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Development of dual-purpose cross for meat and egg production I. Growth performance and carcass composition of the crossbred chickens in comparison to the parent lines

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ABSTRACT

The aim of the study was to develop a dual-purpose cross suitable for rearing in alternative systems and to examine its growth performance and carcass composition in comparison to the parent lines. The experiment was carried out in the experimental poultry farm in the Institute of Animal Science - Kostinbrod. The cross was developed using females of a layer type line L and cocks from line BB. The latter was based on Bresse Gauloise that is also dual purpose but mainly used for meat. The chickens from the lines and the cross were reared in mixed-sex groups on deep litter, at stocking density of 25 birds/m^2, and fed with standard broiler feed until the age of 9 weeks. Then the males were separated and sent to slaughter while the females were left for layers. Crossing hens from layer type line L with BB cocks resulted in dual- purpose chickens with a live weight and feed efficiency that were better in comparison to L line, but lower when compared to the BB line. These parameters were however, lower than the typically observed in this type of poultry. Nevertheless, the chickens displayed good carcass composition and deposited low content of abdominal fat, thus revealing good potential to be successfully realized in market.

Keywords: dual-purpose chickens, layer line, growth performance, carcass composition

INTRODUCTION

The widespread practice of hatching auto-sexed egg-laying hybrids requires that the male chicks be culled immediately after hatching. The poor growth and lower live weight of these birds compared to commercial broilers make them unprofitable (Damme and Ristic, 2003, Lichovníková et al., 2009). The practice of culling of the male layer-type chickens goes against all principles for animal welfare and is in conflict with Council Regulation (EC) No 1099/2009. Apart from the proposed approaches for avoiding it including *in ovo* sex determination, and fattening of male chickens for meat, the use of dual-purpose combinations appears to be a good option (Baldinger and Bussemas, 2021a). The concerns that started with the problem of the way the male layer-type chickens are killed, transferred to other problems in the poultry industry, leading to change of certain EU policies under the pressure of non-governmental organizations. In the last decade this has led to the emergence of several very important trends concerning egg hybrids and a very strong public pressure was observed to abandon cages and move to alternative systems in particular rearing of layers on deep litter or floor. An indicator of the great public pressure, is the refusal by the large retail chains and NGOs and declaration to stop trading with farms that offer eggs from layers raised in cages after 2027, which in turn has forced major EU countries to declare that by the end of 2027 they will completely switch to floor and alternative system to raise layers (Mcdougle, 2021). This will create a vacuum in the stock market due to the lack of choice in terms of parent lines that are able to produce layer type chickens suitable for rearing on floor or in alternative system. Stock lines that in combination with layers could respond to the new market trends are stored in the Institute of Animal Science - Kostinbrod. A few years ago, birds from the French indigenous breed Bresse Gauloise were imported and started a new line BB that is now a part of the gene pool in the country. Research show that crossing Bresse with egg laying lines could result in good dual-purpose crosses, since Bresse Gauloise itself has a laying performance of 250 eggs and the live weight of the males could reach up to 3.0-3.6 kg (Baldinger and Bussemas, 2021b). Previous experiments with BB line showed that the birds have poorer vision compared to the rest of lines selected for industrial conditions and low light intensity. In an early study Ali and Cheng (1985) showed that birds with genetic mutation for poor vision, reared on floors, experienced lower stress and activity levels, but had higher efficiency in converting feed into products. Hence, crossing such lines presents a possibility to solve both problems showed above.

The aim of this study was to develop a dual-purpose cross between a line with reduced vision (BB) and a layer line (L) that will be suitable for rearing in alternative systems, and to examine its performance and carcass traits.

MATERIALS AND METHODS

The trial was carried out in the experimental poultry farm of the Institute of Animal Science- Kostinbrod, Bulgaria with chickens of line L, BB, and their cross ♀L×♂BB. The experimental protocol used in this study, including the animal management and housing was designed in compliance with the guidelines of the European and Bulgarian legislation regarding the protection of animals used for experimental and other scientific purposes (Directive 2010/63; EC, 2010 – put into law in Bulgaria with Regulation 20/2012).

Birds and housing

The line L is an old layer-type line that is an offspring of the Rhode Island Red used for eggs (Fig. 1). At the moment it has been pure bred and together with the BB line is a part of the Bulgarian national gene pool for poultry.

Figure 1. Line L male (left) and female (right)

BB line is newly created dual-purpose line based on Bresse Gauloise but further crossed with other lines (H, L and LB) to improve the laying performance traits. The obtained synthetic line has been consolidated through pure-line breeding (Fig. 2).

Figure 2. Line BB male (left) and female (right)

The cross between the two lines has been developed by the crossing females of line L with cocks from line BB (Fig. 3).

Figure 3. Cross ♀L×♂BB male (left) and female (right)

The birds from L and BB lines were distributed into three experimental pens. The first contained 80 females and 10 males from line L, the second one contained 30 BB females and 4 males, and the third pen consisted of 80 L hens and 10 BB cocks. Stock eggs were collected from the three pens to reproduce the lines and the cross. After hatching, the one-day-old chickens were reared in three mixed-sex groups (line L, n=640; line BB, n=148; cross ♀L×♂BB, n= 605). Each of the groups contained with 5 replicates. The stocking density was set to 25 birds/m^2. The birds were fed *ad libitum* with

broiler starter and grower feed (Table 1). The water was also provided *ad libitum* through gravity drinkers.

Table 1. Diet composition

Component	Starter (1-4 week)	Grower (5-9 week)
Crude protein, %	21.968	17.305
Crude fiber, %	4.473	3.926
Fat, %	5.135	7.138
Ash, %	2.147	1.936
Lys, %	1.490	0.972
Met, %	0.539	0.379
Ca, %	1.047	0.889
Na, %	0.258	0.325
P, %	0.842	0.722
Metabolizable energy, kcal/kg	3006.38	3189.77

The birds from the three genotypes were reared until 9 weeks of age. Since the BB line displays sexual dimorphism later (after 8 weeks of age) to avoid mistakes, the birds were sexed when they were 9 weeks old. After determination of the sex of each of the chickens, the males were separated for slaughter. The females left were further reared for egg production.

Growth performance

During the experiment the feed intake (FI) and the number of dead birds were weekly controlled. The live weight (LW) of the birds was measured at 1 day old and at the end of the trial period (9 weeks of age). The values of the parameters were used to further calculate body weight gain (BWG), feed conversion ratio (FCR) and mortality.

Slaughtering and carcass analysis

At 9 weeks of age, the males from the lines and the cross were slaughtered in a certified abattoir. After stunning, decapitation and bleeding, the carcasses were plucked, eviscerated and their feet removed. The edible by-products (liver, gizzard, heart and spleen) were separated. The hot carcass weight was measured and the dressing percentage was calculated for all the carcasses, according to the genotype. The carcasses were then kept at 4 °C for 24 h. Further, a total of 30 carcasses (10 from each genotype) were selected for carcass analysis based on the average live weight. Each of the carcasses was weighed and cut to neck, breast, thighs, wings and back. The content of each part was expressed as percentage of the ready to cook carcass.

Statistical evaluation

The statistical analysis was performed using JMP v.7 software package. The results were subjected to one way ANOVA, as first the normality of distribution for the data and homogeneity of variances were checked by Shapiro-Wilk and Brown-Forsythe tests. Whenever appropriate, Tukey post hoc comparisons at $P<0.05$ were applied to evaluate the differences between the means of the groups.

RESULTS AND DISCUSSION

Growth performance

Since the birds were reared in mixed-sex groups, the growth performance traits have been presented in regard to the genotype and included both male and female chickens. The live weight of the birds has been additionally reported for males in regard to the dressing percentage, since the males should be subjected to slaughter and the females left for layers. The results in Table 2 show significant effect of the genotype in regard to the growth performance parameters of the lines and the cross ($P<0.0001$).

Table 2. Growth performance of the lines and crossbred chickens

Trait	L	BB	♀L × ♂BB	SEM	Sig.
LW, g	709.33[a]	998.41[b]	816.88[c]	22.32	<0.0001
BWG, g	670.27[a]	954.63[b]	774.31[c]	22.53	<0.0001
FI, g/bird	2499.39[a]	2919.13[b]	2743.61[c]	21.01	<0.0001
FCR	3.73[a]	3.06[b]	3.54[c]	0.09	<0.0001
Mortality, %	6	4	6	0.01	0.0585

Means connected with different superscripts differ significantly ($P<0.05$)

The lowest body weight was recorded for the layer line L (709.33 g), whereas the BB chickens showed the highest values of this parameters (998.41g). The crossbred chickens were in the middle position, and the mean body weight of the mixed-sex group was 816.88 g. In regard to the body weight gain and feed intake, the crossbred chickens were again placed between the layer line L and the BB line. For the whole experimental period the ♀L ×♂BB chickens have consumed 2743.61 g feed and gained 774 g. The lowest body weight gain was observed in L chickens (670.27g) and the highest in BB birds (954.63 g). The latter also showed the highest feed intake (2919.13 g). Our results are in line with Baldinger and Bussemas (2021a) who reported higher live weight and weight gain for Bresse and lower for layer type chickens when compared to reciprocal crosses of Bresse. On the other hand, Mueller et al. (2018) observed higher live weight in dual-purpose breeds fed broiler diet at 9 weeks of age (1317g- 2161g).

Feed efficiency is an important indicator that has great impact on the economy and environment (Willems et al., 2013). In our study, the feed conversion ratio was affected by the genotype of the birds (P<0.0001). The highest amount of feed used to reach the final body weight was recorded in the layer birds (3.73 kg), while the lowest was observed in BB (3.06 kg). The crossbred chickens had FCR 3.54. The FCR observed in this study showed low feed efficiency of the examined lines and their cross. The results are comparable with those of Mueller et al. (2020) for Lohman Brown cockerels (3.66) and also of Fanatico et al. (2005) for slow growing broilers reared indoors and outdoors (3.58-3.37). However, the feed efficiency observed for BB and ♀L×♂BB chickens is lower than the generally observed for dual purpose birds in other studies (Koreleski et al., 2008; Tieman et al., 2020; Fesseha et al., 2021). In an extensive review on the aspects of selection for feed efficiency in meat producing poultry, Willems et al. (2013), showed that the selection for weight gain might indirectly improve the FCR. The observed lower feed conversion for the dual-purpose line BB and the crossbred chickens in our study that is close to the layer type birds might be due to the previous crossings of Bresse with layer type lines to form BB line. While this has been carried out to improve the laying capacities of BB birds, it also led to lower live weight of the line in comparison to the typically observed values of this trait in the pure bred Bresse birds.

The mortality of the birds in the lines and their cross ranged between 4% - 6%, the lower being recorded for the BB. However, the differences were not significant. The highest mortality was observed in the first two weeks after hatching. This is normal since during this period there is a transition into feeding and also the vaccines were administered to the birds.

Carcass composition

The average live body weight of the male chickens differed between the genotypes (P<0.0001), being the highest in the BB line (1112.77 g) and the lowest in the L line (749.82 g). The dressing percentage was affected by the genotype and was the highest in the BB line (Fig. 4.).

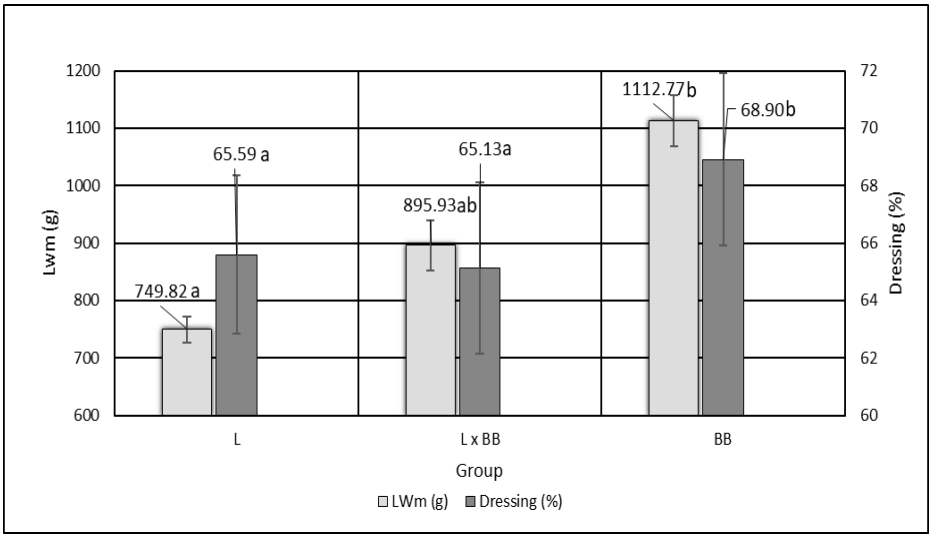

Figure 4. Live weight of males and dressing percentage in the lines and the crossbred chickens

Means connected with different superscripts differ significantly (P<0.05).

The weight of the ready to cook carcass was significantly affected by the genotype of the birds (P=0.0221), as the differences were between the L (657.80 g) and the BB (755.30 g) birds (Table 3).

Table 3. Carcass composition of the lines and crossbred chickens

Trait	L	BB	♀L x ♂BB	SEM	Sig.
Ready to cook carcass weight, g	657.80^{a}	755.30^{b}	719.90^{ab}	74.36	0.0221
Breast, %	23.43	23.60	22.66	0.86	0.0585
Breast muscle, %	14.95^{a}	14.79^{a}	13.49^{b}	1.06	0.0371
Thigh, %	33.14^{ab}	34.12^{a}	32.75^{b}	1.06	0.0215
Thigh muscle, %	21.34^{a}	22.37^{b}	20.74^{a}	0.83	0.0006
Neck, %	4.08^{a}	3.04^{b}	4.14^{a}	0.44	<0.0001
Wings, %	13.73	13.85	13.74	0.63	0.8878
Back, %	21.81	21.38	21.90	0.73	0.2520
Abdominal fat, %	0.43	0.90	1.52	1.09	0.0991

Means connected with different superscripts differ significantly (P<0.05)

The carcass weight of the chickens from the dual-purpose cross did not differ significantly from that of the parent lines and was 719.90 g. In a study on dual-purpose crosses, Baldinger and Bussemas (2021a) recorded higher carcass weights of the birds at 11 weeks of age, however the dressing percentage was lower than what we observed in our work (56%-58%). In a previous study with reciprocal crosses of Bresse and LB lines both from the national gene pool and slaughtered at 12 weeks of age, we recorded dressing

percentage of 59.10%-63.68% (Petkov et al., 2018). For dual-purpose breeds Mueller et al. (2018) reported 65.4%-67.0% which is in line with our results.

Crossing of the BB and L line to create a dual-purpose cross did not negatively affect the dressing percentage. However, in regard to the major carcass cuts, the crossbred chickens had slight disadvantage. The breast (skin+bone) percentage did not differ between the lines and the cross, but there was a tendency for lower value of this trait in the crossbred chickens (P=0.0585). This was also observed in regard to the share of the thighs (P=0.0215), however, the significant differences were found between the percentage of this cut in BB and ♀L×♂BB birds (34.12% vs. 32.75 %, respectively for the line and the cross). The percentage of the breast and thigh meat (boneless and skinless) also differed between the genotypes, the content of both muscles being the lowest in the crossbred chickens. Similar trends toward decreasing the percent of the breast and thigh cuts and meat in crosses was observed in our earlier studies (Petkov et al., 2018; Popova et al., 2018). Our results are comparable to those of Siekman et al. (2018) for Lohman Dual slaughtered at 64 days of age. It could be noticed that the percentage of the legs in the crossbred chickens is higher than that in fast-growing broilers (Fanatico et al., 2008, Siekman et al., 2018). In another study of Fanatico et al. (2005), the breast and thigh percentage of fast and slow-growing broilers were similar to those determined in our study. This indicates that despite the lower percentage of the major carcass parts in the cross compared to the parent lines, the ratio between them remain within normal ranges and the chickens can be successfully offered to the market as whole carcasses (Siekman et al., 2018).

Despite the lower content of the major carcass parts, the crossbred chickens exhibited significantly higher percentage of the neck, as this was also found for the chickens from the egg laying line L. Wings and back shares did not differ between the genotypes. The abdominal fat content tended to differ between the genotypes (P=0.0991). In fact, the highest percentage was recorded for the chickens from the ♀L ×♂BB cross (1.52 %), while the layer birds displayed the lowest content (0.43%). The differences however were not statistically significant due to the great variation that is generally observed for this trait (Nikolova et al., 2007). There was no negative effect of crossing on the content of the abdominal fat, and despite the highest percentage, its content in the cross did not exceed 3% which is considered to be the maximum admissible for broilers (Koreleski et al., 2008). On the one hand, the low accumulation of abdominal fat in the crossbred chickens in this study might be considered a positive trait. As stated by Fouad and El-Senousy (2014), the excessive abdominal fat is a problem in poultry industry since it is considered to be waste of dietary energy and also a waste product with low economic value. Recent studies, however, revealed the potential of including the fat by-products such as abdominal fat and gizzard fat into

formulation of chicken meat products to fully or partially substitute the saturated fats, thus contributing to poultry sector sustainability (Peña - Saldarriaga et al., 2020).

CONCLUSION

The results of the study showed that crossing hens from layer type line L with BB cocks both representative for the national gene pool, produced dual-purpose chickens with lower live weight and feed efficiency than typically observed in this type of poultry. Nevertheless, the chickens had good carcass composition with low abdominal fat deposition, which reveals their potential to be successfully realized in market.

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