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The effect of genotype and sex on carcass composition, digestive system and leg bone traits in broiler breeders after the reproductive season

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The aim of this study was to compare Cobb 500 and Ross 308 broiler breeders for carcass composition as well as morphometric parameters of their digestive system and leg bones. This study is based on 28 birds aged 61 weeks. We determined the body weight, percentages of carcass components, as well as the weight and content of selected internal organs within the body weight. This was followed by measuring the lengths and diameters of each gut segment; bone length and breadth the femur and the tibia. The birds' genotype significantly (p<0.05) affected their body weight, percentages of some carcass components, the lengths of the intestine and femur and tibia dimensions. The birds' sex also significantly affected their body weight and the percentages of carcass components. Differences were also found in the weight of giblets, lengths of the intestine and the length and breadth of the femur and tibia. The results of the study provide information on differences between the genotypes and sexes in Cobb 500 and Ross 308 parent stocks in body weight, percentages of carcass components and giblets, as well as the lengths of each gut segment, and dimensions of the femur and tibia following the reproduction period.

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Global meat production in 2021 reached 357.4 million tonnes. Poultry accounted for as much as 38.6% of global meat production. The largest poultry meat producers in the world in that year were China, followed by USA and Brazil. In the years 2010-2021, the global poultry meat production increased by 38.9% (from 99.3 to 137.9 million tonnes), while pork meat grew by 11.3% (from 108.1 to 120.3 million tonnes), and beef by 11.5% (from 64.9 to 72.4 million tonnes) [FAOSTAT 2022]. Poland was the leading poultry meat producer in the EU, with 2.5 million tonnes produced in 2021 (KRD 2022). In 2020, 11.2 million of broiler breeder hens were reared in Poland [KRD 2022]. Over 85% of the parent stock kept in Poland are the Ross 308 breeding line [Wegner *et al.* 2022]. The mean production period was 256 days, with the mean laying performance of the flock at 64.9% and 152.5 eggs from each layer hen [Wencek *et al.* 2021].

An increase in poultry production depends on producers' business results, which are affected by several factors. According to Tilki and Inal [2004], one can influence production efficiency by selecting the right genetic material. This has been confirmed in another study, where it was also demonstrated that the number of eggs from a layer is affected by the selection of suitable genetic material. However, the environmental conditions were also reported to play a vital role [Biesiada-Drzazga 2020]. Other authors have shown that parent broilers production results depend on how females are fed [van Emous *et al*. 2015].

Choosing the right genetic material involves careful selection of females and males. Genetic selection in male and female lines of broiler breeders is conducted with particular focus on the following traits: growth rate, yield, and the feed conversion ratio (FCR) of produced livestock [Tavarez and de los Santos 2016]. Zuidhof *et al.* [2014] have stated that over the past 60 years, genetic selection has led to increased body weight in chicken broilers on day 42, from 586 g to 2900 g, with simultaneous decrease in FCR from 2.8 kg to 1.7 kg.

Notably, customer preferences concerning poultry meat also keep changing. In the 1960s, 83% of broilers in the US were sold as complete carcasses; cut up animals or parts constituted approximately 15%, while 2% of the meat was sold as processed. But in 2009, only 12% of broiler chickens were sold as complete carcasses, and 42% as cut up carcasses or parts, with 46% as further processed products [Tavarez and de los Santos 2016]. It has become therefore essential to focus on the dimensions and qualities of the parts of the carcass.

In studies by numerous authors, it has been established that feed intake is strongly correlated with the weight of breast muscles and abdominal fat in birds at the age of 38 days [Tavarez and de los Santos 2016]. These results show that the selection has been conducted with the aim of achieving as much of the meat as possible, with a particular emphasis on breast muscles, as this is the meat with a low cholesterol content and high nutritional and dietary value [Augustynska-Prejsnar and Sokołowicz 2018].

By now the literature has discussed dissection results and the percentages of each component and giblets in the carcass, both in broiler chickens and broiler breeders, as well as in other poultry breeds [Mir *et al*. 2017, Cui *et al*. 2019, Indumathi *et al.* 2019, Kokoszyński *et al.* 2019, Zhang *et al.* 2019]. Many authors have conducted research on the effects of various factors on the femur and tibia in ducks [Shewita and Taha, 2018, Zhang *et al.* 2019, Stęczny and Kokoszyński, 2020, Krunt *et al*. 2022, Włodarczyk *et al.* 2023] and geese [Liu *et al*. 2020], but there are no papers on the effects of genotype and sex on the morphometric parameters of the digestive system and on the leg bone measurements in broiler parent stocks, which was the reason for our study.

The aim of this study was to determine how the genotype (Cobb 500 vs Ross 308) and sex (male vs female) affects the composition of an eviscerated carcass; the femur and the tibia measurements; and the morphometric parameters of the digestive systems in broiler breeders, following the first egg-laying season.

Material and methods

Birds

In the present study we used 28 Ross 308 and Cobb 500 broiler breeders aged 61 weeks. Prior to the slaughter, the birds were kept at a commercial broiler breeder farm, in a closed windowless poultry house, without access to outside runs. When producing eggs, the birds were fed with a complete diet designed for broiler breeders, containing 15.0% CP, 11.6 MJ Metabolizable energy, 4.8% Met, 0.55% Lys, and 3.05% Ca. The temperature in the house was 20 °C, while the relative humidity ranged between 65% and 75%. After the laying period, when the birds were 61 weeks old, under the farm protocol, the broiler breeder producer weighed 100 of them, with accuracy to 1 g, using WGJ-R electronic hook scales (by Jotafan, Krakow, Poland). Then, 7 males and 7 females with body weight closest to the mean weight of each genotype were selected and taken to a poultry slaughterhouse.

Carcass analysis

The birds were slaughtered according to the applicable EU poultry industry rules. Electrical water-bath stunning was used (current of 125 mA/bird, stunning time of min. 4 s), followed by bleeding out (min. 2 minutes) on the slaughter line. Eviscerated carcasses with neck and entrails were transported to the laboratory at our university, where they were chilled for 18 hours at the temperature of 2°C in a refrigerator (by Hendi, Gądki, Poland). Then, chilled carcasses were individually weighed using WLC 6/12/F1/R electronic scales (by Radwag, Radom, Poland), with the accuracy to 0.1 g, and the dissection was performed adopting a simplified method as described by Ziołecki and Doruchowski [1989]. During the dissection, we separated the following components from each carcass: the neck without the skin, both wings with the skin, the skin of the entire carcass, breast muscles (two fillets, and two sirloins), leg muscles (all muscles from both thighs, and drumsticks), and carcass remainders, i.e.

the skeleton with some of the remaining muscles. The separated carcass components were weighed on the above-mentioned scales, and then we calculated the percentage shares of their pre-slaughter body weight.

Anatomical analysis

While eviscerating the carcasses obtained from 61-week-old birds, the gut and other internal organs – namely the proventriculus, gizzard, heart, liver, and spleen – were separated. With a measuring tape we determined the length of each segment of the small intestine (duodenum, jejunum, and ileum), as well as the lengths of the caeca and colon, with the accuracy to 1 mm. And the diameter of each intestine segment was measured using callipers, with the accuracy to 0.01 mm. The measurements were made at the beginning, middle, and end of each intestine segment. Then, with PS 1000. R2 electronic scales (by Radwag, Radom, Poland) we checked with the accuracy to 0.01 g the weights of the proventriculus (without digesta), gizzard (without digesta), liver (without gallbladder), heart (without pericardial sac), and spleen; and then we calculated their percentages in the pre-slaughter body weight. The leg bones obtained from the dissection were measured using electronic callipers with the accuracy to 0.01 mm, according to the method described by den Driesch [1976]. On the femur, we determined the lengths (greatest – GL, medial – ML); the greatest breadth of the proximal end – GB, the greatest depth of the proximal end – GD, the breadth of distal end – GC, greatest breadth of the distal end – GE and the smallest breadth of the corpus – SM. Next, measurements of the tibia (the drumstick bone) were made: the greatest lengths (GL), axial lengths (AL); the greatest diagonal of the proximal end (GD), the smallest breadth of the corpus (SB), and the smallest breadth (sd) and the depth of the distal end (DD).

Statistical analyses

We calculated mean values (x) and standard deviations (sd) of the examined traits. In the next stage of the statistical analysis, using the Shapiro-Wilk test, an assessment was made of the conformity of the empirical distributions of the studied traits to a normal distribution. It was shown that the traits were characterized by distributions that were consistent or close to normal. Therefore, a parametric test in the form of a two-way analysis of variance was used to determine the effect of genotype and gender on the registered traits. The following linear model was used:

$$y_{ijk} = \mu + a_i + b_{ji} + (ab)_{ij} + e_{ijk},$$

where:

y_{ijk} – value of the recorded trait;

μ – overall mean;

a_i – fixed effect of *i*th genotype;

b_j – fixed effect of *j*-the sex;

ab_{ij} – the genotype by sex interaction;

e_{ijk} – the random error.

In addition, an assessment of the power of the statistical inference (power analysis) was performed in parallel with the analysis of variance. The results of this analysis, due to the calculated power of the test, allow the results presented in the tables to be considered as reliable. Significant differences between means for the compared broiler breeder genotypes were verified with Tukey's test at a significance level of P<0.05. Statistical calculations were performed using SAS Software version 9.4. [2014].

Results and discussion

The analysis of the body weight and percentage of carcass components of Cobb 500 and Ross 308 birds (Tab. 1) showed significant differences (p<0.05) between genotypes and sexes. The mean body weight of Cobb 500 was higher compared to Ross 308, regardless of the gender (p=0.010). The males also had higher final body weight compared to the females (p<0.001). Cobb 500 was characterized by a higher percentage of leg muscles, and a lower percentage of wings and skin with fat compared to Ross 308 (p<0.001-0.002). It was also shown that males were characterized by a higher percentage leg muscles, neck, remainders, and less abdominal fat compared to females (p<0.001-0.001).

Table 1. Body weight and percentages of carcass components in body weight in Cobb 500 and Ross 308 broiler breeders at the age of 61 weeks

Trait		Genotype (G) – sex (S)				P value		
		Cobb 500		Ross 308				
		male	female	male	female	G	S	G x S
Body weight (g)	mean	5767.8[a]	4324.3[a]*	4670.0[b]	3732.9[b]*	0.010	<0.001	0.114
	sd	306.5	379.1	512.5	354.9			
Breast muscle (%)	mean	21.5	24.6	25.5	23.0	0.057	0.602	<0.001
	sd	0.5	0.7	2.0	2.0			
Leg muscles (%)	mean	28.5[a]	22.4[a]*	23.5[b]	21.8[b]*	<0.001	<0.001	0.001
	sd	0.2	0.2	2.7	1.0			
Skin with fat (%)	mean	6.9[b]	6.4[b]	7.4[a]	8.2[a]	0.002	0.675	0.061
	sd	0.3	0.7	1.1	1.0			
Abdominal fat (%)	mean	-	1.6*	-	1.6*	0.839	<0.001	0.492
	sd	-	0.3	-	0.5			
Neck (%)	mean	3.2	2.7*	3.1	2.4*	0.222	<0.001	0.349
	sd	0.2	0.1	0.1	0.2			
Wings (%)	mean	7.7[b]	7.3[b]*	8.5[a]	7.7[a]*	0.001	0.001	0.046
	sd	0.2	0.1	0.4	0.4			
Remainders (%)	mean	21.3	18.2*	21.0	19.1*	0.551	<0.001	0.159
	sd	1.1	0.9	1.8	0.5			

[ab]Means between genetic groups bearing different superscripts differ significantly at *p*<0.05.
*Differences between males and females within a given genotype, n=7 (*p*<0.05).

Table 2. Weights of selected internal organs in Cobb 500 and Ross 308 broiler breeders at the age of 61 weeks

Trait		Genotype (G) – sex (S)				P value		
		Cobb 500		Ross 308				
		male	female	male	female	G	S	G x S
Proventriculus (g)	mean	9.2	9.6	9.4	11.6	0.125	0.059	0.189
	sd	2.1	1.8	1.2	1.7			
Gizzard (g)	mean	51.4	42.9	46.8	46.4	0.818	0.056	0.083
	sd	5.2	5.3	6.8	5.5			
Heart (g)	mean	22.0	15.2*	18.2	15.1*	0.111	0.003	0.119
	sd	4.7	2.4	2.9	1.5			
Liver (g)	mean	74.5	57.5*	68.9	67.7	0.559	0.025	0.049
	sd	13.2	9.0	7.1	9.8			
Spleen (g)	mean	5.6	3.7*	4.4	4.0	0.366	0.023	0.113
	sd	1.1	1.6	0.9	0.9			

*Differences between males and females within a given genotype, n=7 (p<0.05).

Table 3. Percentages of selected internal organs relative to body weight in Cobb 500 and Ross 308 broiler breeders at the age of 61 weeks

Trait		Genotype (G) – sex (S)				P value		
		Cobb 500		Ross 308				
		male	female	male	female	G	S	G x S
Proventriculus (%)	mean	0.16^{b}	0.22^{b}*	0.20^{a}	0.31^{a}*	<0.001	<0.001	0.658
	sd	0.03	0.04	0.01	0.04			
Gizzard (%)	mean	0.89^{b}	0.98^{b}	1.02^{a}	1.24^{a}*	0.037	0.018	0.268
	sd	0.12	0.10	0.22	0.14			
Heart (%)	mean	0.38	0.35	0.39	0.40	0.079	0.677	0.243
	sd	0.06	0.04	0.05	0.02			
Liver (%)	mean	1.29^{b}	1.32^{b}	1.48^{a}	1.84^{a}*	0.001	0.049	0.111
	sd	0.17	0.13	0.20	0.40			
Spleen (%)	mean	0.10	0.09	0.23	0.11	0.228	0.295	0.388
	sd	0.01	0.03	0.12	0.02			

^{ab}Means between genetic groups bearing different superscripts differ significantly at p<0.05.
*Differences between males and females within a given genotype, n=7 (p<0.05).

Having analysed the internal organs of 61-week-old birds, we did not find any significant differences between the genotypes, while there were significant (p<0.05) differences between males and females. Considerably heavier spleens, livers, and hearts were found in males than females (p=0.003-0.025) (Tab. 2).

An analysis of the organ percentage results (Tab. 3) demonstrated significant differences between genotypes. A higher percentage of the proventriculus, gizzard and liver in body weight was observed in Ross 308 compared to Cobb 500 (p<0.001-0.037). Also, stomach segment percentages (proventriculus, gizzard) and liver in females was higher than in males (p<0.001, p=0.018, and p=0.049, respectively). The genotype by sex interaction for internal organs percentage was not significant (p=0.111-0.658).

We compared birds of different genotypes and established that there were significant differences between them (p<0.05) in the length of some gut segments (Tab. 4). A significantly (p=0.003-0.048) longer jejunum, caeca, colon and total intestine were found in Ross 308 hybrids compared to Cobb 500. The gut segment lengths – duodenum, jejunum, and colon – did not display significant differences; while the caeca and ileum were considerably shorter in females compared to males (p=0.002, and p=0.018, respectively).

We compared birds of different genotypes and established that there were not significant differences between them (p>0.05) in the diameters of each gut section, in except colon diameter. A significantly wider colon was found in Ross 308 hybrids compared to Cobb 500 (p=0.008). The genotype-sex interaction was significant for the duodenum diameter (Tab. 5).

Table 4. Gut segment lengths in Cobb 500 and Ross 308 broiler breeders at the age of 61 weeks

Trait		Genotype (G) – sex (S)				P value		
		Cobb 500		Ross 308				
		male	female	male	female	G	S	G x S
Duodenum (cm)	mean	34.5	33.0	35.7	35.5	0.268	0.606	0.698
	sd	3.9	3.5	5.2	4.1			
Jejunum (cm)	mean	87.8^{b}	85.6^{b}	96.0^{a}	96.1^{a}	0.003	0.695	0.677
	sd	5.3	8.0	8.3	6.3			
Ileum (cm)	mean	93.2	81.4*	95.6	90.6	0.089	0.018	0.308
	sd	5.6	8.7	8.2	10.6			
Caeca (cm)	mean	48.8^{b}	38.6^{b*}	53.7^{a}	45.9^{a*}	0.007	0.002	0.578
	sd	3.3	7.0	6.1	3.9			
Colon (cm)	mean	14.6^{b}	14.5^{b}	16.3^{a}	16.1^{a}	0.008	0.796	0.946
	sd	1.5	1.2	1.8	2.0			
Total intestine (cm)	mean	278.9^{b}	253.1^{b}	288.7^{a}	284.2^{a}	0.048	0.136	0.228
	sd	14.5	21.1	36.4	20.1			

[ab]Means between genetic groups bearing different superscripts differ significantly at $p<0.05$.
*Differences between males and females within a given genotype, n=7 ($p<0.05$).

Table 5. Gut segment diameters in Cobb 500 and Ross 308 broiler breeders at the age of 61 weeks

Trait		Genotype (G) – sex (S)				P value		
		Cobb 500		Ross 308				
		male	female	male	female	G	S	G x S
Duodenum (mm)	mean	11.4	10.1	10.3	11.1	0.879	0.489	0.019
	sd	0.5	0.6	1.1	1.6			
Jejunum (mm)	mean	8.0	8.6	8.7	9.1	0.185	0.272	0.801
	sd	0.6	0.4	1.5	1.4			
Ileum (mm)	mean	7.5	7.6	8.1	8.2	0.228	0.818	0.926
	sd	0.6	0.8	2.0	1.0			
Caeca (mm)	mean	8.6	7.9	8.2	8.2	0.878	0.443	0.418
	sd	0.6	1.3	1.1	0.6			
Colon (mm)	mean	8.1^{b}	8.0^{b}	8.6^{a}	9.4^{a}	0.008	0.796	0.946
	sd	1.5	1.2	1.7	2.1			

[ab]Means between genetic groups bearing different superscripts differ significantly at $p<0.05$.

Comparing the femur dimensions in the Cobb 500 and Ross 308 birds, we showed significant differences (p<0.05) between genotype and sex (Tab. 6). Cobb 500 compared to Ross 308 were characterized by larger GL and GE dimensions of the femur, regardless of gender (p=0.002, and p=0.019, respectively). However, the individual analysed features of the femur GL, ML, GB, GD, SM, GC and GE in males, regardless of the genotype, were longer compared to females (p<0.001). The genotype-sex interaction was significant for GC (p=0.029).

Table 6. Femur dimensions in Cobb 500 and Ross 308 broiler breeders at the age of 61 weeks

Trait		Genotype (G) – sex (S)				P value		
		Cobb 500		Ross 308				
		male	female	male	female	G	S	G x S
GL (mm)	mean	164.2[a]	130.9[a]*	150.8[b]	125.2[b]*	0.002	<0.001	0.086
	sd	4.3	5.6	4.0	3.1			
ML (mm)	mean	110.9	89.9*	103.8	87.8*	0.055	<0.001	0.113
	sd	4.4	3.5	4.3	3.4			
GB (mm)	mean	36.1	30.5*	35.9	28.9*	0.319	<0.001	0.411
	sd	1.5	1.2	1.5	0.9			
GD (mm)	mean	13.8	11.3*	14.2	10.8*	0.892	<0.001	0.312
	sd	1.5	0.7	1.3	0.8			
SM (mm)	mean	10.1	8.3*	10.0	8.4*	0.836	<0.001	0.600
	sd	0.6	0.3	0.4	0.4			
GC (mm)	mean	22.3	17.5*	20.1	17.9*	0.109	<0.001	0.029
	sd	1.1	1.0	1.7	0.9			
GE (cm)	mean	19.8[a]	15.1[a]*	17.6[b]	14.6[b]*	0.019	<0.001	0.130
	sd	1.4	1.4	2.3	1.0			

GL – greatest length; ML – medial length; GB – greatest breadth of proximal end; GD – greatest depth of proximal end; SM – smallest breadth of the corpus; GC – greatest breadth of the distal end; GE – greatest depth of distal end.
[ab]Means between genetic groups bearing different superscripts differ significantly at *p*<0.05.
*Differences between males and females within a given genotype, n=7 (*p*<0.05).

Comparing the tibia dimensions in the Cobb 500 and Ross 308 birds, we showed significant differences (p<0.05) between genotype and sex (Tab. 7). Greater GL, AL and DD were measured in the tibia of Cobb 500 compared to Ross 308. However, males, regardless of the genotype, showed greater GL AL, GD, SB, SD and DD compared to females. A genotype-sex interaction was also demonstrated for the analysed SD trait.

The factors that influence the final body weight and the share of elements in the carcass include the birds' genotype, age, sex, nutrition and housing system for broilers [Zeferino *et al*. 2016, Hussein *et al*. 2019, Indumathi *et al*. 2019, Wegner *et al.* 2022; Wegner *et al*. 2023, Wegner *et al*. 2024; Włodarczyk *et al*. 2022]. The present study showed that bird genotypes influenced the final body weight. Cobb 500 parent flocks after laying, regardless of gender, were characterized by higher body weight compared to Ross 308. Importantly, in an earlier study, Ross 308 parent flocks kept in a litter system without slats were characterized by higher body weight compared to

Table 7. Tibia dimensions in Cobb 500 and Ross 308 broiler breeders at the age of 61 weeks

Trait		Genotype (G) – sex (S)				P value		
		Cobb 500		Ross 308				
		male	female	male	female	G	S	G x S
GL (mm)	mean	164.2^{a}	130.9^{a*}	150.8^{b}	125.2^{b*}	0.002	<0.001	0.086
	sd	5.3	6.8	5.1	4.6			
AL (mm)	mean	153.4^{a}	124.7^{a*}	146.8^{b}	119.7^{b*}	0.044	<0.001	0.766
	sd	10.0	6.6	6.2	4.8			
GD (mm)	mean	36.1	30.5*	35.9	28.9*	0.319	<0.001	0.411
	sd	3.3	1.8	2.4	0.9			
SB (mm)	mean	9.0	7.4*	8.9	7.7*	0.671	<0.001	0.343
	sd	0.7	0.6	0.2	0.6			
SD (mm)	mean	22.3	17.5*	20.1	17.9*	0.109	<0.001	0.029
	sd	1.5	1.3	1.7	1.3			
DD (mm)	mean	19.8^{a}	15.1^{a*}	17.6^{b}	14.6^{b*}	0.019	<0.001	0.129
	sd	1.1	1.8	1.5	1.0			

GL – greatest length; AL – axial length; GD – greatest diagonal of the proximal end; SB – smallest breadth of the corpus; SD – smallest breadth of the distal end; DD – greatest depth of the distal end.
^{ab}Means between genetic groups bearing different superscripts differ significantly at p<0.05.
*Differences between males and females within a given genotype, n=7 (p<0.05).

birds kept in a litter-slat system [Wegner *et al.* 2022]. Compared to the results in our study, the result obtained by the authors Wegner *et al*. [2022] at 57 weeks of age were higher by 737 g in females, while lower by 368 g in males. In the study by Hussein *et al.* [2019], however, it was observed that the final body weight was influenced by the age of the birds. Broiler chickens kept up to 37 days of age were characterized by lower body weight compared to Ross 308 parent flocks kept up to 434 days [Hussein *et al*. 2019]. The same relationship was also confirmed in another study [Indumathi *et al.* 2019]. The present study showed that the final body weight was influenced by the gender of the birds. The males, regardless of genotype, were characterized by higher body weight compared to the females. The same relationship has also been confirmed in other studies [Kokoszyński *et al.* 2016, Hussein *et al.* 2019, Wegner *et al*. 2022, Wegner *et al*. 2023]. In our studies, the genotype of birds influenced the percentage of leg muscles, skin with fat and wings. Ross 308 parent flocks, regardless of gender, were characterized by a higher percentage of wings and skin with fat, and a lower percentage of leg muscles compared to Cobb 500. However, other authors Indumathi *et al*. [2019] showed a higher share of leg muscles (26.4%) in parent flocks at 72 weeks compared to the results in our study (23.5%). Other authors [Biegniewska *et al*. 2017] also obtained higher results (24.1%) for the analysed trait in birds of the same genotype at 64 weeks of age. In another study, it was observed that the share of breast muscles, legs, skin with subcutaneous fat, wings and carcass remainders was influenced by the poultry housing system [Włodarczyk *et al.* 2022]. Broiler breeder hens Ross 308 had a greater share of the above features in body weight compared to dual-purpose hens. Authors Wegner *et al*. [2024] also observed that parent flocks kept in the litter system were characterized by a lower percentage of leg muscles compared to birds kept in the slat-litter system. Our research also observed that the sex of birds had an impact on the percentage of leg muscle, neck, wings, abdominal fat and remainders. Males were characterized by a higher share of the above analysed features, apart from abdominal fat, which was higher in females regardless of the genotype. Also, the authors Biegniewska *et al*. [2017] observed the same relationship in 64-week-old Ross 308 broiler breeders and Hussein *et al*. [2019] at 62 weeks old Ross 308.

In the present study, the bird genotype did not affect the weight of offal (proventriculus, gizzard, heart, liver, spleen), but it did influence the percentage of the proventriculus, gizzard and liver. Ross 308, regardless of the gender, was characterized by a higher percentage of the above features in body weight compared to Cobb 500. In other studies, the spleen weight was influenced by the parent flock maintenance system of Ross 308 [Wegner *et al*. 2024]. Birds kept in the slat-litter system were characterized by lower spleen weight compared to birds kept in the slat-litter system. Other authors Indumathi *et al*. [2019] showed that the age of the birds influenced the weight of the gizzard, heart, liver and spleen. Birds kept until day 37 were characterized by the lower weight of the above features compared to parent flocks Ross 308 on day 434. Another study [Włodarczyk *et al*. 2022] showed that the weight of the proventriculus, gizzard, heart, liver and spleen was influenced by the usability of the birds. Parent flock hens Ross 308 were characterized by a higher weight of offal compared to dual-purpose hens at the end of the laying period. In our studies, we also observed that Cobb 500 males were characterized by a larger heart, liver and spleen weights compared to females. However, the percentage of the proventriculus, gizzard and liver in body weight was lower compared to females.

In our study, bird genotype and sex influenced some intestinal segment lengths. Cobb 500 parent stocks had a shorter jejunum, caeca, colon and total intestine sections compared to Ross 308. Males were also observed to have longer ileum and caeca sections. Another study, however, showed that Ross 308 after the laying period (62 weeks) was characterized by the end of the jejunum, ileum, colon and large intestine compared to dual-purpose hens [Włodarczyk *et al.* 2022]. The results of the length of individual intestinal sections in Ross 308 obtained by the same authors [Włodarczyk *et al*. 2022] were lower compared to the results in our study, except for the duodenum, the length of which was very similar to that in our study. In the study by Wegner *et al*. [2024], there was no influence of the maintenance system of the parent herds on the length of individual intestinal segments. Nevertheless, the length of the jejunum in our study was shorter by 5.3 cm, the caeca by 2.8 cm, and the total intestine was shorter by 15.9 cm compared to the birds kept in the litter system [Wegner *et al*. 2024].

Analysing the diameters of each of the gut sections, no significant differences were demonstrated between genotypes and sexes except for the colon diameter. Ross 308 was characterized by a larger colon diameter compared to Cobb 500. Despite this the mean jejunum, ileum, and colon diameters in Ross 308 hybrids were higher compared to those in Cobb 500. Also, the said gut sections were broader in females.

However, our results proved to be lower compared to those in an assessment of broiler breeders (Ross 308) aged 62 weeks [Renema *et al*. 2001]. Also, Włodarczyk *et al*. [2022] obtained higher duodenum, jejunum, ileum, and caeca dimensions in 62-week-old Ross 308 broiler breeder hens compared to our results. Whereas in another study, the results obtained for the diameters of individual intestinal segments were at a similar level to ours, regardless of the housing system [Wegner *et al.* 2024].

In the presented study, the size of the femur (GL, GE) was influenced by the genotype of the birds. Cobb 500 was characterized by higher GL and GE values compared to Ross 308, regardless of the sex of the birds. In another study, the above-mentioned features of the femur were not influenced by the housing system of the Ross 308 parent herd, but the results obtained were very similar to those presented in this study [Wegner *et al*. 2024]. However, Stęczny and Kokoszyński [2020] showed lower values of the analysed features GL, ML, GB and GC of the femur in 42-day-old broiler chickens, which may indicate that the dimensions of the femur are influenced by the age of the birds. Such a relationship between the influence of bird age on the length and width of the femur and tibia was observed in another study [Damaziak *et al.* 2019]. The length and width of the femur and tibia increased with the age of broiler chickens [Damaziak *et al*. 2019]. In our study, we also observed that the femur measurements were influenced by the sex of the birds. Males were characterized by higher values of GL, ML, GB, GD, SM, GC and GE compared to females, and the measurements of GL, AL, GD, SB, SD and DD of the tibia were higher in males compared to females. The bird genotype also influenced the dimensions of GL and DD of the tibia.

Conclusions

In summary, Cobb 500 parent stock had a higher body weight and the percentage of leg muscles, while Ross 308 had a higher percentage of the proventriculus, gizzard and liver. Also, individual sections of the digestive tract (jejunum, caeca, colon, total intestine) and the diameter of colon was larger in Ross 308. However, Cobb 500 had larger dimensions of GL and GE of the femur and GL, AL and DD of the tibia. Males were characterized by a higher body weight, the percentage of leg muscles, wings and remainders, but also higher heart weight, liver and spleen. However, females had a higher percentage of the proventriculus, gizzard and liver in body weight. Males were also characterized by longer ileum and caeca segments and analysed measurements of the femur and tibia. The results indicate that the carcass composition of Cobb 500 broiler breeder was more favourable due to a higher content of breast and leg muscles (better meatiness), and a lower proportion of skin with subcutaneous fat and abdominal fat (less fatness) in the carcass compared to Ross 308 broiler breeder. Ross 308 broiler breeders, on the other hand, were characterized by better development of internal organs, including the gut than Cobb 500 birds. The information obtained on the body weight and carcass composition can be useful for producers and buyers of meat broiler breeders, while digestive system characteristics and leg bones supplement knowledge of avian anatomy.

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