Brazilian Journal of Poultry Science
Revista Brasileira de Ciência Avícola

ISSN 1516-635X Jan - Mar 2006 / v.8 / n.1 / 29 - 32

Genetic Gain for Body Weight, Feed Conversion and Carcass Traits in Selected Broiler Strains

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Keywords

Control line, crossbreeding, genetic gain, meat production, production, selection.

Arrived: August / 2005
Approved: January / 2006

ABSTRACT

The Brazilian Swine and Poultry Research Center (Embrapa Suínos e Aves) maintains a chicken breeding program for meat production since 1985. Two control lines (LLc and PPc) are maintained, whereas two male lines (TT and ZZ) and three female lines (PP, VV and KK) have been selected. This paper reports the genetic gain after 15 generations of combined selection (mass and independent culling levels) in order to develop the commercial broiler stocks Embrapa 021 and Embrapa 022. Selection pressure has been exerted on weight gain, carcass traits and fertility. In addition, female lines have also been selected for egg production, whereas males have been selected for feed efficiency since 1992. All lines have been selected for breast area instead of carcass traits since 1999. The genetic gain was estimated as the deviation between selected lines and the respective unselected lines at 42 days of age. In female lines, body weight improved 504, 548 and 587 g; average breast area increased 27.60; 16.99 and 26.43 cm^2; adjusted feed conversion (42-49 d) improved -1.46; -0.97 and -1.76 units, and egg production varied 6.99; 7.12 and –3.43% units for PP, VV and KK, respectively. In male lines, body weight improved 758 and 408 g; average breast area increased 31.95 and 19.38 cm^2, and adjusted feed conversion improved (42-49 d) –0.99 and -1.26 for TT and ZZ, respectively. This breeding program has been effective to generate genetic gain and to develop two commercial products, Embrapa 021 (standard) and Embrapa 022 (high yield). Nevertheless, feed efficiency is still not satisfactory.

INTRODUCTION

The Brazilian Swine and Poultry Research Center (Embrapa Suínos e Aves) maintains a chicken breeding program for meat production since 1985. The poultry breeding program of Embrapa is an important research program for the development of new selection strategies and studies related to these strategies, such as conservation of genetic resources. Nowadays, few genetic programs in the world are still funded by the government, which has reduced the possibilities of generating new technologies in this field.

Many approaches may be used to improve chicken lines for meat production; Chambers (1990) has published an extensive review on that issue. Chambers *et al*. (1981) have demonstrated the efficiency of selection to improve broiler body weight. The difference between two lines selected divergently for 7-week body weight was approximately 800g after ten generations (Dunnington & Siegel, 1995). High weight lines have shown a gain of 26 and 20g per generation for males and females, respectively, after 20 generations (Siegel, 1978).

Correlated response, which provides further information regarding the relationship between growth and feed efficiency, is available from selection experiments. The response to divergent selection for feed efficiency in two strains differed little when weight was allowed to vary or was maintained constant (Pym, 1985). This suggests that the genetic relationship between growth rate and feed efficiency is not strong. After 12 generations, the selection for weight gain from 5-9 weeks of age reduced male and female feed conversion by 0.28 and 0.37 on an age basis, and by 0.69 and 0.77 on a weight basis, whereas the selection for feed consumption increased male and female weight by 113 and 87 g at five weeks, and by 333 and 350 g at nine weeks, and increased feed conversion by 0.64 and 0.47 on an age basis and by 0.48 and 0.12 on a weight basis. On the other hand, selection for feed conversion increased male and female weight by 55 and 48 g at five weeks, and by 279 and 244 g at nine weeks, and reduced feed conversion by 0.55 and 0.58 on a constant age basis and by 0.87 and 0.85 on a weight basis. Comparisons between the lines showed that selection for gain caused major increases in weight and also increased feed consumption, whereas selection for feed conversion increased weight with essentially no change in feed consumption.

Among the possible means of implementing selection programs in meat type chicken lines, the methods of mass selection and independent culling levels are the easiest to be used. Although a large number of chicks from each line hatch, on average only 2% of sires and 16% of dams are selected to produce the next generation. This paper reports the genetic gain after 15 generations of selection, and the crossing of White Rock chicken lines for meat production and for developing the commercial broiler stocks Embrapa 021 and Embrapa 022.

MATERIAL AND METHODS

Chicken lines

Data from two male lines (TT and ZZ), three female lines (PP, VV and KK) and the respective control unselected lines (LLc and PPc) of the Brazilian Swine and Poultry Research Center (Embrapa Suínos e Aves) were analyzed from 1985 to 2001. Male lines were selected for 10 (TT) and 3 (ZZ) generations and female lines for 15 (PP), 10 (VV) and 8 (KK) generations. Control random-mating lines were kept for 15 generations. The crossbreeding between TT (male line) and PP x VV (female lines) resulted in a standard broiler line named Embrapa 021, and the crossbreeding between ZZ (male line) and VV x KK (female lines) resulted in a high yield type of broiler named Embrapa 022. Both strains might be feather sexed. In all lines, mating was directed by a computer program to avoid inbreeding. The number of families within the lines decreased from 120 in 1985 to 25 in 2001.

Information source

The genetic and phenotypic information for every individual within each line was collected from the pedigree flock. Information about hatching, growth and feed intake, viability, abnormalities, feather pattern, carcass traits and fertility was also used. Egg production was included for female lines. Since 1999, breast size of live chickens has been also included for all lines. Four hatches at two-week intervals were used in male lines. In female lines, three hatches were used from 1992 to 1998, and only two hatches were used from 1998 to 2001.

Selection strategy

The selection pressure was directed to weight gain and carcass traits for both male and female lines in 1985, besides egg production in female lines. All lines were selected for high fertility. After 1992, the selected sires of all lines were also selected for feed conversion. All chicks with abnormalities and wrong type of feathering were culled at hatch. Selected chicks were housed and body weight was evaluated until a pre-defined age that varied along the years, i.e., 42 days from 1989 to 1990; 35 days from 1991 to 1993; 28 days from 1994 to 1997, and 42 days since 1998. It was also included breast size evaluations in live chickens at the time of weight selection from 1999 to 2001. All lines were subjected to a strict leukosis eradication program in 1999. Sires with the highest body weight were submitted to individual feed efficiency tests from 43 to 49 days of age. Afterwards, the sires that ranked highest in body weight (n=100 per line) were subjected to fertility tests two weeks before mating. Dams were raised up to 16 weeks of age in large flocks, and then separated in groups of eight per pen to be mated with one selected sire. The fertility test was performed at 36 weeks of age, and those sires that failed were replaced. Females were placed in individual cages after 16 weeks of age and evaluated for egg production up to 56 weeks. Afterwards, they were artificially inseminated (fertility test). Five weeks later, dams were inseminated again with fresh semen from selected sires to produce the new generation.

Trait evaluation

In the last generation (2001), the observed means of the following traits in selected and control lines were non-statistically compared: viability, body weight, breast length and width (at the largest and smallest ends) at 42 days; body weight at 49 days and feed conversion from 43 to 49 days of age. Age at first egg and egg production at 64 weeks of age were also compared between female lines.

Experimental trial

In 2003 an experiment was carried out to compare the commercial Embrapa broilers (Embrapa 021 and 022) with two commercially available strains. Body weight and feed conversion up to 56 days of age were evaluated, as well as breast and leg meat weight from 28 to 56 days. Randomized blocks were used according to a 4 x 2 factorial (strains and sex), with 6 replicates and 38 birds each. Means were analyzed using GLM SAS statistical proceedings (SAS, 1996).

RESULTS AND DISCUSSION

Genetic gain in pure lines

In regard to female lines, only PP and PPc had the same genetic basis and were under the same conditions along the 15 generations of selection. Therefore, the deviation between these lines (Table 1) could be considered as an estimate of the genetic gain. The comparison between the other female lines with PPc provides an estimate of the direction of genetic changes due to their different genetic basis. Body weight increased 504, 548 and 587 g; mean breast area (49.07, 76.68, 66.06 and 75.50 for PPc, PP, VV and KK, respectively) increased 27.60; 16.99 and 26.43 cm^2; adjusted feed conversion improved -1.46; -0.97 and -1.76 units, and egg production improved 6.99; 7.12 and -3.43 % units for PP, VV and KK, respectively. It is worth noting that the genetic gain estimated by the difference between PP and PPc do not represent the maximum possible gain for each trait, since PP had to be selected to combine well within an architecture to develop a commercial broiler. In addition, the leukosis erradication program has compromised part of the genetic gain. It is also important to bear in mind that the genetic goal has been dynamic due to commercial strategies, and therefore, traits were under selection for different number of generations and submitted to different pressures of selection. Selection for breast area started at the 12^{th} generation, and was thus under selection only for three generations.

In male lines, body weight increased 758 and 408 g; average breast area (68.57, 100.52 and 87.95 cm^2, respectively, for LLc, TT and ZZ) increased 31.95 and 19.38 cm^2 and adjusted feed conversion improved –0.99 and -1.26 for TT and ZZ, respectively (Table 2). A similar rationale should be considered for male lines as for VV and KK, and therefore such increase cannot be appropriately considered as genetic gain but rather as

Table 1 - Block means in female lines in the last generation (2001).

Age, d	Traits	Strains* PP^{15}	VV^{10}	KK^{8}	PPc^{15}
42	Viability, %	85.24	95.89	90.26	77.85
	Body weight, g	1906	1950	1989	1402
	Breast length, cm	12.77	12.10	12.83	11.23
	Breast width, largest end, cm	7.38	6.88	7.35	5.46
	Breast width, smallest end, cm	4.63	4.04	4.42	3.28
49	Body weight, g	2724	2889	2947	2144
43-49	Feed conversion,	2.41	2.23	2.21	2.79
Production	Age at first egg, d	183	197	189	182
	Egg production at 64 weeks of age, %	68.64	68.77	58.22	61.65

* Superscripts indicate the number of generations under selection.

Table 2 - Flock means in male lines in the last generation (2001).

Age, d	Traits	Strain* TT^{10}	LLc^{15}	ZZ^{3}
42	Viability, %	88.90	94.64	96.54
	Body weight, g	2463	1705	2113
	Breast length, cm	13.99	12.03	12.84
	Breast width, largest end, cm	8.56	6.91	8.25
	Breast width, smallest end, cm	5.81	4.49	5.45
49	Body weight, g	3350	2359	3154
43-49	Feed conversion, g/g	2.71	2.72	2.04

* Superscripts indicate the number of generations under selection.

improvement due to selection, as expected (Chambers et *al.*, 1981). Genetic gain is difficult to measure appropriately, since animal performance is affected by several factors and the interactions between them. Despite the difficulties of following commercial strategies, the present study provides some experimental information on how breeding plans are designed to develop commercial broiler strains.

Test results

Table 3 shows the results of an experimental test in 2003 involving genotypes Embrapa 021, Embrapa 022 and two of the best commercially available strains in Brazil. Embrapa 021 was 116 and 109 g lighter at 42 days of age, and feed conversion ratio was 0.136 and 0.125 units poorer than in the commercial strains (P<0.01). On the other hand, Embrapa 022 showed similar weight to the commercial strains at 42 days of age, but feed conversion ratio was 0.057 and 0.046 units poorer (P<0.01). Table 4 presents the mean weight for breast and leg (drumstick + thigh). Meat production was greater in commercial strain 4 in comparison to the other 3 genotypes (P<0.01). Embrapa 021 ranked last in meat ability, whereas Embrapa 022 was similar to commercial strain 2. Breast meat weight at 42 days of age for Embrapa 021, Commercial 2, Embrapa 022 and Commercial 4 was 342; 391; 395 and 405 g, respectively. The performance of Embrapa broiler strains on field condition was as expected. In comparison to commercial strains, Embrapa 021 presented poorer feed efficiency and lower breast meat yield, but the performance of Embrapa 022 was similar to two other broiler strains commercially available in Brazil.

CONCLUSION

The breeding program carried out by Embrapa Suínos e Aves has been effective in generating genetic gain and developing two commercial products, Embrapa 021 (standard) and Embrapa 022 (high yield), although feed efficiency should still be improved.

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Table 3 - Body weight (BW) and feed conversion (FC) of Embrapa strains and two commercial broiler strains (2003).

Age (d)	Embrapa 021		2-Commercial		Embrapa 022		4-Commercial	
	BW, g	FC	BW, g	FC	BW, g	FC	BW, g	FC
1	41.9	-	44.6	-	44.3	-	43.0	-
7	161	1.270	165	1.242	153	1.355	140	1.402
14	420	1.186	429	1.153	404	1.193	380	1.208
21	700	1.425	720	1.377	711	1.381	684	1.395
28	1197	1.515	1204	1.485	1200	1.486	1184	1.467
35	1714	1.664	1784	1.557	1785	1.594	1745	1.573
42	2259b	1.816a	2375a	1.680c	2375a	1.737b	2368a	1.691bc
49	2679	2.008	2832	1.846	2881	1.909	2872	1.876
56	3050	2.197	3257	2.000	3223	2.131	3287	2.064

Within the same trait and at 42 days of age, means followed by different letters are significantly different (P<0.01).

Table 4 - Breast meat (BM) and leg meat (LM) (g) of Embrapa strains and two commercial broiler strains (2003).

Age (d)	Embrapa 021		2-Commercial		Embrapa 022		4-Commercial	
	BM	LM	BM	LM	BM	LM	BM	LM
28	142	204	162	222	157	212	166	211
35	236	320	264	342	270	334	265	341
42	342b	434c	391a	475a	395a	451b	405a	463ab
49	429	532	504	581	496	585	512	584
56	504	597	598	652	603	609	634	651

Within the same trait and at 42 days of age, means followed by different letters are significantly different (P<0.01).