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Research Report

Free-range rearing characteristics of two German dual-purpose chicken breeds: Dresden chickens and Dresden bantams

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SUMMARY

This study characterized the rearing of two dual-purpose chicken breeds, Dresden chickens (DrChi) and Dresden bantams (DrBa), in terms of growth and slaughter performance and integument condition under extensive free-range conditions. The trial consisted of two rearing groups with 173 DrChi and 197 DrBa, which were reared over a period of 20 weeks. Additionally, 50 slow-growing Cobb Sasso™ (CoSa) broilers served as the control group until week 10. DrChi reached body weights of 2,293.1 ± 356.4 g (roosters) and 1,777.9 ± 201.8 g (hens), while DrBa weighed 1,223.1 ± 120.0 g (roosters) and 880.0 ± 121.9 g (hens) by week 20. The growth data were fitted to a re-parameterized Gompertz function. As a result, the maximum daily weight gain were calculated at 19.5 g, 14.5 g, 9.8 g, and 7.1 g, at week of age 9.5, 10.2, 9.2, and 8.9 for male and female DrChi and DrBa, respectively. Using binary logistic regression models, breed and age showed significant differences in plumage damage ($p < 0.001$ each). In the evaluation of the slaughter data, the effects of breed were found both in terms of the carcass yield (DrChi: 64.4 %; DrBa: 59.8 %; CoSa: 72.5 %; $p < 0.014$) and in the proportions of valuable cuts (breast filet—DrChi: 14.5 %; DrBa: 16.7 %; CoSa: 24.9 %; $p < 0.001$; thigh meat—DrChi: 34.7 %; DrBa: 31.4 %; CoSa: 30.0; $p < 0.001$). In conclusion, both local breeds were suitable for extensive rearing and could be an option for local direct marketing.

Description of problem

The global chicken population can be divided into several groups. In addition to commercially used hybrid lines bred by global companies, there are mainly pedigree chickens kept for hobby purposes, which are not used commercially, but whose populations are often highly endangered (Weigend et al., 2014). They are also an animal genetic resource worth preserving to ensure that hybrid breeding can be adapted to changing husbandry and consumer requirements. Conventional hybrid lines are divided into fattening and laying lines, with the killing of male chicks from laying hybrid lines prohibited in Germany since the amendment of the German Animal Welfare Act 2021 (TierSchG, 2022). Alternatively, there are three methods to avoid killing chicks: the use of sex determination in the egg, the rearing of male chicks as so-called "brother roosters", or the use of dual-purpose hens (Jahn and Tiemann 2022). In addition to breeding dual-purpose hybrids from parent stock of fattening and laying lines, it is also possible to create utility crosses between hybrids and pedigree chickens or to use pedigree chickens suitable for dual purposes (Jahn and Tiemann 2022). The latter have the advantage of preserving old and possibly endangered breeds. The problem is that the production performance of pedigree chickens in Germany is not sufficiently known. This makes it difficult to select breeds that are suitable for commercial use. In the recent past, various researchers have started to quantify the performance and behavioral traits of pedigree chickens, such as Freick et al. (2022), Damme and Schreiter (2020), Kaiser et al. (2019), and Henning et al. (2017). The subjects of this work are the indigenous Saxon breeds: Dresden chickens (DrChi) in the plumage colors brown and white, and Dresden bantams (DrBa) in the plumage colors brown and reddish brown. Both breeds were created in the 1950s as dual-purpose chickens (Zumpe 1976). The results of the performance test at that time were very promising (Marks 1984), which makes both breeds interesting for performance testing even today. Both breeds were analyzed in terms of breeding success, rearing and slaughter performance, laying performance, and egg quality

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during two separate molting periods. In addition, we analyzed animal welfare indicators and endoparasite infestation.

Materials and methods

In this study, the hatching characteristics, rearing performance traits, integument conditions, carcass performance, and meat quality of two local German chicken breeds were examined. For this purpose, we selected the local chicken breeds DrChi and DrBa (Fig. 1), which were originally bred as dual-purpose chickens (Zumpe, 1976; Marks, 1984). Characteristics of the rearing traits and the carcass composition were also examined in a slow-growing fattening hybrid Cobb Sasso™ (CoSa), which served as the control group. The CoSa eggs were not hatched within the experiment, but chicks were obtained from a commercial operation. According to Westermaier (2015), CoSa seems suitable in alternative housing systems.

This study was reviewed by the Country Directorate of Saxony, Germany, as the responsible animal ethics committee and was not classified as an animal experiment (reference AZ 25-5131/526/1).

Hatching eggs and hatching

Hatching eggs of the DrChi and DrBa were provided by private German hobby chicken breeders on a voluntary basis, who were informed by the breeders´ club. Since the eggs came exclusively from non-commercial farms, there was no standardized husbandry in terms of housing type, group size, litter, feed, and feeding of the parent birds. We agreed with the breeders in advance that the hatching eggs would be

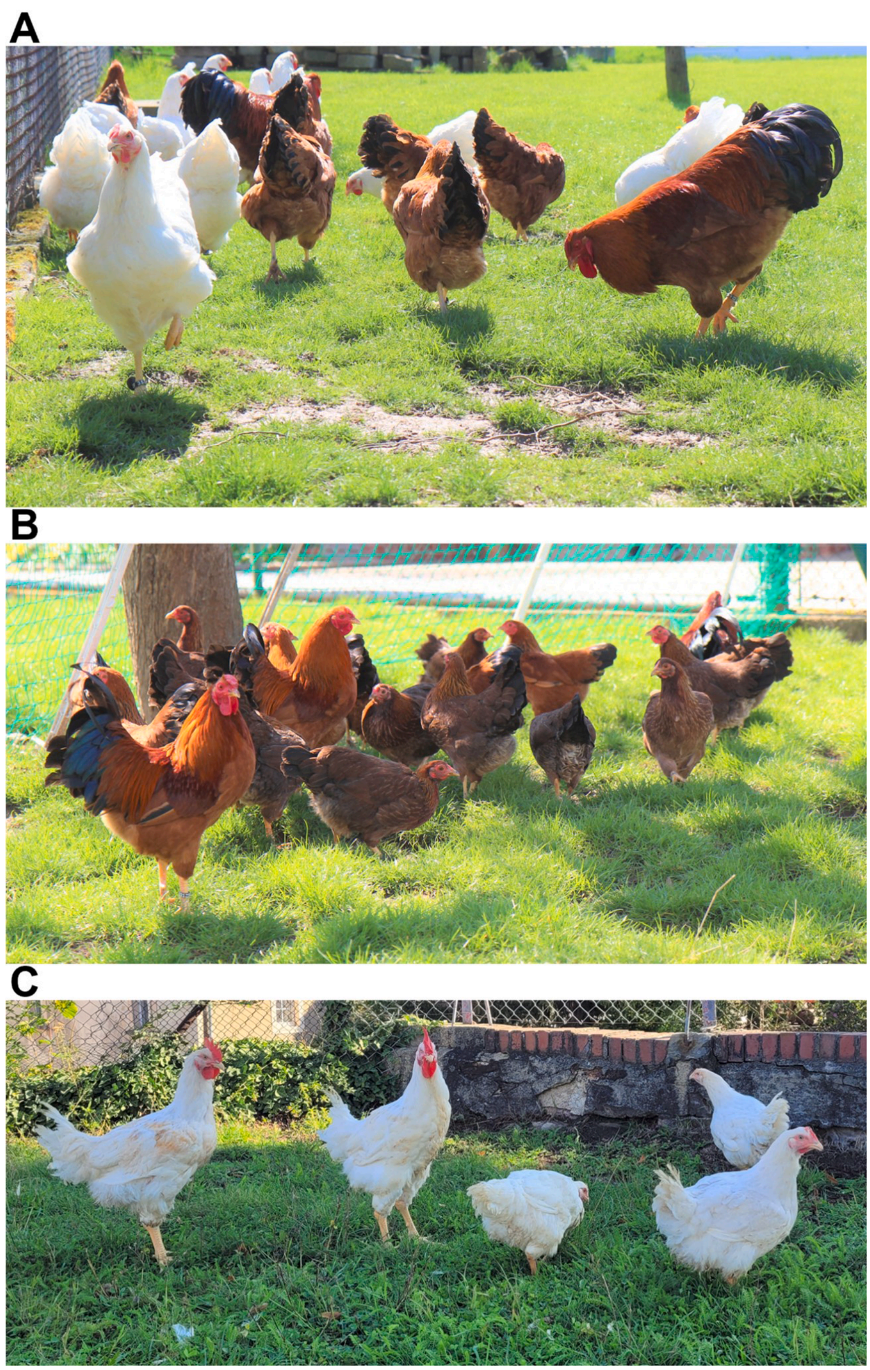


Fig. 1. Phenotype of Dresden chickens (A), Dresden bantams (B), and Cobb Sasso (C).

collected for a maximum of 12 days and stored at 70 % relative humidity with a temperature between 8 and 14°C. The breeders were instructed to mark the eggs individually before delivery. Hatching eggs were stored on egg racks (Ovobest Eiprodukte GmbH & Co. KG, Neuenkirchen-Vörden, Germany) and transported to the hatchery in hatching egg cartons (Jens Bernhardt, Penig, Germany) by car. The maximum transport time from the breeders to the hatchery was 7 h. After transport, the eggs were stored for 24 h at room temperature for acclimatization. Eggs were then hatched artificially in incubators (Favorit-Olymp 660; Heka, Rietberg, Germany) in a private hatchery specializing in fancy chickens (Heiner Nipper's Hatchery Inc., Großschirma, Germany), according to current guidelines (incubation temperature: 37.5°C; humidity: 55 %; turning settings: 12 per day) (Brown, 2009). Hatchery personnel performed egg candling on days 10 and 18 using a Powerlux egg tester (Olba, Coevorden, The Netherlands). On day 10, eggs without visible embryonic development were declared as "unfertilized". Subsequently, on day 18, all eggs that did not show timely embryonic development were grouped as showing "early embryonic death" (Brown, 2009). Unfertilized eggs and those with a dead or severely slow developing embryo were removed at each candling. After a total incubation period of 21 days, those chicks hatched from the eggs were categorized under the groups "hatched" (i.e., that left the egg alive); in contrast, unhatched eggs were categorized as "late embryonic death" (i.e., found dead in the shell after egg transfer). The hatching date was 22 May 2022. Individual animal identification of the chicks was performed using wing tags (Rista Kükenmarke, Sollfrank KG, Nuremberg, Germany).

Animals, housing, and management

Fattening broilers ($n = 50$), which served as a comparison group, were not hatched but purchased from "Schönberger Geflügelhof Weber GmbH & Co. KG" (Schönberg, Germany), as day-old chickens.

The animals were kept on a private farm (Rump's Agricultural Farm, Dresden-Ockerwitz, Germany), which was a project farm at the Dresden University of Applied Sciences. A total of 173 DrChi, 197 DrBa and 50 CoSa (Table 1) were housed, separately, in the farm's mixed-sex rearing pens. The sample sizes vary due to the different hatching results of DrChi and DrBa. In a solid barn, a compartment with a floor area of 7 × 4 m was available for each breed as a single-level housing system(stocking density (animals/m^2) [wk 5; wk 20]: DrChi: 6.2; 3.1; DrBa: 6.6; 3.5; CoSa: 1.75). Electric radiant heaters (Siepmann GmbH, Herdecke, Germany) were used as the heating source to achieve the recommended ambient temperature for the chicks (Lohmann Breeders, 2017). For this purpose, the chicks were located, within their compartments, in an area of 2 × 2 m around the heat source in a chick ring formed by partition grids (Siepmann GmbH, Herdecke, Germany) until day 10. Thereafter, the animals had access to the entire barn area. The floor area was littered with softwood shavings and straw pellets (Einstreuprofi, Seelingstädt, Germany). A total length of 10.5 m of wooden perches (3 × 5 cm diameter) was available per compartment (4 perches per barn in height of 40, 80, 100 and 120 cm).

Table 1
Sample size for determination of the individual animals body weights and integument scoring during the rearing period.

Breed / Plumage colour	Number of animals[1] (male/female)				
	day 0	day 35	day 70	day 105	day 140
Dresden chickens					
Brown	116 (63/53)	116 (63/53)	104 (63/41)	86 (49/37)	58 (24/34)
White	57 (25/32)	57 (25/32)	48 (25/23)	42 (21/21)	30 (10/20)
Total	173 (88/85)	173 (88/85)	152 (88/64)	128 (70/58)	88 (34/54)
Dresden bantams					
Brown	127 (62/65)	127 (62/65)	121 (62/59)	98 (45/53)	62 (13/49)
Reddish Brown	70 (37/33)	58 (30/28)	55 (29/26)	48 (22/26)	36 (11/25)
Total	197 (99/98)	185 (92/93)	176 (91/85)	146 (67/79)	98 (24/74)
Cobb Sasso™	50 (25/25)	49 (25/24)	49 (25/24)		

[1] Since the study was part of a project on the conservation of animal genetic resources, breeding animals were also provided to interested persons during rearing, which explains the reduction of the sample size beyond the animal losses.

Each compartment had a window area of 1.5 × 0.5 m. The lighting program was based on a regime specified for local chickens according to Damme and Schreiter (2020), with high-frequency light sources (aviary lamps; Tageslichtlampen24.de, Kiel, Germany). Feed was provided in 4 round feeders per compartment (Heka, Rietberg, Germany), each with a feeding surface of 125 cm. For the water supply, a nipple drinking system (Kari Farming, Herzebrock, Germany) with 12 nipples was available in each compartment. As additional environmental enrichment materials, pecking stones (Vilolith medium; Deutsche Vilomix Tierernährung GmbH, Neuenkirchen-Vörden, Germany) and hard-pressed alfalfa blocks (Einstreuprofi, Seelingstädt, Germany) were offered ad libitum in the barn.

From wk 9, the animals had access to a free-range area (15 × 25 m per group) with grass vegetation available for eight hours daily. Furthermore, a two-phase feeding program was provided with a complete diet for the chicks from wk 1 to 10 (Küken Premium, Agrargenossenschaft Dorfchemnitz, Zwönitz, Germany; 11.4 MJ ME/kg, 18.7 % CP, 4.5 % CF, 0.44 % methionine, 1.1 % calcium, 0.7 % total phosphorus, 0.18 % sodium) and a complete diet for the pullets from wk 11 to 20 (Junghennen Premium, Agrargenossenschaft Dorfchemnitz, Zwönitz, Germany; 11.2 MJ ME/kg, 15.8 % CP, 4.7 % CF, 0.36 % methionine, 1.0 % calcium, 0.7 % total phosphorus, 0.18 % sodium). All diets were offered ad libitum in mash form. In addition, 2 g of grit per animal with a particle size of 2–4 mm (Geflügel-Magenkies, Einstreuprofi, Seelingstädt, Germany) was provided once a week.

Feed consumption was determined for each of the three groups via continuous initial and back-weighing (scale: Defender 3000, Ohaus, Parsippany, NJ, USA) in 35-day periods. The individual body weight (BW) of each animal was recorded (scale BAT1, Veit Electronics, Moravany, Czech Republic). At the same time, the uniformity among each sex within the breed was calculated on the basis of the individual animals' masses according to Pottgüter et al. (2018). Uniformity indicates the proportion of sample animals presenting BW within ± 10 % of the arithmetic mean of the sample (Jeroch and Müller, 2018). As a further measure of homogeneity within the group, we determined the percentage of deviation in each individual animal mass from the arithmetic mean of BW for each plumage color and sex within the breed.

To prevent infectious diseases, the flock veterinarian carried out a vaccination program tailored to the farm. The prophylaxis included vaccination against Marek's disease (Nobilis Rismavac + CA126, MSD Tiergesundheit, Unterschleißheim, Germany), Newcastle disease (Nobilis ND Clone 30, MSD Tiergesundheit, Unterschleißheim, Germany), infectious bronchitis (Poulvac IB Primer, Zoetis Deutschland GmbH, Berlin, Germany; Nobilis IB MA5, MSD Tiergesundheit, Unterschleißheim, Germany; AviPro IB H52, Elanco Animal Health, Bad Homburg, Germany), infectious laryngotracheitis (Nobilis ILT, MSD Tiergesundheit, Unterschleißheim, Germany), coccidiosis (Paracox 8, MSD Tiergesundheit, Unterschleißheim, Germany), Mycoplasma gallisepticum infection (Nobilis MG 6/85, MSD Tiergesundheit, Unterschleißheim, Germany), and infectious bursal disease (AviPro Gumboro vac, Elanco Animal Health, Bad Homburg, Germany).

Animal losses were recorded daily. Notably, since this study was part of a project on the conservation of animal genetic resources, breeding animals were also provided to interested persons during rearing, as one of the aims of the project is to preserve the DrChi and DrBa breeds. This leads to a reduction in the sample size beyond animal losses. The removal of the animals was random and had no effect on the outcome of the study.

Animal welfare assessment

For the assessment of animal welfare and to indirectly quantify the occurrence of feather pecking and cannibalism, integument scoring was performed in all animals during rearing at four time points (days 35, 70, 105, and 140). The sample size at each observation date is shown in Table 1.

Integument scoring was based on Keppler (2017) for the traits of plumage damage, skin and feather follicle injuries, footpad condition, and keel bone condition. The scoring of the plumage was differentiated according to the back, belly (including cloacal region and ventral rump), dorsal neck, and wing feathers. In addition to the four individual scores, a total plumage score was calculated for each individual animal by adding the individual scores (Schreiter et al., 2020b). The feathers on the front of the neck and the breast were not included in the scoring, as feather damage in these areas due to mechanical stress from the feeding trough does not provide strong evidence for severe feather pecking (Bilcik and Keeling, 1999). To assess skin injuries and injuries of the blood-filled feather follicles in the pullets, all body regions except for the head and feet (including toes) were considered relevant. For all traits, a three-level rating scale (Keppler, 2017) was applied, with a score of 0 representing an intact condition, a score of 1 representing moderate damage, and a score of 2 representing severe damage. For a summarized graphical representation of the plumage condition of the four regions assessed, the following grouping was made based on the total plumage score: intact plumage (0), marginal changes (1), slight damage (2), moderate damage (3), and severe damage ($\geq$4). Integument scoring was performed by three observers who completed a training period on 300 animals to determine inter-observer reliability.

Slaughter and carcasses collection

The roosters (n = 20 per breed) were slaughtered on day 140 according to regulation (EC) Nos. 853/2004 and 1099/2009. The 49 broilers were already slaughtered on day 70. After eight hours of fasting (food and water), the birds were weighed alive, electrically stunned (9 s, 100–150 mA), bled via neck incision, scalded (58°C, 170 s), defeathered, and gutted. Until dissection on the following day, they were chilled at 4°C. After storage for 24 h, the weights of the carcasses (without head, innards and feet) and the abdominal fat were determined according to Damme et al. (2015) (scale: Navigator NV1101, Ohaus, Parsippany, NJ, USA) at the laboratory facilities of the Bavarian State Farms, Research and Education Center for Poultry, Kitzingen, Germany, and treated as previously described by Altmann et al. (2020) and Siekmann et al. (2018).

Briefly, 24 h after slaughter (i.e., 24 h postmortem [p.m.]), the carcasses were weighed and manually dissected. The breast fillet (skinless) and both thighs (with bones) as well as the wings and the abdominal fat were weighed. The breast fillet yield and thigh yield were calculated as the percentage of carcass weight.

Statistical analyses

Microsoft Excel (Version 2013, Microsoft Corporation, Redmond, WA, USA) was used for the data collection and processing and the creation of the selected diagrams. For further descriptive and inferential statistical analyses, the IBM SPSS Statistics program (Version 23, SPSS Inc., Chicago, IL, USA) was used.

Cross-tabulations and Fisher's exact test were used to analyze the nominal data (i.e., to compare hatching results between breeds and between plumage colors within breeds).

The BW and slaughter characteristics (slaughter weight, carcass yield, share of valuable cuts in the carcass) were found to be normally distributed, as determined using a Kolmogorov–Smirnov test and graphical analysis using Q-Q plots, but not for the percentage of deviation from the mean BW (Weiß, 1999).

T-tests for independent samples (du Prel et al., 2010) were used to compare the slaughter traits between the DrChi, DrBa, and CoSa chickens. Error correction to adjust the significance level due to multiple testing was performed using the Benjamini–Hochberg procedure (Victor et al., 2010).

ANOVA linear models with a between-subject effect (plumage color) and a within-subject effect (age) (one-within-one-between ANOVA) were used to compare the courses of the individual animal BWs over the rearing period between the different plumage colors within each breed and sex (Rasch et al., 2010). For the BW in wk 20, a test for the homogeneity of variance between the breeds and between the sexes within each breed was performed using Levene's test (Weiß, 1999). The percentage of deviation from the mean BW in wk 20 (i.e., the end of the rearing period) was tested as a non-normally distributed trait using a Kruskal–Wallis test with the effects of breed and color within breed (du Prel et al., 2010). As a test between the breeds, and in the presence of significant differences between the plumage colors, a pairwise comparison was made using a Mann–Whitney U test (du Prel et al., 2010).

The time-dependent individually recorded growth data were fitted to the growth function of Gompertz (1825). For this process, we used the re-parameterization $W(t) = A\exp(-\exp(-kG(t-T_i)))$, where W(t) is the expected value (BW) as a function of time, and t is time (i.e., wk since hatching); A represents the upper asymptote (mature value); kG is the growth-rate coefficient (which affects the slope); and Ti represents the time at inflection (Tjørve and Tjørve, 2017). To obtain valid growth curves, we included data from the first laying period in this analysis (i.e., individual BW at wk 25, 30, 35, and 40). Parameter estimations were performed in the IBM SPSS Statistics program (Version 23, SPSS Inc., Chicago, IL, USA). The Gompertz model was characterized by an inflection point such that the A/e of the total growth occurred before the inflection point, with the remainder occurring after (Grimm and Ram, 2009). The coordinates of the point of inflection, inflection point time (IPT), and weight at inflection point (IPW) were obtained as follows (Rizzi et al., 2013; Tjørve and Tjørve, 2017): $IPT = T_i$ and $IPW = A/e$ (where e is Euler's number). The maximum daily weight gain was computed by substituting the genotype-specific calculated IPT in the derivative of the cumulative growth function of the associated genotype and sex.

A concordance analysis was performed to quantify the degree of agreement in integument scores. For this purpose, the prevalence-adjusted and bias-adjusted kappa (PABAK) was calculated as a characteristic of the inter-observer reliability according to Gunnarsson et al. (2000). Regarding the extent of agreement, the generated PABAK values were interpreted according to Landis and Koch (1977) and Kwiecien et al. (2011) as follows: $\leq$0.20, insufficient; 0.21–0.40, low; 0.41–0.60, moderate; 0.61–0.80, good; and >0.80, very good. A Mann–Whitney U test was used to evaluate the effect of the fixed factor of breed on the ordinally scaled integument characteristics at each observation date (du Prel et al., 2010).

A binary logistic regression (BLR) model (Baltes-Götz, 2012) with total plumage score as the dependent variable and breed, sex, and age as independent variables was fitted to the data. In the second step, an additional BLR model was calculated with footpad dermatitis as the dependent variable and the same independent variables. For the models, independent variables and interactions were retained using a backward selection approach when $p < 0.1$ in an attempt to reduce the type II error risk while maintaining a stringent type I error risk of 5 % (Hosmer and

Lemeshow, 2000). Multiple logistic, rather than ordinal, regression models were used because some scores were occupied by only very few observations. For multiple logistic regressions, the ordinal data scaling (as defined by Keppler, 2017) was transformed into nominal scaling (the total plumage score was 0 for scores of 0, and 1 for scores of ≥1). The absence of multicollinearity was ensured by calculating the Pearson's correlation coefficient and performing a collinearity diagnosis with the variance inflation factor and condition index (Menard, 2002; Field, 2013).

In all of the described inferential statistical analyses, differences were considered statistically significant for $p \leq 0.05$.

Results and discussion

Animals

A total of 442 hatching eggs from DrChi (9 breeders, 17 breeding groups) and 464 eggs from DrBa (11 breeders, 19 breeding groups) from parents with different plumage colors were included in this study (DrChi: brown—n = 292 eggs, seven breeders, 13 breeding groups; white—n = 150 eggs, two breeders, four breeding groups; DrBa: brown—n = 302 eggs, seven breeders, 14 breeding groups; reddish-brown—n = 162 eggs, four breeders, five breeding groups). A total of 173 DrChi (88 roosters and 85 hens), 197 DrBa (99 roosters and 98 hens), and 50 fattening broilers as a control group (26 roosters and 24 hens) were housed.

Hatching eggs and hatching characteristics

Hatching outcomes are illustrated in Fig. 2, with significant differences between the breeds, a notably higher early embryonic death in DrChi (29.4 %) compared to DrBa (26.3 %) ($p < 0.001$), and a lower late embryonic death in DrChi (5.2 vs. 0.6 %, $p < 0.001$). Additionally, differences were observed within DrBa between plumage colors, where reddish-brown had a higher late embryonic death (9.9 %) compared to brown (3.6 %, $p = 0.013$). Ultimately, 258 DrChi and 282 DrBa hatched successfully.

The hatching rates in relation to all incubated eggs observed for DrChi (58.4 %) and DrBa (60.8 %) are significantly below those of previously reported data from commercial hybrid strains (~85 %, Lohmann Breeder GmbH, 2017). These values align with other studies on regional breeds, such as Augsburg chickens (~54 %, Damme and Schreiter, 2020), Saxonian chickens (~77 %), and German Langshan Bantams (~40 %) (Freick et al., 2022). In addition to genetic differences, inbreeding, targeted external selection, sex ratio, and external characteristics, the reasons for these results and the observed differences in plumage color within breeds are likely to be the non-standardized housing and feeding conditions of private breeders.

Performance characteristics

The feed consumption per animal was 7.8 kg for DrChi and 5.3 kg for DrBa during the 20 wk rearing period, and 7.7 kg for CoSa during the 10 wk rearing period. Overall mortality rates were 2.3 % for DrChi, 1.5 %

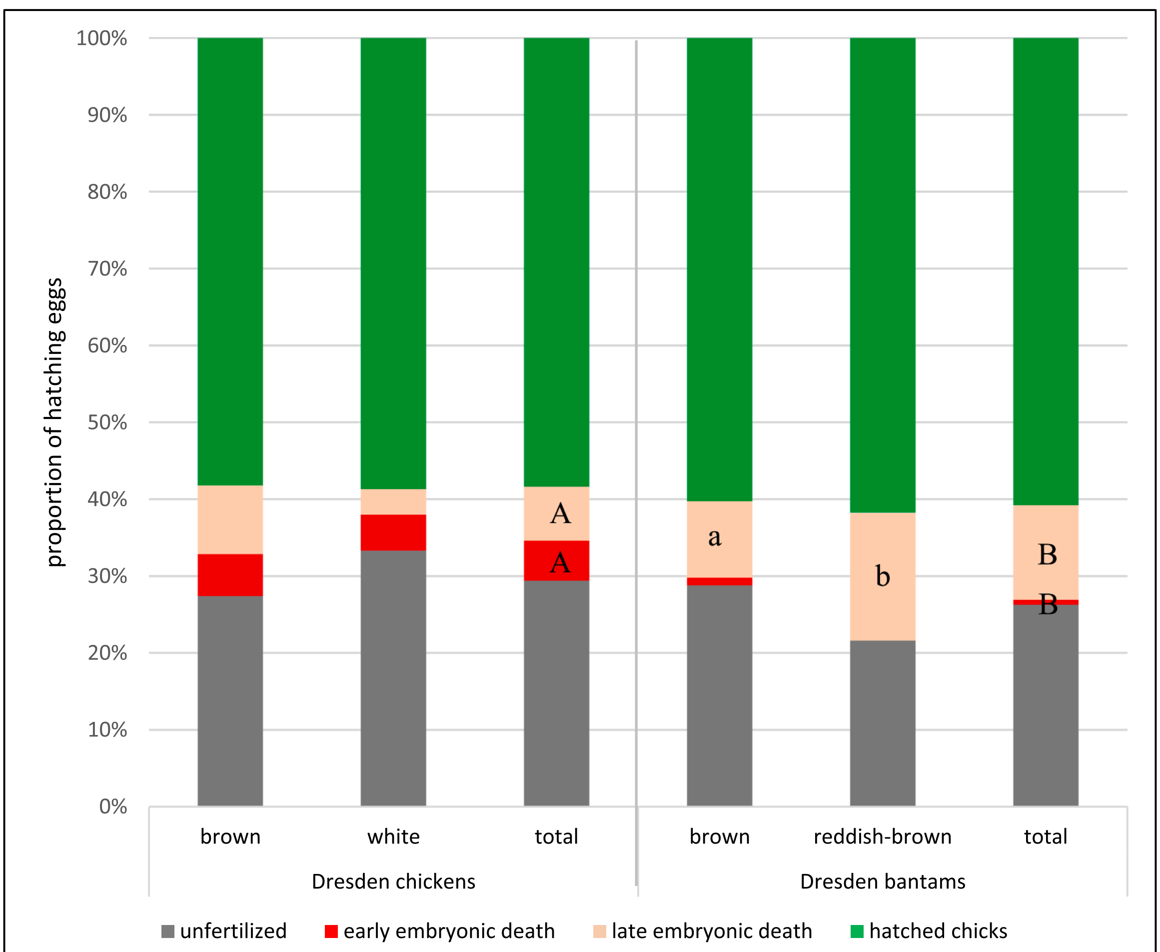


Fig. 2. Hatching results of the two endangered German chicken breeds Dresden chickens and Dresden bantams in different plumage colors. Different indices indicate significant differences within the respective category between breeds (uppercase letters) or between colors within a breed (lowercase letters).

for DrBa, and 4.0 % for CoSa. The BW of day-old chicks was 41.1 g for DrChi, 31.1 g for DrBa, and 39.0 g for CoSa. By 20 wk, DrChi males reached 2,293.1 g and females reached 1,777.1 g, whereas DrBa males weighed 1,223.1 g and females weighed 880.0 g. CoSa did not achieve the growth performance stated by the breeding company. With an average live weight of 1245 g on day 35, they were almost 400 g below the reference values (Sasso, 2024). One possible explanation for this is that pullet diet was fed instead of a fattening diet, which is more suitable for the dual-purpose chickens that were mainly examined. The values of weight development for all scoring dates are shown in Table 2. Homogeneity of variance was observed in DrBa ($p = 0.421$) but not in DrChi ($p = 0.002$), reflecting a more uniform BW in DrBa than in DrChi (66.7 and 59.5 % vs. 48.5 and 44.4 % for males and females, respectively). The relative deviations in the individual animal BW from the mean value of the breed in wk 20 amounted to the following values: DrChi: 6.8 (3.5 - 13.7)%; DrBa: 5.0 (2.3 - 9.6)% (median [1st - 3rd quartile]) ($p = 0.030$). The relative deviations in the individual animal BW from the mean value of the breed when considering the different colorings were as follows: DrChi brown: 6.8 (2.7 - 13.4)%; DrChi white: 7.0 (5.0 - 15.6)%; DrBa brown: 4.7 (2.3 - 8.8)%; DrBa reddish-brown: 5.9 (2.1 - 10.3)%. There was no significant difference between the colors of the two breeds (DrChi: $p = 0.324$; DrBa: $p = 0.580$). Body mass differences, particularly between DrChi and DrBa, are expected due to the bantam status of DrBa. Differences in BW between plumage colors could possibly be due to past crossbreeding to improve the exterior exterior for poultry exhibitions or indirectly due to different selection priorities. According to Six (2004), the two colors of the DrBa breed have a completely different breeding history: the brown DrBa were the original color and were created in the 1950s, whereas the plumage color reddish-brown was only created in the 1990s with the usage of other breeds. This could possibly also explain the different growth performance. Compared to other local chicken breeds, the BWs of DrChi were lower than those of Bresse Gauloise (Nolte et al., 2020), Rheinlander (Tiemann et al., 2020), and Malines and Swiss chickens (Müller et al., 2018) and similar to the BW of Vorwerk chickens (Nolte et al., 2020) and Saxonian chickens (Freick et al., 2022), but higher than those of Augsburg chickens (Damme and Schreiter, 2020). However, it should be noted that in our own study, the roosters and hens were fed a diet intended for laying hens, as mixed-sex rearing was followed by a laying performance test for the pedigree hens and all genotypes were also to be fed the same diet during rearing. At least this effect was observed by Becker et al. (2023).

Table 2
Development of body mass (mean ± standard deviation) of two German dual-purpose chicken breeds in comparison to a slow growing commercial broiler strain during the rearing period and effect of plumage color within breed and sex.

Breed/Sex/ Plumage colour	Body mass (g)				p-value (plumage color)[1]
	day 35	day 70	day 105	day 140	
Dresden chickens					
Roosters					
Brown	450.9 ± 71.6	1 041.4 ± 137.3	1 664.6 ± 145.1	2 276.0 ± 366.9	0.297
White	502.1 ± 91.5	1 175.7 ± 167.9	1 761.8 ± 286.3	2 334.2 ± 345.2	
Total	465.4 ± 80.7	1 079.1 ± 157.7	1 693.8 ± 159.9	2 293.1 ± 356.4	
Hens					
Brown	379.4 ± 62.3	853.0 ± 98.7	1 282.5 ± 147.4	1 695.3 ± 146.7	< 0.001
White	406.2 ± 86.1	1 001.0 ± 152.3	1 403.1 ± 223.4	1 918.4 ± 208.0	
Total	389.5 ± 72.8	907.0 ± 139.7	1 326.1 ± 186.1	1 777.9 ± 201.8	
Dresden bantams					
Roosters					
Brown	257.2 ± 32.8	537.1 ± 66.1	815.1 ± 87.6	1 156.0 ± 105.1	0.001
Reddish Brown	336.8 ± 30.9	679.6 ± 56.0	1 039.3 ± 95.7	1 302.5 ± 84.2	
Total	283.2 ± 49.3	582.5 ± 91.6	888.7 ± 138.8	1 223.1 ± 120.0	
Hens					
Brown	229.7 ± 28.8	457.4 ± 47.6	657.9 ± 87.8	821.5 ± 79.4	< 0.001
Reddish Brown	292.1 ± 29.9	575.3 ± 71.0	798.8 ± 86.9	994.6 ± 109.2	
Total	248.5 ± 43.3	493.5 ± 77.8	704.3 ± 109.6	880.0 ± 121.9	
Cobb Sasso					
Roosters	1 327.3 ± 157.5	2 992.9 ± 354.6			
Hens	1 195.3 ± 164.5	2 665.1 ± 353.6			
Total	1 245.5 ± 167.2	2 807.7 ± 372.6			

[1] ANOVA linear models with a between-subject effect (plumage colour) and a within-subject-effect (age) were used to compare the course of the individual animal body masses over the rearing period between the different plumage colours within breed and sex.

The estimated growth and daily weight gain curves after the non-linear regression of the growth data were fitted to the re-parameterized Gompertz function (Gompertz, 1825; Tjørve and Tjørve, 2017) and are visualized in Fig. 3. The asymptotic BWs were 2778.4 g (95 % confidence interval: 2686.4-2870.5 g), 2419.2 g (2364.4-2474.0 g), 1466.0 g (1415.7-1516.4 g), and 1148.5 g (1120.8-1176.3 g); the IPT was 9.5, 10.2, 9.2, and 8.9 wk; the IPW was 1022.1, 890.0, 539.3, and 422.5 g; and the maximum daily weight gain was 19.5, 14.5, 9.8, and 7.1 g among male DrChi ($R^2 = 0.933$), female DrChi ($R^2 = 0.955$), male DrBa ($R^2 = 0.948$), and female DrBa ($R^2 = 0.928$) chickens, respectively. As expected, the inflection point in the growth curve of the roosters occurred later in DrChi than in DrBa (9.5 vs. 9.2 weeks of age), but an even later inflection point would have been expected for DrChi. The three Italian chicken breeds studied by Rizzi et al. (2013) showed much later turning points (at 12.0-12.6 wk). In addition, the Saxony chickens, which reach similar weights as DrChi in wk 20, have a slightly later turning point in the growth curve (wk 10.5) (Freick et al., 2022). The early turning point of DrChi roosters therefore indicates rapid juvenile growth compared to other breeds. According to Freick et al. (2022), the German Langshan bantams show the turning point at the same time as DrBa and therefore earlier than the larger breeds. Slaughtering closer to the inflection points of the Gompertz model would probably result in better feed conversion in these breeds. However, the lower carcass weights at this time would make successful marketing to consumers more difficult.

Animal welfare criteria

Plumage damage and skin lesions, as indirect characteristics of feather pecking, as well as the keel bone status and foot condition are influenced by genetic disposition (Kjaer et al., 2006; Preisinger, 2017). Therefore, these integument conditions were evaluated. Very good inter-observer reliability was achieved with PABAK scores of 0.92 for plumage condition, 0.96 for skin lesions, 0.91 for foot condition, and 0.90 for keel bone deformities. Throughout the rearing period, keel bones remained intact. In contrast, Jung et al. (2024) found an average of 44.2 % of birds with keel bone damage in the pullets and laying hens of 13 different local breeds. DrChi mature hens were also examined by Jung et al. (2024) ($n = 14$), of which 35.7 % showed keel bone damage. The DrChi hens were kept on two different farms, with one flock showing no keel bone damage at all, while 71 % of the birds in the other flock were affected. The authors surmised that this characteristic was dependent on the management of the hens and cited the height of the perches in particular as an example.

The indirect detection of severe feather pecking and cannibalism was

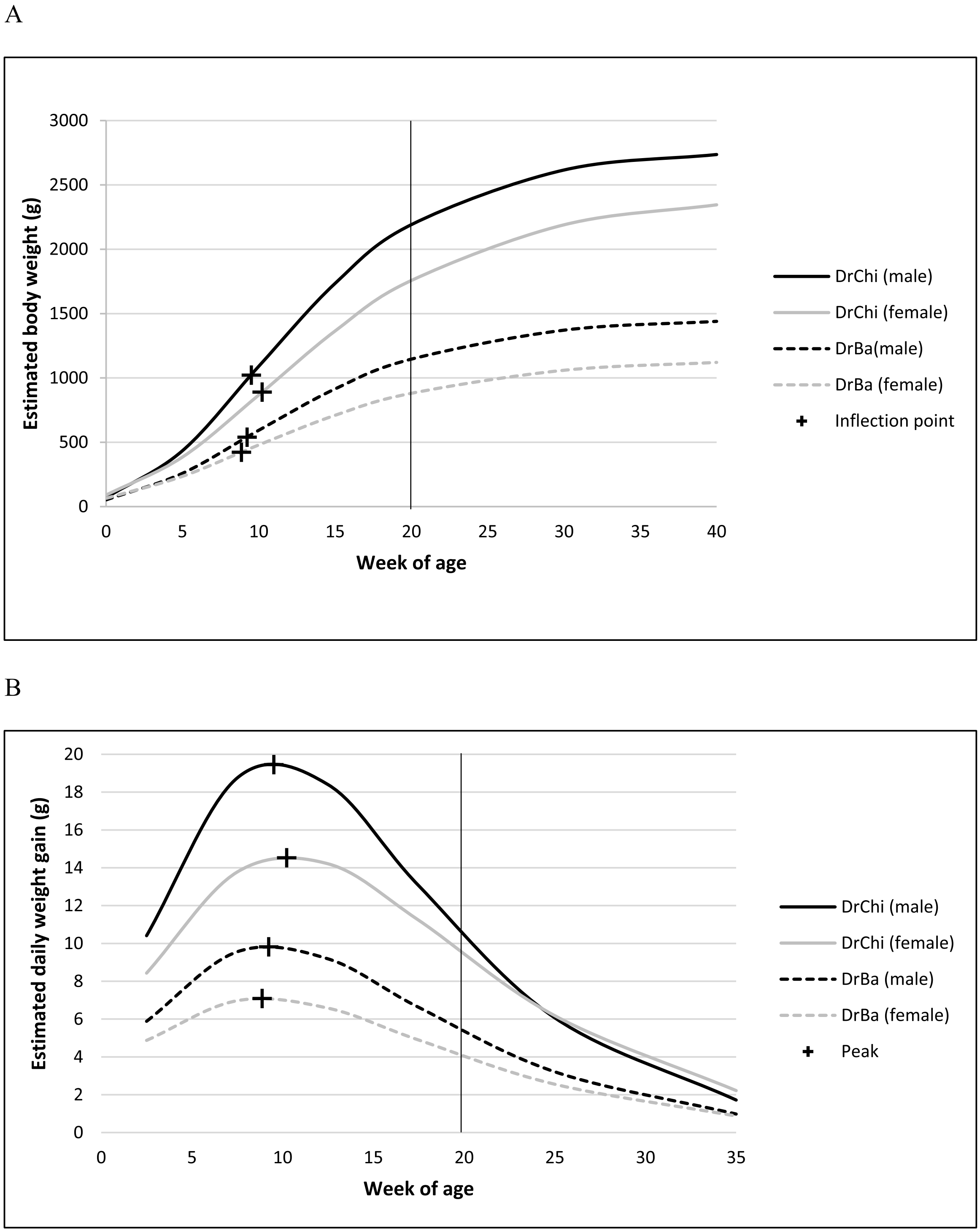


Fig. 3. Non-linear regression of growth data from hatching to 40 weeks of age of the local German chicken breeds Dresden chickens (DrChi) and Dresden bantams (DrBa) fitted to the Gompertz equation (A) and the derived course of daily weight gain (B). The vertical line in week 20 represents the end of the rearing period.

attempted by assessing plumage condition. The condition of the plumage during rearing is an important factor to ensure intact plumage during the laying period (Schreiter et al., 2020a), although feather pecking occurs to a lesser extent during rearing than during the laying period (Janczak and Riber, 2015). The plumage condition, which is easily visible to consumers, is of particular interest, as improved animal welfare appears to be necessary for the marketing of products using regional breeds (Escobedo del Bosque et al., 2020). Moderate plumage damage was noted by day 35 in both DrChi (1.2 % score 2, 98.8 % score 0) and DrBa (1.6 % score 2, 1.6 % score 1, 96.8 % score 0), peaking around day 70 (DrChi: 0.6 % score 3, 6.3 % score 1, 93.1 % score 0; DrBa: 1.1 % score 3, 3.2 % score 2, 12.4 % score 1, 83.2 % score 0). However, broilers in the control group showed plumage damage in a higher proportion of the animals (CoSa day 35: 8.2 % score 2, 36.7 % score 1, 55.1 % score 0; day 70: 2.1 % score 2, 39.6 % score 1, 58.3 % score 0). In the following observation points on day 105 (DrChi: 2.9 % score 1, 97.1 % score 0; DrBa: 2.7 % score 2, 0.5 % score 1, 96.8 % score 0) and day 140 (DrChi: 1.2 % score 1, 98.8 % score 0; DrBa: 2.7 % score 2, 0.5 % score 1, 96.8 % score 0), the observed plumage damage decreased; thus, at the end of the rearing period, the plumage of the two dual-purpose breeds was found to be nearly intact. In the present study, which showed generally good plumage conditions, plumage damage and skin lesions were most pronounced at 35 and 70 days of age. These ages are also considered critical in laying hybrids, as these are the times when most preferentially pecked and blood-filled feather follicles are present during molt (Keppler et al., 2017; Schreiter et al., 2020a). Plumage damage during rearing in White Plymouth Rock, Bresse, and New Hampshire chicken breeds was observed by Hörning et al. (2020) primarily in wing feathers (up to 60 % of birds) and less commonly in back and belly feathers. However, the roosters studied by Hörning et al. (2020) showed greater plumage loss during rearing than the hens. The BLR models (Table 3) included animals of all three breeds (i.e., DrChi, DrBa, and CoSa). The first BLR model analyzed the effect of breed, age, and sex on the occurrence of plumage damage. Breed and age were shown to influence plumage condition ($p < 0.001$ each), but sex had no effect ($p = 0.256$). The remarkable differences in plumage damage between DrChi and DrBa chickens indicate the presence of breed effects in the incidence of feather pecking and cannibalism in native chicken breeds; these effects are also known to occur in hybrid laying strains (Schreiter et al., 2020b).

The higher prevalence of plumage damage in broiler genetics may also be related to the fact that the rearing environment in this study does not correspond to standard commercial broiler rearing practices (genotype-environment interaction) and also that the scoring scheme for plumage is validated for laying hens.

In contrast to CoSa, the local chickens showed only very slight footpad swelling, with DrChi and DrBa showing completely intact footpads on days 35 and 105 (day 35: CoSa: 12.2 % score 1, 87.8 % score 0; day 70: CoSa: 12.5 % score 1, 87.5 % score 0; DrChi: 0.6 % score 1, 99.4 % score 0; DrBa: 0.5 % score 1, 99.5 % score 0; day 140 DrChi: 0.6 % score 1, 99.4 % score 0; DrBa: 0.5 % score 1, 99.5 % score 0) (Fig. 4).

The second BLR model showed that only breed had an effect on the occurrence of footpad dermatitis ($p < 0.001$). In contrast, age ($p = 0.555$) and sex ($p = 0.250$) had an NS effect on foot pad health. The moderate footpad dermatitis observed in 20 % of the Rhineland hens from wk 15 in Tiemann et al. (2020) was not found in our study, possibly due to the housing conditions, as well as the lower BWs of the DrChi and DrBa hens and the resulting lower mechanical pressure on the footpad.

Table 3
Results of logistic regression models: effects of breed, age, and sex on the occurrence of plumage damage and foot pad dermatitis in the German dual-purpose chicken breeds Dresden Chickens (DrChi) and Dresden bantams (DrBa) and the commercial hybrid strain Cobb Sasso (CoSa) from 5 to 10 weeks of age.

Trait	Score 1 (%)	Coefficients (SE)	Odds Ratio (95 % CI)	Individual *p*-Value	Overall *p*-Value
Total plumage score					
breed					< 0.001
CoSa	43.3	reference	baseline		
DrChi	4.0	−3.01 (0.35)	0.05 (0.03-0.09)	< 0.001	
DrBa	10.1	−2.02 (0.28)	0.13 (0.08-0.23)	< 0.001	
age					
day 35	7.4	reference	baseline		
day 70	15.5	0.99 (0.26)	2.70 (1.64-4.47)	< 0.001	
sex					
female	12.6	reference	baseline		
male	10.7	−0.28 (0.24)	0.76 (0.47-1.22)	0.256	
Intercept		−0.64 (0.28)			
foot pad dermatitis					
breed					< 0.001
CoSa	12.4	reference	baseline		
DrChi	0.3	−3.90 (1.05)	0.02 (0.00-0.15)	< 0.001	
DrBa	0.3	−3.97 (1.05)	0.19 (0.01-0.14)	< 0.001	
age					
day 35	1.5	reference	baseline		
day 70	2.0	0.34 (0.57)	1.40 (0.45-4.32)	0.555	
sex					
female	1.2	reference	baseline		
male	2.2	−0.67 (0.58)	0.51 (0.16-1.61)	0.250	
Intercept		−1.83 (0.49)			

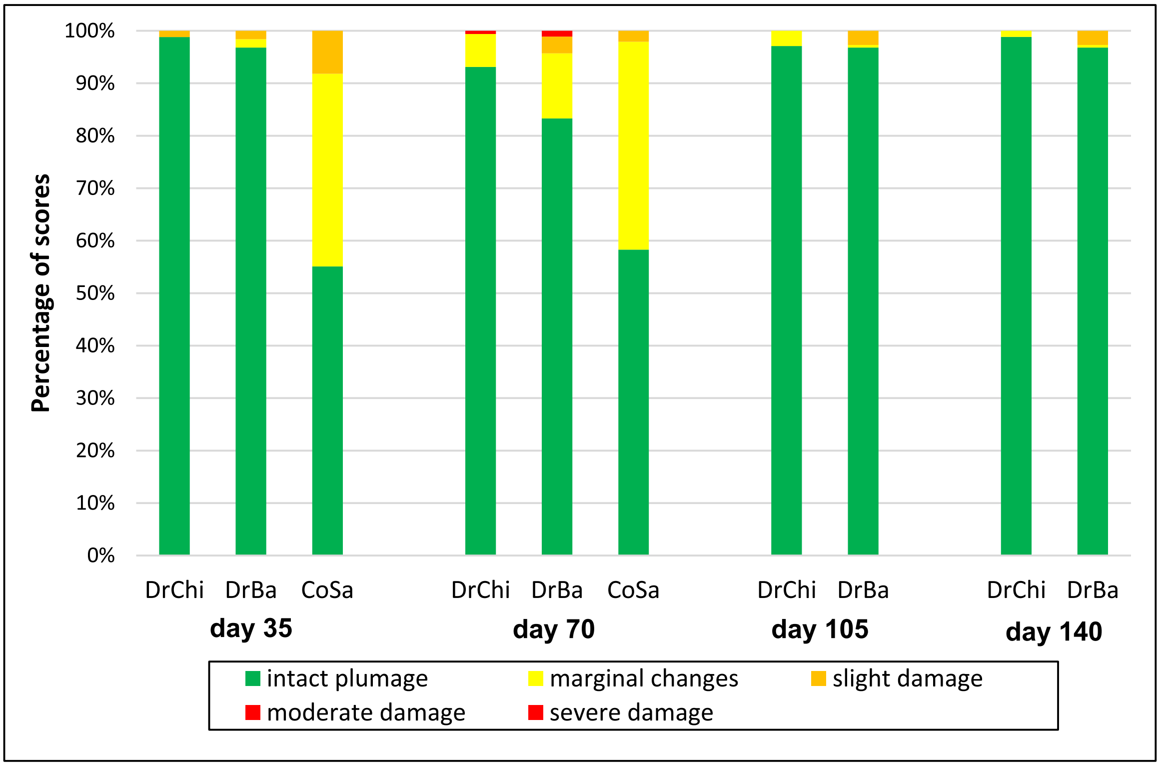
CI – confidence interval; SE – standard error; Score 0—intact plumage; Score 1—plumage damage.

Slaughter performance

Table 4 shows the carcass characteristics of both dual-purpose chicken breeds and the broilers. The roosters of DrChi did not only show the expected higher carcass weights than those of DrBa, but also a significantly higher carcass yield than the bantam breed ($p = 0.014$) ([mean ± SD] DrChi: 64.4 ± 5.6 %; DrBa: 59.8 ± 2.7 %; CoSa: 72.5 ± 5.7 %). However, in terms of carcass weight and carcass yield, CoSa clearly outperformed both breeds, which is analogous to the results obtained for other local chickens (Müller et al., 2018; Nolte et al., 2020). However, even compared to other local chickens (Müller et al., 2018; Nolte, 2020; Freick et al., 2022), the carcass yield was quite low. The thigh is the largest usable cut of the three breeds studied. The proportion of thigh in the carcass is higher in DrChi than in DrBa and CoSa ($p < 0.001$). The bantams have a higher breast percentage than the large breed ($p < 0.001$), but the broilers exceed both breeds in both breast percentage ($p < 0.001$) and breast weight with skin ([mean + SD] CoSa: 545.9 ± 156.1 g; DrChi: 233.5 ± 33.7 g; DrBa: 133.9 ± 15.4 g). The thigh weight was 508.3 ± 74.9 g for DrChi, 227.5 ± 30.6 g for DrBa, and 617.1 ± 167.5 g for CoSa.

The lower carcass weights of DrChi and DrBa compared to commercial broilers reflect the trade-off between the preservation of chicken-genetic resources and production efficiency. However, the higher proportion of valuable cuts with breast filets and thighs (DrChi: 49.2 %; DrBa: 48.1 %) can partially compensate for the low carcass yield in marketing. This confirms the results of the studies by Henning et al. (2017) (Augsburg chickens: 34 %; German Langshan: 31 %; German Empire Breed: 28 %; German Grey Chickens cuckoo: 19 %) and Freick et al. (2022) (Saxonian chickens: 43.8 %; German Langshan bantams: 43.1 %). The thighs in DrChi and DrBa are each approximately twice as heavy (DrChi: 508.3 g, 34.7 %; DrBa: 227.5 g, 31.4 %; cut weight and proportion of the carcass, respectively) as the breast filets (DrChi: 213.1 g, 14.5 %; DrBa: 121.1 g, 16.7 %). This leads to a different appearance compared to CoSa, a slow-growing broiler, whose thigh and breast yield are 30 and 24.9 %, respectively. The focus on high-quality cuts might appeal to specific consumer preferences in local or specialty markets. Additionally, the relatively low abdominal fat yield observed in these breeds may indicate their suitability for extended rearing periods without risk of obesity, further enhancing their marketability. To maintain the DrChi breed and, at the same time, produce a more economical chicken, e.g., with a higher carcass yield, crossbreeding trials should also be considered for DrChi in the future (Werner et al., 2023).

A



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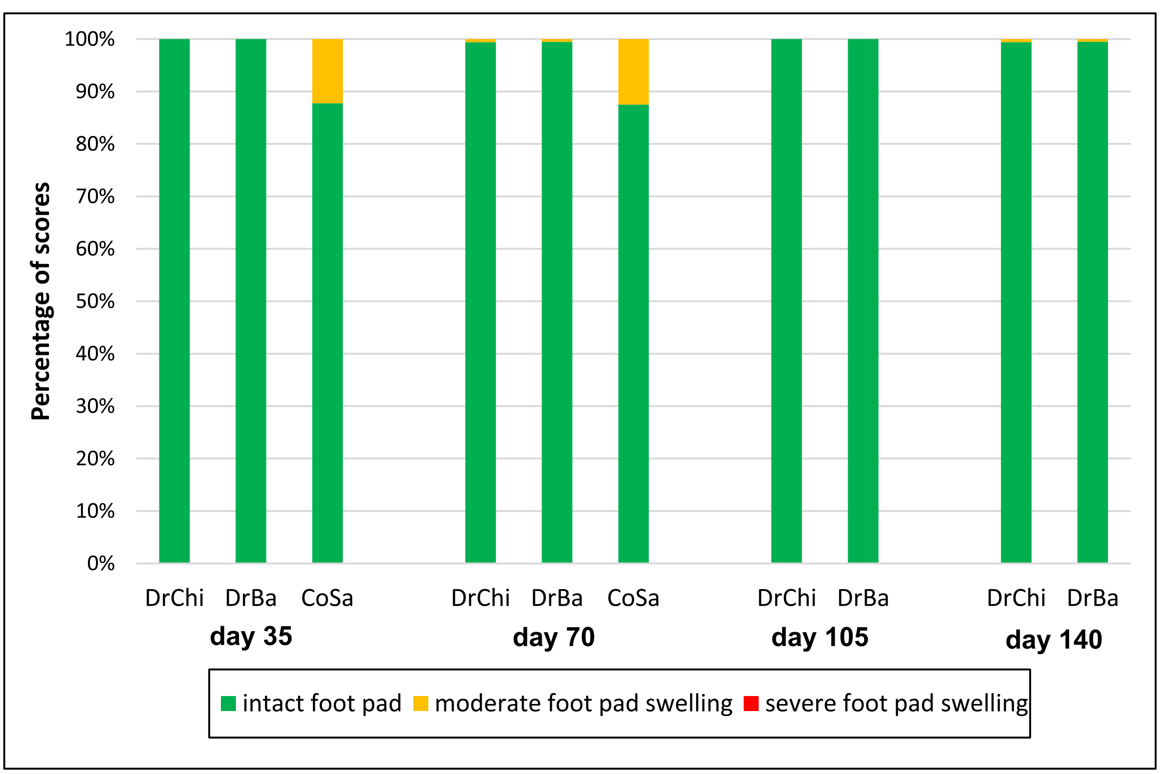

Fig. 4. Plumage (A) and foot-pad condition (B) in the local German chicken breeds Dresden Chickens (DrChi) and Dresden Bantams (DrBa) as well as the hybrid strain Cobb Sasso (CoSa) during the rearing and fattening period. (A) shows the total score of the plumage, which represents the arithmetic mean of the four scored individual regions (back, belly, dorsal neck, and wing feathers). Logistic regression models showed a significant breed effect on plumage and foot-pad condition ($p < 0.001$).

Table 4
Carcass characteristics and meat quality in 140-day old male Dresden chickens and Dresden bantams (mean ± standard deviation).

Trait		Dresden Chickens	Dresden Bantams	Cobb Sasso	p-Value
Live weight	(g)	2 277.5[a] ± 257.2	1 210.9[b] ± 113.9	2 794.0[c] ± 344.2	< 0.001
Carcass weight	(g)	1 463.95[a] ± 190.4	723.85[b] ± 78.8	2 032.6[c] ± 346.9	< 0.001
Carcass yield	[%]	64.4[a] ± 5.6	59.8[b] ± 2.7	72.5[c] ± 5.7	0.014
Thigh yield	[%]	34.7[a] ± 1.2	31.4[b] ± 0.8	30.0[b] ± 2.9	< 0.001
Breast fillet yield with skin	[%]	15.9[a] ± 0.9	18.5[b] ± 0.9	26.5[c] ± 2.9	< 0.001
Breast fillet yield	[%]	14.5[a] ± 0.9	16.7[b] ± 0.8	24.9[c] ± 2.7	< 0.001
Wing yield	[%]	11.8[a] ± 0.7	11.8[a] ± 0.8	11.4[a] ± 2.9	1.000
Abdominal fat yield	[%]	1.0[a] ± 0.7	0.6[a] ± 0.9	3.3[b] ± 2.9	< 0.001
carcass with wings yield	[%]	31.9[a] ± 1.3	32.8[a] ± 0.9	28.1[b] ± 2.9	< 0.001

a,b,c: Indices indicate significant differences between the breeds ($p \leq 0.05$).

Conclusion and applications

1. The DrChi and DrBa breeds are inferior to the slow-growing broiler strain CoSa in terms of growth performance and feed conversion. However, they have a comparable BW to other dual-purpose breeds in wk 20.
2. Compared to CoSa, both DrChi and DrBa show significantly less plumage damage and footpad dermatitis during rearing.
3. DrBa and DrChi have a low carcass yield in comparison with broiler hybrids. The share of thighs is increased in both breeds and the proportion of breast is lower compared to broilers, resulting in a different carcass appearance.
4. Both breeds are suitable for extensive rearing and local direct marketing. On the other hand a different overall impression of the carcasses of both breeds compared to broilers must be communicated to consumers.

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Ethical statement

This study was reviewed by the Country Directorate of Saxony, Germany as the responsible animal ethics committee and was not classified as an animal experiment (reference AZ 25-5131/526/1).

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used DeepL translator and DeepL writer in order to translate the text from German to the English language and to improve the readability and language. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Declaration of competing interest

none

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