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Effect of sexing on the performance and carcass characteristics of Ross® 308 AP broilers

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ABSTRACT

The study aimed to evaluate the effect of sexing on performance, carcass characteristics, bone development, and profitability of Ross® 308 AP broilers. Six hundred chicks, one day old, reared by sex separation, were used. The experimental design used was completely randomized, with three treatments composed of lots separated by sex (males, females, and mixed) and five replications. Live weight, weight gain, feed intake and conversion, carcass weight and yield, commercial cuts, edible offal, and abdominal fat were evaluated. The length, thickness, weight, and Seedor index of the long bones (tibiotarsus and femur) were measured to assess bone development. An analysis of viability (VB), productive efficiency index (PEI), and profitability was carried out. The productive performance of broilers raised in male and mixed lots was higher from 1 to 21 days compared to the productive performance of females. The broilers from the mixed lots had greater femur length than the female lot, not differing from the males. Ross® 308 AP male broilers had better performance, carcass characteristics, and most parameters related to bone development than the mixed and female lots. However, mixed lots showed higher profitability than male and female lots.

Keywords: Poultry, Bone development, Profitability, Economic viability.

Efeito da sexagem no desempenho e características de carcaça de frangos de corte Ross® 308 AP

RESUMO

Objetivou-se avaliar o efeito da sexagem no desempenho, características de carcaça, desenvolvimento ósseo e lucratividade de frangos de corte Ross® 308 AP. Foram utilizados 600 pintinhos, com um dia de idade, criados por separação do sexo. O delineamento experimental utilizado foi o inteiramente casualizado, com três tratamentos que foram lotes separados por sexo (machos, fêmeas e mistos) e cinco repetições. Avaliou-se o peso vivo, ganho de peso, consumo de ração e conversão alimentar, o peso e rendimento de carcaça, cortes comerciais, miúdos comestíveis e gordura abdominal. Para avaliação do desenvolvimento ósseo foram mensurados o comprimento, espessura, peso e índice de Seedor dos ossos longos (tibiotarso e fêmur). Realizou-se análise de viabilidade criatória (VC), índice de eficiência produtiva (IEP) e lucratividade. O desempenho produtivo dos frangos criados em lotes de machos e mistos foram maiores a partir do período de 1 a 21 dias quando comparado ao desempenho produtivo de fêmeas. Os frangos dos lotes mistos apresentaram maior comprimento de fêmur do que o lote de fêmea não diferindo dos machos. Frangos de cortes machos, da linhagem Ross® 308 AP apresentaram melhores desempenho produtivo, características de carcaça e a maioria dos parâmetros relacionados ao desenvolvimento ósseo do que os lotes de mistos e de fêmeas. Porém, lotes mistos apresentaram maior lucratividade que os lotes de machos e fêmeas.

Palavras-chave: Avicultura, Desenvolvimento ósseo, Lucratividade, Viabilidade econômica.

1. Introduction

The production of broilers in Brazil and the world has been highlighted intensely, being considered a large production chain. According to the ABPA annual report (2021), in the 2020 ranking, Brazil was the third largest producer of chicken meat globally, corresponding to 13.845 million tons, behind the United States and China. In terms of exports, Brazil is the country that most exports chicken meat, and in 2020 it exported 4,231 thousand tons. National consumption per capita was 45.27 kg per inhabitant in 2020 (ABPA, 2021).

To create broilers, genetically improved and fast-growing lines have been used, among which we can mention the Ross® 308 AP line, which has a robust size, fast growth, excellent feed conversion, and good carcass yield, satisfying, thus, the need for producers and market requirements. However, to obtain the desired result, or meat cutting efficiency and low costs, it is necessary to carry out adequate management at each stage of chicken development, such as access to water and food, keeping the birds in a thermal comfort zone, and maintain hygiene standards to reduce the risk of illness (Aviagen, 2017).

With a demanding consumer market for quality products, the challenge is to produce broilers with higher yields, uniformity, and better feed conversion. This improvement in the yield and uniformity of the production lot can be obtained with the separation by sex, which provides satisfactory results since males raised under the same conditions as females have significantly higher body weights, in addition to achieving better regulation of the equipment, and in this way, it is possible to obtain better uniformity in the production of these birds (Albuquerque et al., 2006).

Api et al. (2017) evaluated the effect of lineage and sexing of broilers concerning the productive carcass performance and observed that from the initial phase until 14 days, there was no difference in the creation of separate lots between males, females, and mixed. However, from the third week onwards, male broilers differed in weight gain and live weight until slaughter, aspects also evidenced with the mixed ones. In addition, male broilers showed better feed conversion when compared to the lot of females.

Even with all the genetic advances and studies carried out to reduce slaughter time and increase muscle deposition, there is an incidence of locomotor problems in broilers, which raises concerns for slaughterhouses (Almeida-Paz et al. al., 2010; Ponso et al., 2012), hence the need to study the behavior of bone development in broilers. The study aimed to evaluate the effect of sexing on performance, carcass characteristics, bone development, and profitability of Ross® 308 AP broilers.

2. Material and Methods

The experiment was carried out in the experimental broiler shed of the Animal Science Sector of the State University of Mato Grosso do Sul, Cassilândia Unit, (19º07'21" S, 51º43'15" W, and altitude of 516 m) from October 16 to November 26, 2019. The project was approved by the Ethics Committee on the Use of Animals (CEUA) of the State University of Mato Grosso do Sul (UEMS) under protocol n. 028/2019. A genetic group of Ross® 308 AP broilers was used, totaling 600 day-old broilers, 300 males and 300 females, with an average weight of 40 grams. The chicks were sexed and vaccinated in the hatchery against Newcastle, Marek, Infectious Bronchitis, and Fowl Pox diseases.

The birds were housed in boxes of 3 m^2 each, in a conventional shed, with fiber-cement tile, 22 m long by 6 m wide and with a ceiling height of 2.30 m, with the presence of fans and nebulizers. All boxes were equipped with a heating source (hoods) with 150 W lamps. A first-use wood shavings bed was used on the floor with approximately 8 cm in height; it was removed in parts and replaced weekly (when they were drawn to carry out the weighing) and, when necessary, to control the plastering.

During the first eight days of the chicks' life, the infant pressure cup type and infant tubular feeders were used. Later, they were gradually replaced by automatic pendulum drinkers and adult tubular feeders. A 0.60 m high sheet of plywood sheet protection was used in all boxes to protect the chicks in the first days of life, keeping them close to the heat source, feeder, and drinker and avoiding air currents. The circles were opened gradually following the growth of the chicks, and on the eighth day, they were removed for the greater comfort of the birds.

The control of heating, as well as the handling of the curtains, was carried out according to the needs of the birds. The temperature inside the shed was recorded using a digital maximum and minimum thermometer, kept in the center of the shed, and recorded twice a day, at 7:30 am and 4:00 pm, throughout the experiment, with a minimum average of 25.7 ºC and maximum average of 35.0 ºC. Diets made with energy concentrate (corn bran), and protein concentrate (soybean meal) were used, according to the tables of nutritional requirements of broilers according to Rostagno (2011), corresponding to three phases: initial ration (1 to 21 days), grower feed (22 to 35 days) and final feed (36 to 42 days), whose compositions are shown in Table 1. During the experimental period, feed and water were provided ad libitum to the birds.

Table 1. Percentage and chemical composition of experimental diets for Ross® 308 AP broilers.

Ingredients (%)	Initial phase	Growth phase	Final phase
Ground corn	53.33	54.64	62.10
Soybean meal	39.94	37.53	30.49
Soybean oil	2.91	4.71	4.70
Dicalcium phosphate	1.61	1.10	0.90
Calcitic limestone	1.40	1.43	1.33
Common salt	0.45	0.33	0.25
DL-Methionine	0.21	0.06	0.03
Mineral-vitamin supplement[1]	0.15	0.20	0.20
Total	100.00	100.00	100.00
Calculated Nutritional Values			
Metabolizable energy (kcal per kg)	2,950	3,100	3,200
Crude protein (%)	22.00	21.00	18.50
Calcium (%)	1.00	0.90	0.80
Available phosphorus (%)	0.45	0.35	0.30
Methionine + Total Cystine (%)	0.90	0.72	0.60
Methionine (%)	0.53	0.38	0.32
Lysine (%)	1.24	1.00	0.85
Relationship ME:CP	134.10	147.62	172.97

[1]Mineral-vitamin supplement (content per kg of product) = Vitamin A - 3,000,000 UI; Vitamin E - 9,500 UI; Vitamin B1 - 588 mg; Vitamin B2 - 1660 mg; Vitamin B6 - 792 mg; Vitamin B12 - 4,150 mcg; Vitamin K3 - 520 mg; Vitamin D3 - 800 UI; Calcium pantothenate - 3,230 mg; Niacin - 9,800 mg; Folic acid - 200 mg; Biotin - 20 mg; Zinc - 13 g; Iron - 13 g; Manganese - 15 g; Copper - 3,120 mg; Iodine - 254 mg; Cobalt - 48 mg; Selenium - 88 mg; Ethoxyquin - 52 mg; B.H.A. - 40 mg; Q.S.P Vehicle - 1,000 mg.

Weekly, performance data was collected in the accumulated periods from 1 to 7, 1 to 14, 1 to 21, 1 to 28, 1 to 35, and 1 to 42 days of age, and later the evaluations were carried out. All birds in each pen were weighed at the beginning of the experiment and weekly. Weight gain was calculated by the difference between the final and initial weights of the evaluated period. Feed intake was obtained by the difference between the total feed supplied and the feed leftovers at the end of each period, being corrected by the average number of birds in the period. The feed conversion was calculated by the ratio between the total feed consumed and the weight gain in the period, corrected for mortality according to Sakomura and Rostagno (2016).

The viability of the birds was determined through the number of live birds within each treatment, given as a percentage: VB = FN*100/IN, where VB is the viability (%), FN is the number of live birds at the end of the experiment and IN is the number of birds placed in each treatment at the beginning of the experiment. The productive efficiency index was determined through live weight, viability, feed conversion, and age at slaughter by the formula: PEI = ((LW*VB)/(FC*AS)*100), where PEI is the productive efficiency index, LW is the live weight (kg), VB is the breeding viability (%), FC is the feed conversion of animals from 1 to 42 days, and AS is the age at slaughter (at 42 days).

To evaluate the weight, carcass yield, commercial cuts, edible offal, and abdominal fat of the animals up to 42 days of age, two birds were chosen per experimental unit with ± 5% of the average live weight of the box, making a total of 10 broilers. by treatment to evaluate carcass characteristics. After eight hours of fasting, the birds were subjected to normal slaughter procedures (stun, bleeding, plucking, and evisceration).

The carcass yield was calculated concerning the live weight before slaughter [CY (%) = (carcass weight*100/live weight)] where the weight of the eviscerated carcass (without head, feet, and neck) was considered concerning the live weight of slaughter. The cuts of breast, back, thigh, drumstick, wing, wing drumstick, and edible offal (liver, heart, and gizzard) had their respective yields determined as a function of carcass weight [PY (%) = (weight of part*100 /carcass weight)], where PY is part yield.

The abdominal fat collected consisted of the adipose tissue from the gizzard to around the cloaca and bursa of Fabricius. The yield was determined according to the carcass weight. To assess bone development, two birds per repetition were slaughtered weekly at 7, 14, 21, 28, 35, and 42 days of age, with an average cage weight (± 5%) for collecting long bones (tibiotarsus and femur). For better standardization, the bones on the right side were collected. After the collection, the bones were frozen, and then the muscle was removed; in this way, the bone analyzes were performed.

A semi-analytical precision scale (±0.01g) was used to measure bone weight. Both bone length and thickness were measured using a digital caliper (0.1mm). The

length was measured by taking the greatest distance between the epiphyses and thickness by taking the central point of the bone, and measurements were always made at the same points and by the same person on all bones. Using bone weight and length, the Seedor index (Seedor et al., 1991) was calculated with bone weight expressed in mg divided by bone length expressed in mm.

The economic analysis of this study was based on a standard aviary for raising broilers, with 2100m2, and the results were simulated with birds separated by sex (males, females, and mixed), thus obtaining three treatments, using the results obtained by the birds in the different treatments, at 42 days of age. Profitability analysis was done using the financial expenditure of chicks and feed. The financial expenditure per kilo of feed was calculated based on the prices of the raw materials used, and the price of a kg of live chicken and the one-day-old chick was quoted in July 2020. The average feed cost was R$1.20/kg, the price of live chicken was R$2.90/kg, and the price of a day-old chick was R$1.60.

The experimental design used was completely randomized with three treatments: males, females, and mixed, with five replications each, totaling 15 experimental units. The performance data, carcass weight and yield, commercial cuts, edible offal, abdominal fat, productive efficiency index, and viability were submitted for analysis of variance, and the means were compared by the Tukey test at the level of 5% of probability. Data related to bone development were previously tested for normality using the Kolmogorov-Smirnov test. When this assumption was not verified, the data were transformed using the Box-Cox transformation, given by the equation: $y\lambda = (y\lambda - 1)/\lambda$. Statistical analyzes were performed using the Sisvar software version 5.6 (Ferreira, 2011).

3. Results and Discussion

Table 2 shows the productive performance characteristics in the accumulated periods from 1 to 7, 1 to 14, 1 to 21, 1 to 28, 1 to 35, and 1 to 42 days.

Table 2. Means of live weight (LW), feed intake (CR), weight gain (WG), and feed conversion (FC) of male, female, and mixed Ross® 308 AP broilers in the accumulated periods from 1 to 7, 1 to 14, 1 to 21, 1 to 28, 1 to 35 and 1 to 42 days of age.

Parameters	Male	Female	Mixed	P	CV (%)
		Period from 1 to 7 days			
LW 7 days (g)	204	205	208	0.4520	2.31
FI (g)	184	189	184	0.3488	3.06
WG (g)	165	165	167	0.5739	2.20
FC	1.114	1.147	1.100	0.3048	4.21
		Period from 1 to 14 days			
LW 14 days (g)	510	497	514	0.2003	2.83
FI (g)	609	600	601	0.7110	2.97
WG (g)	471	457	473	0.1368	2.82
FC	1.294	1.316	1.271	0.5987	5.24
		Period from 1 to 21 days			
LW 21 days (g)	1.045a	967b	1.009ab	0.0110	3.37
FI (g)	1.302a	1.228b	1.254ab	0.0220	2.90
WG (g)	1.006a	926b	968ab	0.0077	3.40
FC	1.296	1.327	1.296	0.5365	3.76
		Period from 1 to 28 days			
LW 28 days (g)	1.583a	1.431b	1.497b	0.0014	3.27
FI (g)	2.212a	2.047b	2.107ab	0.0075	3.21
WG (g)	1.544a	1.390b	1.456b	0.0011	3.31
FC	1.433	1.473	1.447	0.3430	2.88
		Period from 1 to 35 days			
LW 35 days (g)	2.321a	2.027c	2.166b	0.0002	3.39
FI (g)	3.522a	3.156c	3.325b	0.0003	2.93
WG (g)	2.282a	1.986c	2.125b	0.0001	3.42
FC	1.544	1.590	1.565	0.2188	2.50
		Period from 1 to 42 days			
LW 42 days (g)	2.862a	2.509b	2.707ab	0.0048	5.00
FI (g)	5.003a	4.358c	4.621b	0.0000	3.08
WG (g)	2.823a	2.468b	2.666ab	0.0045	5.06
FC	1.779	1.766	1.734	0.6978	4.83

a-c = means within each line, for each variable, followed by different letters differ by the Tukey test at a 5% probability level.
CV = Coefficient of variation.

In the period from 1 to 7 and 1 to 14 days, there was no influence of sexing on the productive performance of broilers (Table 2). Murakami et al. (2010), working on productive performance and meat quality of broilers fed with feeds containing linseed oil, also found that in the 1 to 7-day phase, there was no influence of sex on the productive performance of the birds, that is, the sexing did not interfere in the chick development during the starter phase.

The live weight, weight gain, and feed consumption of the broilers were higher for the male broilers, not differing from the mixed lot, while the females obtained lower results than the males and similar to the mixed ones for live weight, weight gain, and feed intake in the period from 1 to 21 days. There was no influence of sexing for feed conversion from 1 to 21 days. According to the Gompertz curve (Santos et al., 2005), male broilers differ from females in the second week of life, which leads them to consume more feed, gaining greater body weight; with advancing age, this difference tends to increase, despite the difference in weight, the growth behavior is the same. In addition, during this period, it is important to keep the temperature below 21ºC to improve the growth rate of the broilers.

The male broilers had feed consumption similar to the mixed lot in the rearing period from 1 to 28 days; however, the weight at 28 days, feed intake, and weight gain were higher than the females and mixed. There was no difference in feed conversion between the sexes. Male broilers had higher feed intake and weight gain and greater weight at 35 days than females and mixed broilers; mixed broilers had higher feed intake and greater weight gain than females in the period from 1 to 35 days (Table 2). For feed conversion, there was no difference between the sexes. When evaluating the effect of sex on productive performance and carcass characteristics of broilers, Gottardi et al. (2019) observed that males showed higher weight gain and feed intake than females in the phase from 1 to 28 and 1 to 35 days for the feed conversion parameter they did not differ from each other.

For the total rearing period from 1 to 42 days (Table 2) for both live weight and weight gain at 42 days, broilers from mixed lots and males had higher rates, differing from females, in terms of feed intake. In the same period, the male lot consumed more than the mixed lot, which presented higher consumption than the female lot; these results are similar to those of Api et al. (2017) who, when evaluating the effect of sexing and lines on development and carcass yield, observed that males have better live weight, weight gain and feed consumption compared to females. In the present study, feed conversion did not differ between the sexes.

The Ross line manual (Aviagen, 2017) cites the average weight of 3,103g for males, 2,920 g for mixed, and 2,737 g for females at 42 days of age, while in this research, the results obtained were: 2,862 g for males, 2,707 g for mixed and 2,509 g for females, that is, 241 g less in weight for males, 213 g for mixed, and 228 g for females, this lower performance may have occurred because the broilers were raised in the Midwest region, a region that is very hot during practically the whole year, as noted in this work, where the minimum temperature throughout the experiment was 25.7 ºC and the maximum was 35 ºC, and after 21 days the temperature must be below 21 ºC. Broilers have difficulties carrying out heat exchanges with the environment, which causes these animals to increase their respiratory rate to perform these exchanges and, consequently, reduce feed consumption as the room temperature increases.

Another crucial point to be considered is the type of shed, which, in this study, is a conventional shed with fans and nebulizers; in this type of shed, the relative humidity of the air (RH) ends up being low which makes it difficult for the animals to exchange heat and thermal comfort causing damage to the general performance of the animals. This same manual cites for feed conversion from 1 to 42 days 1.619 for males, 1.631 for broilers from mixed lots, and 1.644 for females; in the present study, 1.779, 1.734, and 1.766 were obtained, respectively, a little above the recommended, possibly due to the high temperature during the experiment, which averaged 30 ºC.

Table 3 shows carcass weight and yield, commercial cuts, edible offal, and abdominal fat. Broilers from the male lot had higher carcass weight than females, not differing from mixed lots. For thigh weight, the lot of male broilers had higher weight than females and mixed ones, and the latter two did not differ from each other. For the weight of the breast, back, drumstick, wing, and wing drumstick, there was no influence of sex. As for the weight of edible offal and abdominal fat, only the heart was influenced by sex, where male broilers had higher averages than females, not differing from the mixed lot. This occurs because male broilers have a greater accumulation of muscle tissue and consequently a greater demand for blood irrigation, which makes them need a larger heart to meet this demand.

Similar results were obtained by Marcato et al. (2010). They, evaluating the growth and deposition of nutrients in the organs of broilers from two commercial strains, observed that the heart weight values of males of both the Cobb 500 line and the Ross® 308 AP line were higher than that of females. There was no difference in weight and abdominal fat yield between the sexes (Table 3). The results of carcass characteristics of commercial cuts showed differences in the carcass, thigh, and heart weight; the lot of male broilers showed higher weight than the females for carcass and heart weight, not differing from the mixed lot.

Table 3. Means of carcass weight and yield, commercial cuts (breast, thigh, drumstick, wing, and wing drumstick), edible offal (liver, heart, and gizzard), and abdominal fat of Ross® 308 AP broilers.

Parameters	Male	Female	Mixed	P	CV (%)
Weight (grams)					
Carcass	2,060a	1,808b	1,891ab	0.0485	7.53
Breast	683	599	649	0.1396	9.52
Back	452	426	421	0.4617	9.51
Thigh	292a	244b	250b	0.0049	7.57
Drumstick	331	293	302	0.0821	8.17
Wing	102	93	94	0.1981	7.90
Wing drumstick	111	104	107	0.5303	8.92
Liver	42	39	40	0.3331	8.79
Heart	11a	8b	9ab	0.0081	12.64
Gizzard	39	37	37	0.4888	8.34
Abdominal fat	32	32	30	0.9374	23.31
Yield (%)					
Carcass	75.02	76.00	75.68	0.1672	1.02
Breast	34.00	33.11	34.33	0.5229	5.69
Back	21.93	23.58	22.32	0.2021	6.31
Thigh	14.19a	13.50ab	13.22b	0.0274	3.68
drumstick	16.12	16.22	15.96	0.9341	6.91
Wing	4.93	5.16	4.97	0.1628	3.78
Wing drumstick	5.39	5.74	5.70	0.2664	6.34
Liver	2.07	2.16	2.10	0.5315	6.18
Heart	0.51a	0.43b	0.48ab	0.0400	9.38
Gizzard	1.90	2.04	1.94	0.4415	8.77
Abdominal fat	1.54	1.75	1.62	0.5873	19.29

a-b = means within each line, for each variable, followed by different letters differ by the Tukey test at a 5% probability level.
CV = Coefficient of variation.

For thigh weight, the lot of males was superior to the lot of females and mixed, which did not differ. There was no difference between the sexes for carcass yield, breast, back, drumstick, wing, and wing drumstick. For edible offal yield, there was a significant difference for thigh and heart; the lots of male broilers had superior thigh yield when compared to the mixed lot, not differing from the female lot; for heart yield, the lot of males and mixed did not differ; however, the male lot showed higher yield than the female lot.

Satisfactory breast yield is observed for lots of male broilers; the average was 34.00%, for females, 33.11%, and for mixed broilers, 34.33% (Table 3). Considering that in the period of 36 to 42 days of the experiment, the minimum and maximum temperatures were 25.9 and 33.9 ºC, respectively, with an average of 29.9 ºC, and that, according to the Ross manual (Aviagen, 2017), the ideal temperature for the birds in this period must be below 21 ºC, although the Central-West region is hot, the creation of broilers is viable, as long as quality and ideal feed is used for each phase, perform proper handling, that is, adjustment of feeders and drinkers according to the requirements of each lot. It is also necessary to keep the birds in the thermal comfort zone or as close as possible to achieve good weight and carcass yield results in the creation of Ross® 308 AP broilers. The means of viability (VB) and PEI (productive efficiency index) are shown in Table 4.

During the entire experimental period, the total mortality of the broiler lot was 4.89%. There was no difference in CV for sex (Table 4), even knowing that males are more likely to have a heart attack or locomotor problems; in the present study, all lots are within the ideal CV values, up to 5%. As for the line, the results of this study corroborate those observed by Nowicki et al. (2011), who, working with the viability of the Cobb and Ross lines, concluded that the Ross line has better viability than the Cobb. This is because the bone structure of Cobb does not support its high capacity for weight gain, which increases the development of locomotor problems and a high death rate from infarction.

Table 4 also shows the PEI values, which most companies use to remunerate their producers. These values are determined by four parameters: live weight (kg), viability (%), feed conversion, and slaughter age. In the present study, there was no difference in the PEI concerning the sexes; although the four parameters were below average, the others compensated.

Table 4. Viability (VB) and productive efficiency index (PEI) of Ross® 308 AP broilers submitted to sex separation from 1 to 42 days.

Parameter	Male	Female	Mix	P	CV (%)
VB (%)	95	98	97	0.2441	2.96
PEI	356	329	357	0.1653	6.93

Non-significant effect by the Tukey test at 5% probability.
CV = Coefficient of variation.

A PEI value considered optimal is above 250, and all lots had a PEI within the expected; that is, regardless of the sex of the lot, the producers will receive the same price. These data corroborate those of Moro et al. (2005), who worked with the productive performance of four broiler lines and concluded that, regardless of sex, the PEI was the same at 56 days of age. There was no interaction between sex and age for the length and thickness of the tibiotarsus and femur (Tables 5 and 6).

Table 5 presents the parameters related to the bone length of both the tibiotarsus and the femur of the broiler concerning sex and age. There was no difference in tibiotarsus length concerning sex. The broilers of the mixed lot had greater femur length than the lot of females, not differing from the males. It can be noted that the lengths of the tibiotarsus and femur increased with the age of the birds because they are constantly growing, thus, obtaining greater bone development at 42 days of age.

Table 5. Means and analysis of variance for the effect of sex and age on the length of long bones (tibiotarsus and femur) of Ross® 308 AP broilers.

Treatments	Tibiotarsus length (mm)	Femur length (mm)
Sex		
Male	79.37	56.88ab
Female	78.55	55.90b
Mixed	79.59	57.33a
Age (days)		
7	44.95f	33.12f
14	60.07e	43.57e
21	75.18d	54.80d
28	86.10c	60.99c
35	99.74b	71.16b
42	108.97a	76.58a
CV (%)	3.95	3.26
Source of Variation	Probability > F	
Sex	0.3024	0.0033
Age	0.0000	0.0000
Sex x Age	0.1695	0.1121

a-f = means within each column, for each variable, followed by different letters differ by the Tukey test at a 5% probability level.
CV = Coefficient of variation.

Table 6. Means and analysis of variance for the effect of sex and age on the thickness of long bones (tibiotarsus and femur) of Ross® 308 AP broilers.

Treatments	Tibiotarsus Thickness (mm)	Femur Thickness (mm)
Sex		
Male	7.15a	7.78a
Female	6.53b	7.18c
Mixed	6.61b	7.44b
Age (days)		
7	3.32e	3.44e
14	5.10d	5.65d
21	6.89c	7.56c
28	7.57b	8.51b
35	8.63a	9.67a
42	9.08a	9.96a
CV (%)	11.40	9.27
Source of Variation	Probability > F	
Sex	0.0000	0.0000
Age	0.0000	0.0000
Sex x Age	0.1472	0.1577

a-e = means within each column, for each variable, followed by different letters differ by the Tukey test at a 5% probability level.
CV = Coefficient of variation.

When analyzing the thickness of the tibiotarsus (Table 6), it is observed that male broilers showed higher values than females and mixed ones. Femur thickness was greater for males, differing from mixed ones; the latter was superior to the lot of females. These results corroborate those of Oliveira et al. (2012), who evaluated the same parameters and concluded that the length and thickness tend to increase with the age of the birds. There was no interaction between sex and age for broiler tibiotarsus weight (Table 7). It was observed that males had higher tibiotarsus bone weight than females, which did not differ from the mixed ones. About age, as the weeks go by, the bones of males, females, and mixed broilers become heavier, reaching their heaviest weight at 42 days.

There was an effect of the interaction between sex and age on femur weight (Table 8). Male broilers had higher femur weight than females at 28 days of age, not differing from the mixed lot. For the age of 35 and 42 days, males had higher femur weights when compared to mixed and female lots and, in turn, mixed lots had higher femur weights than females. About age, it was observed that, as the weeks passed, the femur of males, females, and mixed ones became heavier, reaching their greatest weight at 42 days of age due to the increase in bone growth over the days; consequently, their weight also increases.

There was no interaction between sex and age for weight and Seedor index of tibiotarsus (Table 9). Males showed a higher Seedor index of tibiotarsus than females and mixed ones, which in turn did not differ from each other. This result was possibly due to the weight of the male tibiotarsus being greater than that of the female and mixed lots; with this, the density is higher for males.

Table 7. Means and analysis of variance for the effect of sex and age on the tibiotarsus weight of Ross® 308 AP broilers.

Treatments	Tibiotarsus Weight (g)
Sex	
Male	10.98a
Female	9.48b
Mixed	9.95b
Age (days)	
7	1.49f
14	3.88e
21	8.13d
28	11.33c
35	16.65b
42	19.36a
CV (%)	7.76
Source of Variation	
Sex	0.0000
Age	0.0000
Sex x Age	0.0640

a-f = means in the column followed by different letters differ by the Tukey test at a 5% probability level.
CV = Coefficient of variation.

Table 8. Influence of interaction between sex and age of Ross® 308 AP broilers on femur weight.

Age (days)	Broiler sex		
	Male	Female	Mixed
7	1.09f	1.08f	1.05f
14	3.15e	2.89e	3.05e
21	6.33d	5.59d	6.06d
28	8.78cA	7.59cB	8.54cAB
35	13.91bA	11.29bC	12.29bB
42	15.76aA	13.06aC	14.05aB

Means followed by distinct letters, lowercase in the column (a-f) and uppercase (A-C) in the line differ by the Tukey test at the 5% probability level.

Table 9. Means and analysis of variance for the effect of sex and age on the Seedor index of tibiotarsus of Ross® 308 AP broilers.

Treatments	Seedor Index of Tibiotarsus (mg/mm)
Sex	
Male	0.12a
Female	0.11b
Mixed	0.11b
Age (days)	
7	0.03e
14	0.06d
21	0.11c
28	0.13b
35	0.17a
42	0.18a
CV (%)	9.67
Source of Variation	
Sex	0.0000
Age	0.0000
Sex x Age	0.0634

a-e = means in the column followed by different letters differ by the Tukey test at a 5% probability level.
CV = Coefficient of variation.

There was an effect of the interaction between sex and age on the Seedor index of the femur of Ross® 308 AP broilers (Table 10). At 28 days, males had a higher Seedor index of the femur than females, not differing from the mixed lot, as for age at 35 and 42 days, the male lot had a higher Seedor index of the femur when compared to female and mixed lots which did not differ from each other. According to the evaluations, the Seedor index increased over time, reaching the highest index at 42 days. These same data corroborate with Henrique et al. (2017), who stated that bone length and weight gain tend to increase over time. Male broilers had higher production cost when compared to mixed and female lots (Table 11). Profitability was higher for mixed lots when compared to the lot of males and females because this lot contains both sexes (males and females).

Table 10. Influence of the interaction between sex and age of Ross® 308 AP broilers on femur Seedor index.

Age (days)	Broiler Sex		
	Male	Female	Mixed
7	0.03e	0.03e	0.03e
14	0.07d	0.07d	0.07d
21	0.12c	0.10c	0.11c
28	0.14bA	0.12bB	0.13bAB
35	0.19aA	0.16aB	0.17aB
42	0.20aA	0.17aB	0.18aB

Means followed by distinct letters, lowercase in column (a-e) and uppercase in line (A-B) differ by the Tukey test at the 5% probability level.

Table 11. Effect of sexing on profitability and production costs (R$) of Ross® 308 AP broilers at 42 days of age, estimated in a conventional shed of 2100 m^2.

Factor	Unit Price (R$)	Sex		
		Male	Female	Mixed
Housed broilers	-	21,000.00	21,000.00	21,000.00
Slaughtered broilers	-	19,950.00	20,580.00	20,370.00
Productivity (kg m^{-2})	-	29.61	27.34	29.09
Total productivity (kg)	-	62,177.24	57,405.22	61,088.06
Price of broiler (R$ per kg)	2.90	180,313.99	166,475.15	177,155.37
Financial expenditure of chicks (R$)	1.60	33,600.00	33,600.00	33,600.00
Financial expenditure of feed per kg (R$)	1.20	119,771.82	107,600.47	112,931.28
Total cost (R$)	-	153,371.82	141,200.47	146,531.28
Profit (R$)	-	26,942.17	25,274.68	30,624.09

Looking at Table 11, profitability was higher for mixed lots because females consumed less feed than males; male broilers, in turn, have high productivity, in the period from 1 to 42 days the mixed ones consumed less feed than the males, but the weight at 42 days was the same, which led to greater profitability. The mixed lot is more profitable due to the lower financial expense of the feed, which despite being a little higher than the female lot, still compensates for the creation of mixed lots since they obtained greater live weight and weight gain at the end of rearing.

4. Conclusions

Ross® 308 AP male broilers showed better performance, carcass characteristics, and most parameters related to bone development than the mixed and female lots. However, mixed lots showed higher profitability than male and female lots.

Authors' Contribution

Andréia Fróes Galuci Oliveira de Souza and Anaisa Aparecida Perez Gonçalves contributed throughout the experimental and drafting the article. Thales Silva Ferreira, Higor Jonathan de Oliveira Silva, Guilherme Henrique Fernandes, Leticia Gabriela Talhaferro Cassuci, Elyan Carlos da Silva Domingues, and Ana Letícia Ribeiro Marques helped in the experimental part and the author Carlos Henrique Leandro Domiciano helped in the weekly weighing of the animals and in the collection of bones.

Bibliographic References

ABPA. ASSOCIAÇÃO BRASILEIRA DE PROTEÍNA ANIMAL. 2021. Relatório Anual 2020. São Paulo: ABPA. http://abpa-br.org/mercados/#relatorios. (acessado 06 de abril de 2022).

Albuquerque, R., Marchetti, L.K. Fagundes, A.C. Bittencourt, L.C., Trindade Neto. M.A., Lima, F.R. 2006. Efeito de diferentes densidades populacionais e do sexo sobre o desempenho e uniformidade em frangos de corte. Brazilian Journal of Veterinary Research and animal Science, São Paulo-SP, 43 (5), 581-587. DOI: https://doi.org/10.11606/issn.1678-4456.bjvras.2006.26565.

Almeida Paz, I.C.L.; Garcia, R.G.; Bernardi, R. Selecting appropriate bedding toreduce locomotion problems in broilers. 2010. Brazilian Journal of Poultry Science, Campinas-SP, 12(3), 189-195. DOI: https://doi.org/10.1590/S1516-635X2010000300008.

Api, I.; Takahashi, S.E.; Mendes, A.S.; Paixão, S.J.; Refati, R.; Restelatto, R. 2017. Efeito da sexagem e linhagens sobre o desempenho e rendimento de carcaça de frangos de corte. Ciência Animal. Brasileira, Goiânia, 18, 1-10. DOI: https://dx.doi.org/10.1590/1809-6891v18e-32691.

Aviagen, 2017 (Ross 308 AP 95) Objetivos de desempenho. http://pt.staging.aviagen.com/assets/Tech_Center/BB_Foreign

_Language_Docs/Portuguese/Ross308AP-Broiler-PO-2017-PT.pdf. (acessado 01 de fevereiro de 2021).

Ferreira, D.F. 2011. Sisvar: a computer statistical analysis system. Ciência e Agrotecnologia, Lavras, 35 (6), 1039-1042. DOI: https://doi.org/10.1590/S1413-70542011000600001.

Gottardi, C.P.F.F., Oliveira, A.F.G., Souza, A.R.Q., Ferreira, B.R., Ferreira, T.S., Abaker, J.E.P. 2019. Efeito do sexo sobre desempenho produtivo e características de carcaça de frangos de corte. Revista de Agricultura Neotropical, 6(2), 52-58. DOI: https://doi.org/10.32404/rean.v6i2.1738.

Henrique, C.S.; Oliveira, A.F.G.; Ferreira, T.S.; Silva, E.S.; Mello, B.F.F.R.; Andrade, A.F.; Martins, V.S.F.; Paula, F.O.; Garcia, E.R.M.; Bruno, L.D.G. 2017. Effect of stocking density on performance, carcass yield, productivity, and bone development in broiler chickens Cobb 500®. Semina: Ciências Agrárias, 38 (4), 2705-2717. DOI: https://doi.org/10.5433/1679-0359.2017v38n4Sulp1p2705.

Marcato, S.M.; Sakomura, N.K.; Fernandes, J.B.K.; Siqueira, J.C.; Dourado, L.R.B.; Freitas, E.R. 2010. Crescimento e deposição de nutrientes nos órgãos de frangos de corte de duas linhagens comerciais. Revista Brasileira de Zootecnia, 39 (5), 1082-1091. DOI: http://dx.doi.org/10.1590/S1516-35982010000500019

Moro, D.N.; Zanella, I.; Figueiredo, E.A.P.; Silva, J.H.S. 2005. Desempenho produtivo de quatro linhagens de frangos de corte. Ciência Rural, 35 (2), 446-449. DOI: https://doi.org/10.1590/S0103-84782005000200032.

Murakami, K.T.T.; Pinto, M.F.; Ponsano, E.H.G.; Neto, M.G. 2010. Desempenho produtivo e qualidade da carne de frangos alimentados com ração contendo óleo de linhaça. Pesquisa Agropecuária Brasileira, Brasília, 45 (4), p. 401-407. DOI: https://doi.org/10.1590/S0100-204X2010000400008.

Nowicki, R.; Butzge, E.; Otutumi, L.K.; Piau-Júnior, R.; Alberton, L.R.; Merlini, L.S.; Mendes, T.C.; Dalberto, J.L.; Gerônimo, E.; Caetano, I.C.S. 2011. Desempenho de frangos de corte criados em aviários convencionais e escuros. Arquivo de Ciências Veterinárias e Zoologia. 14 (1). 25-28. DOI: https://doi.org/10.25110/arqvet.v14i1.2011.3738.

Oliveira, A.F.G.; Bruno, L.D.G.; Garcia, E.R.M.; Leite, M.C.P.; Ton, A.P.S.; Lorençon, L. 2012. Efeito da densidade de criação e do grupo genético sobre o desempenho e o desenvolvimento ósseo de frangos de corte. Scientia Agraria Paranaensis, 11(1), 49-64. http://e-revista.unioeste.br/index.php/scientiaagraria/article/view/6353 (acessado 01 de fevereiro de 2022)

Ponso, R.; Faria, D.E.; Alburquerque, R.; Paz, C.L.A.; Artoni, S.M.B.; Santos, A.L.; Saviane, G.; Araújo, C.M.M. 2012. Avaliação do desenvolvimento da discondroplasia tibial em frangos de corte submetidos à dieta com 25 hidroxicolecalciferol. Brazilian Journal of Veterinary Research and Animal Science, São Paulo–SP, 49 (2), 153-161.DOI: https://doi.org/10.11606/T.74.2008.tde-17022009-082528.

Rostagno, H.S. 2011. Tabelas brasileiras para aves e suínos: composição de alimentos e exigências nutricionais. 3. ed. UFV, Viçosa, Departamento de Zootecnia.

Sakomura, N.K.; Rostagno, H.; S. 2016. Métodos de p pesquisa em nutrição de monogástricos. Jaboticabal: Funep

Santos, A.L.; Sakomura, N.K.; Freitas, E.R.; Maria, C.; Fortes, L.S.; Carrilho, E.N.V.M.; Fernandes, J.B.K. 2005. Estudo do crescimento, desempenho, rendimento de carcaça e qualidade de carne de três linhagens de frango de corte. Revista Brasileira Zootecnia, 34 (5), 1589-1598. DOI: https://doi.org/10.1590/S1516-35982005000500020.

Seedor, J.G., Quartuccio, H.A., Thompson, D.D. 1991. The biophosphonate alendronate (MK-217) inhibit bone loss due to ovariectomy in rats. Journal of Boneand Mineral Research, 6, 339-346. DOI: https://doi.org/10.1002/jbmr.5650060405.