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Differences in growth and carcass composition of growing male and female turkeys

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Abstract: An experiment was conducted with 1 680 one-day-old turkey poults (720 males and 960 females) of the Hybrid Converter™ genotype to compare the growth performance of male and female turkeys. The experiment lasted until 119 days of age for males and 126 days for females, during which 6 commercial-type feeds were administered, with changes occurring at 21, 42, 63, 84 and 102 days of age. Performance was evaluated by weekly weighing and measuring feed consumption in each pen at weekly intervals. At 1, 7, 14, 21, 35, 56, 77, 119 (males) and 126 (female) days, 12 birds from each sex were sampled for weights of carcass, liver, gizzard, heart, thighs and breast. The Gompertz equation fitted separately to male and female growth data suggested that the mature weight of males would be by 16 kg heavier than in females (34.6 vs 18.7 kg) and that the females would mature 36% faster than males (0.023 2 vs 0.017 0/day). The weights of liver, gizzard and heart were similar in males and females in the early part of the growth period but they diverged from 35 days for the gizzard, 56 days for the liver and 77 days for the heart. However, the allometric coefficients describing the growth of each of these internal organs in relation to body weight were the same for males and females. Thigh weight was allometrically related to body weight, with males and females sharing the same relationship, but although the slope of the allometric relationship for breast weight in males and females was the same, breast weights in females were heavier than in males at any given body weight. Female turkeys became fatter than males from 56 days onwards.

Keywords: sex; performance; carcass yield; allometry

Turkeys have been selected for growth for many years, which has led to increasing their slaughter weight. At present, a large type of turkeys is used offering variable products from the whole carcass to carcass components according to consumer demand. Growth analysis is valuable for economical production, which is given by slaughter maturation. In a large type of turkeys, slaughter maturation differs in males and females. Emmans (1989) reported a mature weight of 20.1 kg for males and 10.4 kg for females. Later Rivera-Tores et al. (2011) observed a mature weight 18.1 kg in males of BUT9 hybrid. Gous et al. (2019) revealed similar mature weight for hybrid BUT Big 6 and Hybrid

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Converter™. The authors estimated mature weight by the Gompertz curve in females 19–20 kg and in males 36–38 kg, which is assumed to be a continued genetic improvement. Growth is supported by development of internal organs. Tumova and Chodova (2018) observed that in restricted chickens a priority is given to the growth of internal organs compared to muscles. A higher heart mass increases oxygen supply for a higher metabolic rate (Mohammadalipour et al. 2017), the size of the gizzard affects feed consumption and liver is the main organ for fat metabolism (van der Klein et al. 2017). However, there is a lack of data on changes in organ development in turkeys.

Increasing body weight is usually accompanied by growing carcass weight and weight of carcass components. With advancing age, carcass composition of turkeys varies in carcass parts. Muscle tissue content increases, bone content decreases, and the content of skin with subcutaneous fat does not change (Murawska et al. 2015). As consumer demand for breast meat increases, the changes in carcass composition play an important role in slaughtering of birds at the time with the highest proportion of the requested carcass component. Murawska et al. (2015) observed that the breast proportion increased in males until 20 weeks of age, whereas in females until 14 weeks. The proportion of the changes in carcass components is determined by the allometric coefficients of the carcass parts (Govaerts et al. 2000). The dynamics of carcass composition and differences between males and females can be used to predict carcass composition. A large type of turkeys is fattened according to sex due to a shorter growth curve of females, whose fattening period is terminated around 17–18 weeks of age. Therefore, the aim of the present study was to reveal differences in internal organs and valuable carcass parts between turkey males and females during 17 weeks of the fattening period, evaluate growth allometry of internal organs and carcass components and estimate the relationship between performance and carcass composition.

MATERIAL AND METHODS

The experiment was carried out with 1 680 one-day-old turkey poults (720 males and 960 females) of Hybrid Converter™ genotype. After wing banding, poults were placed int 48 littered pens. Each pen housed 30 males (0.512 m^2/bird) or 40 females (0.384 m^2/bird).

The experiment was conducted at the International Poultry Testing Station Ústrašice and was approved by the Ethics Committee of the Czech University of Life Sciences Prague and the Central Commission for Animal Welfare at the Ministry of Agriculture of the Czech Republic.

The growth experiment lasted until 119 days of age in males and 126 days of age in females, during which 6 feeds were administered, with changes occurring at 21, 42, 63, 84 and 102 days of age. Commercial-type feed mixtures were fed in a crumbled form in the 1st phase and in a pelleted form thereafter. Feed and water were supplied *ad libitum* during the whole experiment. The composition of the feeds is given in Table 1. The lighting regime consisted of 24 h light from 1 to 5 days of age with light intensity 80 lux. On day 6, the daylength was reduced to 17 h light and the intensity to 5 lux. This lighting regime was maintained until the end of the experiment. Other environmental conditions were maintained in agreement with the requirements of the turkeys.

Performance of turkeys was evaluated by weekly weighing from day 1, measuring feed consumption in each pen at weekly intervals, and mortality daily over the whole experimental period. Carcass analysis was carried out at the age of 1, 7, 14, 21, 35, 56, 77 days, the last analysis was carried out at 119 days of age in males and 126 days in females. Twelve birds of each age and sex, close to the average pen weight, were selected to determine differences between sexes at the given ages. Birds were slaughtered in the experimental slaughterhouse of the International Poultry Testing Station Ústrašice after overnight fasting. Turkeys were

Table 1. Content of nutrients in feed mixtures (g/kg)

Nutrient	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6
Crude protein	262	230	217	201	174	169
Metabolizable energy (MJ/kg)	11.9	122	12.2	12.3	12.6	12.6
Lysine	18.9	18.3	16.4	13.9	11.1	9.50
Calcium	13.8	12.8	12.6	11.3	10.8	10.2

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slaughtered by electrical stunning and bleeding. Thereafter birds were defeathered, bled and eviscerated. Their internal organs (liver, gizzard and heart) were weighed. Carcass analysis was performed on the hot carcass to determine carcass weight, weight of breast and thighs with skin, abdominal and subcutaneous fat weight. Subcutaneous fat was evaluated on the basis of the weight of thigh skin.

The mean weights of the body, carcass and all components were calculated using ANOVA (SAS v9.4). Gompertz growth curves were used to describe changes in the live weight of males and females over the experimental period. Allometric relationships between live weight and body components, namely carcass, breast, thighs and internal organs, were investigated using the equation (Huxley and Teissier 1936):

$$y = bx^k$$

where:
y – weight of carcass, carcass part or organ;
b – constant (origin index);
x – live weight;
k – allometric growth constant.

Table 2. Live weight of male and female turkeys (g)

Age (days)	Males	Females	RMSE
1	61.1	60.9	2.36
7	165	153	11.0
14	391	365	24.2
21	736	676	35.0
28	1 286	1 161	127
35	1 996	1 782	200
42	2 940	2 505	302
49	4 079	3 481	441
56	5 248	4 424	526
63	6 465	5 498	632
70	7 884	6 822	763
77	9 066	7 387	831
84	10 461	8 241	1 016
91	12 016	9 220	1 165
98	13 269	9 740	1 035
105	14 811	10 830	1 201
112	16 096	11 385	1 131
119	17 692	12 697[1]	1 493

RMSE = root mean square error
[1]Females weighed at 126 days of age

The respective weights were converted to natural logs (*ln*) and simple linear regression with groups was used to test for significant differences in constant terms and/or regression coefficients between sexes, using GenStat (VSN International 2017).

RESULTS

Growth rates (Tables 2 and 3) differed significantly between sexes. The Gompertz equation fitted separately to male and female growth data suggested that the mature weight of males would be by 16 kg heavier than in females (34.6 vs 18.7 kg) and that the females would mature by 36% faster than the males (0.023 2 vs 0.017 0/d). Consequently, the age at which the birds grew at their maximum rate was reached earlier in females (71 days) compared with males (96 days). Feed intake and feed conversion efficiency (FCE) differed significantly between males and females (Table 4). Feed intake and FCE were lower in females by 28% and 8%, respectively. Higher mortality was observed in males.

Carcass weight increased in both males and females by the end of the experiment (Table 5).

Table 3. Gompertz parameters describing the growth of male and female turkeys

	Males		Females	
	mean	SEM	mean	SEM
Mature weight (kg)	34.6	2.25	18.7	1.80
Rate of maturing (day)	0.017 0	0.001 1	0.023 2	0.001 4
Age at maximum growth rate (t*) (days)	95.8	4.44	71.3	3.91

SEM = standard error of the means

Table 4. Mean total feed consumption, feed conversion efficiency and mortality over the trial period

Measurement	Males	Females	RMSE
Feed intake (kg/bird)	45.7[a]	33.3[b]	2.11
FCE (g gain/kg feed)	385[a]	357[b]	8.33
Mortality (*n*)	53	21	–

FCE = feed conversion efficiency; RMSE = root mean square error
[a,b]Denotes a significant difference at $P < 0.05$

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Table 5. Mean live weight, carcass weight and weight of internal organs by sex and age (g)

Sex	Age (days)	Live weight	Carcass weight	Liver weight	Gizzard weight	Heart weight
Males	1	61.0	25.8	–	2.17	0.33
	7	166	77.1	4.58	4.59	1.06
	14	391	217	9.38	10.5	2.27
	21	737	445	16.7	17.9	4.29
	35	1 997	1 291	36.8	41.5	10.9
	56	5 248	3 743	97.3	79.3	24.7
	77	9 066	6 578	137	108	42.5
	119	17 283	13 336	159	136	58.3
Females	1	61.0	24.5	–	1.75	0.29
	7	154	74.2	4.01	4.47	0.99
	14	365	204	8.72	9.87	1.98
	21	677	407	15.7	15.5	3.99
	35	1 783	1 186	33.9	33.6	9.58
	56	4 423	3 118	77.2	55.1	20.8
	77	7 384	5 535	113	86.1	28.9
	126	12 697	9 892	131	116	50.0
RMSE		528	432	13.3	10.0	4.58

RMSE = root mean square error

Table 6. Weight of carcass components by sex and age (g)

Sex	Age (days)	Thigh weight	Breast weight	Abdominal fat weight	Subcutaneous fat weight
Males	1	9.86	0.89	–	0.77
	7	23.7	11.3	–	1.55
	14	59.3	54.0	–	3.03
	21	129	122	–	4.97
	35	391	331	–	13.5
	56	1 242	952	15.2	43.3
	77	2 145	1 721	28.3	68.7
	119	3 558	3 830	245	223
Females	1	10.3	0.95	–	0.68
	7	23.5	10.9	–	1.30
	14	59.0	53.7	–	2.85
	21	118	112	–	4.81
	35	355	310	–	12.6
	56	997	815	17.1	39.2
	77	1 742	1 566	72.3	91.7
	126	2 958	3 274	315	245
RMSE		152	130	41.8	12.9

RMSE = root mean square error

This relationship is allometric, but it differed significantly between males and females as shown in Table 7.

For males, the constant term was lower (–1.118 vs –1.056) and the regression coefficient was steeper (1.098 vs 1.087) than for females.

The weights of liver, gizzard and heart (Table 5) were similar in males and females in the early part of the growth period but they diverged from 35 days of age for the gizzard, 56 days for the liver and 77 days for the heart. However, the allometric coefficients describing the growth of each of these internal organs in relation to the increase in body weight were the same for males and females (Table 7). Liver weight was not determined on the first day of age because it was very small and was tightly connected to the yolk sac.

Breast and thigh weights were similar in males and females until 14 days of age but then they diverged (Table 6) and differed significantly by the end of the growth period. In the first two weeks the breast weight in males and females did not conform to the allometric relationship with body weight, thereafter causing a poor fit to this relationship (Table 7).

By excluding these weights, the relationship improved (from an R^2 of 95.5 to 99.6) but this resulted in the relationships for males and females being parallel (the same slope) but with breast weights for females being heavier at any given body weight than for males. Thigh weight was allometrically re-

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lated to body weight, with males and females sharing the same relationship (Table 7).

Abdominal fat was measured only from 56 days of age onwards, and in all the measurements taken, females had higher values than males (Table 6). Subcutaneous fat was numerically lower in females to 56 days of age but it surpassed that of males thereafter (Table 6). The allometric relationship with body weight reflected this change over time, with the constant term being lower for females than for males (–7.852 vs –7.158, respectively), but with the regression coefficient being higher (steeper) for females (1.250 vs 1.133 respectively) than for males (Table 7).

DISCUSSION

The objective of the experiment reported here was to compare the growth performance of male and female turkeys. The differential in mature weight between males and females in the turkey strain used here (Hybrid Converter) is considerably greater than that in commercial broiler genotypes. For example, the weight of turkey females at maturity was 54% of the male weight (18.7 vs 34.6 kg), whereas broiler females at maturity weigh close to 80% of the male weight (6.7 vs 8.4 kg) (Vargas et al. 2020).

Consequently, it is of interest to determine to what extent the relationships between the various components of the body and live weight would differ between male and female turkeys.

The males at the end of the experiment were 33% heavier than the females, this difference being the same as that reported by Herendy et al. (2004) where BUT Big 6 males were about 34% heavier than females at the age of 140 days. This difference increases as the birds get older, as seen in Table 3, reaching 54% by the time the birds have matured, and this is related to the faster rate of maturation of the females (0.023 vs 0.017/days) resulting in their earlier mature weight than in the males. Females reached the age at which their growth rate is at the highest at 71 days of age, with the growth rate declining thereafter, whereas the age at which males achieved their most rapid growth rate was only at 96 days (Table 3).

Gompertz growth curves were fitted to the growth data for the two sexes as a formal means of comparing the potential growth rates of the sexes to maturity. Thus, instead of comparing mean weekly weights, the three components of the Gompertz equation could be compared statistically. Such information is applicable to describing each genotype, this being the first step in predicting voluntary feed intake (Emmans 1987; 1989).

As is generally the case, the rate of maturation is inversely related to mature body weight, thus females reach the age of maximum growth rate (t*) and maturity sooner than males, as shown in Table 3.

It is expected that feed intake will be higher in males than in females due to the more rapid growth rate of males during the test period. Females consumed only 72% of the amount consumed by males (Table 4) but they had similar FCE in part due to the higher mortality rate in male turkeys. No specific reasons could be given for the higher mortality in males, while the faster growth rate may be the main cause. No literature could be found that compared mortality rates between the sexes in commercial turkey operations.

Table 7. Allometric coefficients of growth of carcass components and internal organs

Component	Constant term		Regression coefficient		R^2
	males	females	males	females	
Carcass	–1.118 ± 0.027	–1.056 ± 0.018	1.098 ± 0.036	1.087 ± 0.003	99.9
Liver	–2.306 ± 0.057		0.779 ± 0.007		98.5
Gizzard	–2.140 ± 0.063		0.743 ± 0.008		97.4
Heart	–4.692 ± 0.062		0.923 ± 0.008		98.3
Subcut. fat	–7.158 ± 0.182	–7.852 ± 0.273	1.133 ± 0.023	1.250 ± 0.035	96.3
Breast[1]	–4.892 ± 0.156		1.387 ± 0.021		95.5
Breast[2]	–2.576 ± 0.060	–2.537 ± 0.081	1.111 ± 0.006		99.6
Thigh	–3.583 ± 0.041	–3.538 ± 0.020	1.084 ± 0.005		99.5

[1]Including all data; [2]Excluding data < 21 days

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Internal organs play a vital role in the growth of birds. The importance of internal organs in growth is evident in experiments where feed intake is restricted, when the growth of internal organs is given priority over muscle growth (Govaerts et al. 2000). Once feed restriction is lifted, the internal organs then play a supporting role in enabling the bird to compensate for the period of restricted growth (Tumova et al. 2016; Tumova and Chodova 2018). In spite of the differences in the growth rate of these organs between males and females when related to the growth of the body these differences disappear (Table 7), enabling the weight of these organs to be predicted from the body weight of the bird at any stage of the growth period. Given the importance of these internal organs to the bird, and the functions they perform, it is not surprising that the allometric coefficients are similar between the sexes.

Female turkeys have the 1.4–1.9 times higher amount of body lipids than the males (Emmans 1987; Gous et al. 2019) and by virtue of this large difference carcass weight and the weights of thighs and breast contain different amounts of lipids in males and females. As a result it is unlikely that the males and females would share the same allometric coefficients for these components. This is borne out by the results in Table 7 which demonstrate that the subcutaneous fat in females increases at a faster rate than in males as the birds mature. The regression coefficients for both thigh weight and breast weight were the same for males and females, thus these components developed at the same rate in both sexes. However, the constant term is higher for females than for males, this difference representing the additional amount of fat in these tissues in the females. This has also been shown in broilers (Danisman and Gous 2011; 2013). Of interest is the deviation of initial breast weights from the subsequent allometric relationship with body weight which caused the relationship to deviate from a linear trend. When these initial breast weights were excluded, the linear relationship improved. Danisman and Gous (2011; 2013) demonstrated the same issue in broilers, so this is more than just a characteristic of turkeys. The explanation suggested by Danisman and Gous (2011; 2013) is that some nutrients become limiting for growth towards the end of the incubation period and the developing embryo thus draws on nutrients from the breast muscle to supplement these nutrients, which then allows the embryo to develop normally. About two weeks are required for these reserves to be replenished whereafter the allometric relationship between breast weight and body weight remains the same throughout the remainder of the growth period.

CONCLUSION

In conclusion, this study demonstrates that male turkeys are heavier than their female counterparts from an early age and this difference increases as the birds mature. Females mature more rapidly than males as a result of their smaller mature size, reaching the age when their rate of growth is maximized more early than males. In spite of these differences in potential growth rate, the internal organs, the thighs and breasts all develop at the same rate in the two sexes, with differences in the allometric constant term being the result of the additional amount of fat that is deposited in the tissues of females during the growth process. Although the difference in mature weight is far greater in turkeys than in broilers, nevertheless the allometric relationships and the anomaly with initial breast weight found in turkeys are also present in broilers.

Conflict of interest

The authors declare no conflict of interest.

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