of the growth of broiler chickens from the first

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to the last day of rearing and the changes occurring at that time in the growth and development of the skeletal and muscle systems. It seems that the studies on the growth of bones as well as their structure and changes, especially in the age of production intensification are justified. A negative effect of the fast growth can be seen, among others, in the commonly occurring lameness in broilers [Sanotra et al. 2003] or in the development of joint diseases [Kestin et al. 2001]. Moreover, Corr et al. [2003] emphasize that, with increasing growth rate, modern broilers clearly change their conformation. Also, the studies performed in our country show that the poor quality of the skeleton is a serious problem, affecting the economic results of rearing of slaughter birds and their welfare [Burs et al. 2008; Świątkiewicz and Świątkiewicz 2009; Tykałowski et al. 2010]. The results obtained by the cited authors were the reason for undertaking the present study. Its aim was to analyze the growth of the selected skeletal bones and muscle groups in broiler chickens during the rearing period.

MATERIAL AND METHODS

The research material consisted of the Ross 308 broiler pullets kept under standard environmental conditions. They were fed ad libitum full-ration diets, whose nutritive value is presented in Table 1. The chickens were reared for 42 days. During the whole rearing period, the body weight of chickens was measured by individual weighing of randomly selected birds at 1, 14, 21, 28, 35 and 42 days of age. The results of weighing were then used to determine growth rate calculated according to the formula given by Janiszewska [1993].

Table 1. Nutritive value and period of feeding standard feeds

Tabela 1. Wartość pokarmowa i okresy skarmiania mieszanek standardowych

Specification Wyszczególnienie	Feed type and period of use, days Rodzaj mieszanki i okres jej skarmiania, dni		
	KW-1 1-10	KW-2 11-25	KW-3 26-42
Metabolizable energy, kcal Energia metabol., kcal	2995	3050	3150
Crude protein, % Białko ogólne, %	22.0	20.2	19.0
Crude fibre, % Włókno ogólne, %	3.5	3.3	4.2
Lysine, % Lizyna, %	1.26	1.19	1.14
Methionine, % Metionina, %	0.58	0.55	0.54
Ca, %	0.90	0.80	0.75
Available P, % P przyswajalny, %	0.45	0.42	0.38

Moreover, at each of the aforementioned dates, 10 birds were selected from among the weighed ones and slaughtered. After slaughtering, bleeding and plucking, birds were weighed and then the slaughter analysis was conducted according to the method of Ziółcecki and Doruchowski [1989]. Carcasses chilled at 10°C were dissected after 24 hours. From each carcass, skin with the subcutaneous and abdominal fat, wing muscles (located along humerus and ulna), breast, thigh and drumstick muscles as well as the so-called carcass remainders (bones), were separated and weighed. From the carcass remainders, the following was precisely separated and determined:

- keel (*sternum*) length,
- tarsometatarsus (*os tarsometatarsale*) length,
- femur (*femur*) length,
- tibia (*tibia*) length,
- humerus (*humerus*) length,
- ulna (*ulna*) length.

The measurements were performed based on the methods by Driesch [1976] using the electronic caliper for biometric measurements of birds. The results were analysed statistically [StatSoft® 2001] by calculating the mean value and coefficient of variation for each trait. Due to the normal distribution of the traits, Pearson's correlation coefficient was used.

RESULTS AND DISCUSSION

The mean body weight of day-old chickens and their body weight in consecutive weeks of life are summarized in Table 2. Day-old chicks weighed 36.5 g on average and during the whole rearing period, i.e. until 6 weeks of age increased their body weight to 2229.2 g. In the study by Skomial et al. [2000], the Starbro broilers at the age of 49 days gained body weight of 2264 g, and in the study by Czaja and Gornowicz [2004] the same value for the Ross broilers ranged from 1900 to 2013 g. The body weight gains increased in consecutive weeks of rearing, amounting to 106 g at one week of age and 492 g at six weeks of age.

The data on the zoometric measurements of birds show the characteristic traits of body conformation [Bernacki and Adamski 2001; Biesiada-Drzazga 2007]. The measurements of keel length have great importance, among others, for determining the level of musculature in poultry. In day-old chicks, the keel length was 20.4 mm, and on the day of slaughter, i.e. at six weeks of rearing, it was 132.6 mm (Table 2). During the rearing period, its length increased over 6 times. However, the growth rate for keel length in the consecutive weeks of chickens' life decreased systematically from 72% at 1 week to 7% at six weeks.

On the other hand, the measurements of the length of tarsometatarsus, tibia and femur can be used for the evaluation of conformation and the level of leg musculature of a bird. In day-old chicks, the lengths of tarsometatarsus, tibiotarsus and femur were 25.6 mm, 32.0 mm and 24.7 mm, respectively, whereas in the 6-week-old birds the respective values were 81.7 mm, 105.8 mm and 78.5 mm (Table 2). Within six weeks, the length of above-mentioned bones increased over three times. The ulna and humerus lengths in day-old

chicks were 17.7 mm and 17.0 mm, respectively, whereas the respective values at 6 weeks of age were 73.9 mm and 77.8 mm. The length of these wing bones in the studied period increased over four times. The increase in the length of the analysed skeletal bones was rather different in individual weeks of life. Both in the first and the last week of broilers' life, the tibia and ulna as well as keel were characterized by the highest absolute increase.

Table 2. Mean values of body weight (in g) and some dimensions of body for broiler chickens (in mm) during rearing

Tabela 2. Wartości średnie masy (w g) i wybranych wymiarów ciała (w mm) kurecząt w okresie odchowu

Item Wyszczególnienie	Age, days – Wiek, dni							
		1	7	14	21	28	35	42
Body weight Masa ciała	\bar{x}	36.50	142.42	399.50	643.28	1251.20	1737.21	2229.20
	C_v	3.21	7.42	3.90	7.02	3.91	7.22	7.81
Keel length Długość mostka	\bar{x}	20.42	43.04	68.40	84.37	106.87	124.02	132.59
	C_v	3.11	2.13	0.92	7.11	3.45	5.12	2.31
Shank length (<i>os tarsometatarsale</i>) Długość skoku (kość stępowo-śródstopna)	\bar{x}	25.55	31.24	43.25	60.49	66.10	77.25	81.73
	C_v	1.53	7.72	4.76	9.21	3.61	3.73	2.85
Drumstick length (<i>tibia</i>) Długość podudzia (kość piszczelowa)	\bar{x}	32.02	42.83	60.31	71.36	87.45	94.15	105.77
	C_v	0.98	4.11	6.23	3.79	3.11	4.40	7.00
Thigh length (<i>femur</i>) Długość uda (kość udowa)	\bar{x}	24.70	32.15	44.80	52.64	63.95	77.22	78.45
	C_v	0.89	2.21	3.32	3.67	7.80	6.12	2.65
Humerus length Długość kości ramiennej	\bar{x}	17.00	25.59	40.83	51.09	60.98	70.52	77.75
	C_v	1.45	4.12	0.67	4.49	3.76	2.89	9.02
Ulna length Długość kości łokciowej	\bar{x}	17.54	21.18	40.29	48.41	57.43	64.70	73.94
	C_v	0.59	0.76	3.12	2.89	7.02	2.70	3.70

At 45 days of age, from among all the analysed skeletal bones, the highest length was characteristic of keel (132.6 mm), tibia (105.8 mm) and tarsometatarsus (81.7 mm). The length of tibia was significantly greater than that in the study by Kwiecień [2006]. The research on the bones in broilers is significant due to the production results obtained by birds. According to Wójcik [2008], the diseases of legs and problems with birds' locomotion can result in the inability of food and water intake and thus lower feed consumption and lower body weight gains. The most frequently mentioned leg problems in poultry are deformations of long bones (e.g. bent tibias).

The mean values for the weight of muscles separated from the carcass at successive dates are summarized in Table 3. From 1 to 42 days of age, the weight of breast muscles increased from 0.91 to 429.9 g, that of thigh muscles changed from 1.95 to 218.0 g and

that of drumstick muscles increased from 1.27 to 140.7 g. At that time, the weight of wing muscles increased from 0.74 to 38.9 g.

Table 3. Mean values of muscles weight (in g) separated from the carcass at successive dates
Tabela 3. Wartości średnie (w g) masy mięśni wydzielonych z tuszki kurcząt brojlerów

Item Wyszczególnienie	Age, days – Wiek, dni							
		1	7	14	21	28	35	42
Thigh muscles Mięśnie udowe	\bar{x}	1.95	12.63	27.63	52.63	101.02	147.93	217.95
	C_v	0.72	0.70	3.02	7.02	7.34	6.23	5.12
Drumstick muscles Mięśnie podudzi	\bar{x}	1.27	9.11	19.92	30.69	86.50	118.92	140.72
	C_v	0.23	1.60	0.72	2.11	3.08	7.63	3.23
Thigh and drumstick muscles Mięśnie nóg	\bar{x}	3.22	21.70	47.55	83.69	187.52	266.85	358.67
	C_v	1.32	3.71	2.62	3.42	7.05	8.11	8.20
Breast muscles Mięśnie piersiowe	\bar{x}	0.91	19.00	47.60	106.59	207.75	326.35	429.88
	C_v	0.39	2.43	2.11	3.73	7.13	4.04	3.45
Wing muscles I Mięśnie skrzydłowe I	\bar{x}	0.48	5.20	8.07	10.42	14.72	17.33	20.92
	C_v	0.30	0.70	0.65	0.45	0.43	1.34	0.97
Wing muscles II Mięśnie skrzydłowe II	\bar{x}	0.26	3.1	5.21	7.21	10.80	14.11	17.93
	C_v	0.21	0.51	0.23	0.55	1.11	1.09	2.45
Total wing muscles Mięśnie skrzydłowe łącznie	\bar{x}	0.74	7.3	13.28	17.63	25.52	31.44	38.85
	C_v	0.42	1.02	1.30	0.89	1.34	1.37	3.23

The growth rate of the analysed traits is presented in Table 4. The high growth rate of tarsometatarsi lasted until 3 weeks of rearing, that of tibia and keel till 28 days, and that of thigh bone till 35 days. After the aforementioned periods, the growth rate decreased gradually amounting to 2–3% in the last weeks of chickens' life (Table 4). On the other hand, during the first two weeks of rearing, the growth rate of the wing bones averaged approx. 40–45% and clearly decreased after this period in successive weeks of broiler chickens' utilization.

Young chickens were characterized by the greatest growth rate in the first two weeks of life (approx. 120–95%). In subsequent weeks, this rate decreased gradually, amounting to 25% between the fifth and the sixth week of rearing (Table 4).

For the most analysed traits, it can be stated that the growth rate of individual muscles was, on average, three times higher than that of the individual skeletal bones included in the analysis (thigh muscle weight – femur length, drumstick muscle weight – tibia length etc.).

From 1 to 42 days of age, the growth rate of the thigh muscles weight decreased from 146.5% to 38.3% and that of the femur length changed from 26.2 to 1.6%. The respective values for drumstick muscle weight and tibia length as well as for the breast muscle weight and keel length were 151.1–16.8%, 28.9–11.6%, 181.7–27.4% and 71.3–6.7%.

Analysing the rate of an increase in the body weight and body size of the broilers, it can be stated that, with increasing age, the growth rate of all analysed traits clearly decreased (Table 4). The highest growth rate concerned body weight of birds, then the length of keel and humerus.

Table 4. Growth rate (%) of bones and muscles in chickens during rearing period
 Tabela 4. Tempo wzrostu (%) kości i mięśni u kurcząt w okresie odchowu

Item Wyszczególnienie	Growth rate, % – age, days Tempo wzrostu, % – wiek dni					
	1–7	7–14	14–21	21–28	28–35	35–42
Body weight Masa ciała	118.40	94.90	46.76	64.18	32.53	24.81
Thigh muscles Mięśnie udowe	146.50	74.52	62.30	63.00	37.55	38.27
Thigh length (<i>femur</i>) Długość kości udowej	26.20	32.87	16.09	19.40	18.80	1.58
Drumstick muscles Mięśnie podudzi	151.06	74.45	42.55	95.23	31.56	16.79
Drumstick length (<i>tibia</i>) Długość kości piszczelowej	28.88	3.89	16.78	20.26	7.38	11.62
Breast muscles Mięśnie piersiowe	181.65	85.80	76.51	84.46	44.40	27.38
Keel length Długość mostka	71.29	45.51	20.91	23.54	14.85	6.68
Wing muscles I Mięśnie skrzydeł I	166.08	42.71	25.46	34.20	16.28	18.77
Humerus length Długość kości ramiennej	40.33	45.89	22.32	17.65	14.51	9.75
Wing muscles II Mięśnie skrzydeł II	168.64	50.48	32.21	39.85	26.57	23.85
Ulna length Długość kości łokciowej	18.80	62.17	18.31	17.04	11.90	13.33
Shank length (<i>os tarsometatarsale</i>) Długość skoku (kości stępowo-śródstopnej)	20.04	32.24	33.24	8.86	15.56	5.64

The values of the correlation coefficients between the analysed traits in chickens at 45 days of age are summarized in Table 5. Positive relationships were obtained between the analysed traits. Highly significant relations were found between the body weight of chickens and their breast muscle weight and drumstick muscle weight as well as between drumstick muscle weight and the weight of thigh and breast muscles. Highly significant relationships were also determined for thigh muscle weight and wing muscle weight. A positive significant correlation was also found between body weight of broilers and thigh muscle weight, between drumstick muscles weight and tibia length as well as between wing muscle weight and keel length. The comparison of the obtained results with those from other studies turned out to be impossible. In the available national literature, no similar studies on broiler chickens could be found.

Table 5. Correlation coefficients between analysed traits in 6-weeks old chickens

Tabela 5. Współczynniki korelacji prostej między analizowanymi 6-tygodniowymi kurczętami

Trait – Correlation coefficients Cecha – współczynnik korelacji	
	Body weight – Masa ciała
Thigh muscles – Mięśnie udowe	0.693*
Drumstick muscles – Mięśnie podudzi	0.711**
Breast muscles – Mięśnie piersiowe	0.793**
Wing muscles I – Mięśnie skrzydeł I	0.215
Wing muscles II – Mięśnie skrzydeł II	0.109
	Drumstick muscles – Mięśnie podudzi
Thigh muscles – Mięśnie udowe	0.802**
Breast muscles – Mięśnie piersiowe	0.723**
Drumstick length (<i>tibia</i>) – Długość kości piszczelowej	0.716*
	Thigh muscles – Mięśnie udowe
Breast muscles – Mięśnie piersiowe	0.816**
Thigh length (<i>femur</i>) – Długość kości udowej	0.733*
	Breast muscles – Mięśnie piersiowe
Keel length – Długość mostka	0.721*
	Wing muscles I – Mięśnie skrzydeł I
Ulna length – Długość kości łokciowej	0.423
	Wing muscles II – Mięśnie skrzydeł II
Humerus length – Długość kości ramiennej	0.273

* – statistically significant difference at $P \leq 0.05$ – różnica istotna na poziomie $P \leq 0,05$;

** – statistically significant difference at $P \leq 0.01$ – różnica istotna na poziomie $P \leq 0,01$.

CONCLUSIONS

A different growth rate of the analysed traits and a clear decrease in this rate with an increasing age of birds were found. For most traits included in the analysis, the rate of increase in muscle weight was three times higher than that of the length of individual skeletal bones. Positive significant and highly significant correlations between most analysed traits were obtained.

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WZROST WYBRANYCH KOŚCI I GRUP MIĘŚNI U KURCZĄT BROJLERÓW W OKRESIE ODCHOWU

Streszczenie. Celem przeprowadzonych badań było określenie wzrostu długości kości szkieletowych i grup mięśni u kurek kurcząt brojlerów w okresie odchowu. Materiał badawczy stanowiły kurki brojlery Ross 308. Analizą objęto mostek, kości nóg (stępowo-śródstopna, udowa i piszczelowa) i kości skrzydeł (ramienna i łokciowa) a także mięśnie piersiowe, ud i podudzi oraz skrzydłowe, umiejscowione wzdłuż kości ramiennej i łokciowej. Jednodniowe pisklęta ważyły średnio 36,5 g, i przez cały okres odchowu, tj. do 6. tygodnia życia, zwiększyły swoją masę ciała do 2229,2 g. Między 1. a 42. dniem życia kurcząt ich masa mięśni piersiowych zwiększyła się z 0,91 do 429,9 g, mięśni udowych z 1,95 do 218,0 g, a mięśni podudzi z 1,27 do 140,7 g. W tym czasie masa mięśni skrzydłowych wzrosła z 0,74 do 38,9 g. U piskląt jednodniowych kość stępowo-śródstopna miała długość 25,6 mm, kość piszczelowa 32,0 mm, kość udowa 24,7 mm, kość łokciowa 17,5 mm, a kość ramienna 17,0 mm, natomiast u ptaków sześciotygodniowych odpowiednio 81,7; 105,8 i 78,5 mm, 73,9 i 77,8 mm. Wykazano zróżnicowane tempo wzrostu analizowanych cech oraz wyraźne zmniejszanie się tego tempa wraz z wiekiem ptaków. U większości objętych analizą cech tempo zwiększania masy mięśni było trzykrotnie większe niż tempo zwiększania się długości poszczególnych kości szkieletowych. W tym czasie mostek zwiększył swoją długość z 20,4 do 132,6 mm. Uzyskano dodatnie istotne i wysoce istotne współzależności między większością analizowanych cech. Dotyczyło to m.in. masy ciała kurcząt i masy ich mięśni piersiowych oraz mięśni nóg.

Słowa kluczowe: kości, kurki brojlery, mięśnie, wiek

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