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The Effect of Male Broiler Parent Live Weight Differences during the Growing Period on Progeny Broiler Performance

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ABSTRACT
With the increase in demand for broilers, breeds that provide rapid weight gain, efficient use of feed and high carcass yield have been selected for chicken meat production. The trial was carried out to determine the effect of broiler male parent's body weights of growing period (six and eighteen weeks) on progeny broiler performance traits. Cockerels in the study were allocated into 5 groups as Light Standard (LS), Light Light (LL), Standard Standard (SS), Heavy Heavy (HH) and Heavy Standard (HS) according to the live weight at the 6th and 18th weeks. When these cocks were young (24 weeks of age), prime (35 weeks of age) and old (48 weeks of age), the broiler performance of the offspring obtained from them by artificial insemination was evaluated. In terms of sire body weights during the study, the HH group had the highest live weight. In terms of the 35th d body weights of broilers, HH group reached the highest average in all periods, while the LS group had the lowest average and LL, SS and HS were close to each other. The average European Production Efficiency Index (EPEI) values of LL, LS, SS, HS and HH groups were found to be 434, 423, 429, 422 and 460, in three broiler trials average, respectively. The heritability for the body weight trait was found as for the 7th d= 0.18, 14th d= 0.21, 21st d= 0.31, 28th d= 0.30 and 35th d= 0.37. In conclusion, it was determined that the highest broiler performance was observed in the offspring of HH cock (heavy at the 6th and 18th week). In addition, it was determined that changes in live weight of sires after the 6th week (efforts to bring them to standard weight) would negatively affect the broiler performance of the offspring. Considering the EPEI, in which feed conversion rate and liveability are also included in the formula in addition to live weight it is suggested that HH group sires should be preferred for heavier broiler and more economical meat production.

Keywords: Parent stock, Body weight, Heritability, Broiler performance, Rearing period

1. Introduction

Chicken was the first animal species for which Mendelian inheritance was proven nearly a century ago, and also the first animal whose genome was sequenced in 2004 among farm animals (International Chicken Genome Sequencing Consortium 2004). Industrial production has made it easy to replace dual-purpose chicken with stocks grown specifically for meat or eggs. With the increase in demand for broilers, breeds that provide rapid weight gain, efficient use of feed and high carcass yield have been selected for chicken meat production (Eitan & Soller 2002; Thiruvenkadan et al. 2011). Poultry genetics has entered a new era with the contribution of a century of research on poultry genetics, chicken genome sequencing and the application of molecular genetic information in commercial breeding programs, especially on body weight gain (Mebratie et al. 2019).

Live weight gain has been the first and most significant trait in the breeding of meat-type chickens, and it will continue to be significant (Emmerson 1997; Nyalala et al. 2021). Improvement in body weight has consistently been the primary selection trait for decades because of its ease of selection, high heritability, and major impact on the overall cost of meat production (Arthur & Albers 2003). After evaluating the quantity of meat obtained from broilers at slaughter age for many years, it was concluded that meat quantity obtained per breeder should also be taken into consideration in genetic selection programs (Pollock 1999). Unlike layer breeders, uniformity and live weight control are more important in rearing broiler breeders (Sweeney et al. 2022).

A female broiler parent can produce approximately 150-160 chicks in a production period lasting 40 weeks. Broilers reach 2.3-2.8 kg slaughter weight and 1.5-1.7 feed conversion ratio with high viability during the 5th-6th week of fattening period (Sarıca et al. 2018; Türkoğlu & Sarıca 2018a). Considering the reproductive performance of the parents and the performance of their offspring, it is clear that more than 300 kg meat per female parent and about 3 tons of meat per male parent can be produced, indicating why the financial values of the broiler parents are higher (Uçar et al. 2017). Each rooster is of great importance in order to get the greatest benefit from the broiler chicken lines with superior genetic structure created by primary breeding companies through very laborious and challenging processes (Emmerson 2003).

In natural mating flocks, which are usually housed in mixed male-females, the structure of production is planned according to the female. Under these conditions, there is less interest in male reproductive performance. However, the fact that economic value of males cannot be ignored shows the necessity of increasing their reproductive capacity (Sexton 1983). Efforts are mainly made to keep male parent weights at standard level in order to optimize reproductive performance (Burke & Mauldin 1985; Ingram et al. 1987; Hocking & Duff 1989; Beer 2009). While breeding companies place great emphasis on selecting the heaviest males in their sire line populations to produce heavier broilers, parent-stock firms rarely use this information, considering this selection to be complete. Although selection has been made during the breeding phase, there is still enough genetic variation in the parent stocks obtained from the selected birds to allow selection for heavier males (Leeson & Summers 2010). It has been reported that there is a low but positive correlation between the body weights of male parents at 3 and 20 weeks of age, and a significant correlation at the level of 0.42 between 5 and 20 weeks of body weights. Likewise, it is stated that there is a strong positive relationship between parental weights and the body weights of their offspring, and that the offspring of heavy males are heavier than other males (Van Wambeke et al. 1979; Van Wambeke et al. 1981). When we selected 20% and 50% of the parent males starting from the heaviest at 3-4 weeks of age, an increase of approximately 2% and 1% in the average live weight of broilers is expected, respectively. It is reported that if we choose 50% of the parent males, about 4 times the extra expense that will be made can be returned from the slaughter of broilers (Leeson & Summers 2010).

Breeding companies provide guidance to companies that raise parent stock with care and management guides. It is known that the main task is to reach a standard weight suitable for genotypes in field conditions. However, our knowledge about the extent to which this is achieved is limited. Furthermore, there is no information about the performance of broilers obtained from sires that have been brought to standard weight or not. Our study was designed to shed light on this uncertainty, at least partially. This trial was carried out to determine the effect of broiler male parent's body weights of growing period (six and eighteen weeks) on progeny broiler performance traits.

2. Material and Methods

All procedures were carried out in accordance with the rules declared by the Ankara University Experimental Animals Ethics Committee (2020-1547).

2.1. Selection and rearing of male parents

Male parents, which are the main animal material used in the experiment, were provided by a broiler parent breeding farm of Erpiliç (Türkiye) company. At the five week of age, when the Ross 308 male chicks were classified according to their weight, the birds were assigned into 3 separate pens, each with a capacity of 1200 birds, as light, standard and heavy males in the same pens. In the 6^{th} week of the growth period, which is accepted as the beginning of the experiment, all young roosters were weighed individually and wing tags were attached to 100 birds of the same weight from each pen (300 in total). The average live weights according to the pens were determined as 850 g (light), 1150 g (standard) and 1450 g (heavy), indicating a 300 g BW difference among them. The backs of these 300 selected roosters were painted blue to distinguish them from those that were not selected. All cockerels were weighed individually on the same day of each week between weeks 6 and 18 of the rearing period. The descriptive statistics of the 6^{th} and 18^{th} week weight data of selected males are presented in Table 1.

Thus, the roosters were divided into five groups as a result of their live weight values at the 6th and 18th weeks: Light Light (LL), Light Standard (LS), Standard Standard (SS), Heavy Standard (HS) and Heavy Heavy (HH). A total of 25 roosters (5 from each group) were determined in these five groups, with average weights of 2230 g, 2715 g, 2740 g, 2760 g and 3260 g, respectively (Table 1).

Table 1- BW mean of the selected males from pens according to groups (g)

Week	*LL*	*LS*	*SS*	*HS*	*HH*	*SEM[1]*
6	851 [c]	851 [c]	1151 [b]	1453 [a]	1453 [a]	2.06
18	2230 [c]	2715 [b]	2740 [b]	2760 [b]	3260 [a]	18.50

[1]SEM: Standard Error of Mean; a,b,c: Differences between means indicated with different letters in the same row are significant ($P<0.05$)

During the rearing period, a total of 17.0, 15.5 and 15.5 kg of feed per male was provided in light, standard and heavy pen, respectively. A total of 25 males were randomly placed in individual male cages in the Poultry House of Ankara University. Each cage was arranged to have 1 bowl feeder and 1 nipple drinker. The size of each cage compartment was 47x50x55 cm.

2.2. Selection and rearing of female parents

220 female breeders at the age of 45 weeks were selected from the production farm belonging to the company from which the roosters were selected. These were determined to be egg laying by physical checks and were weighed and those within the range of 3800-3900 g were selected. Afterwards, these females were transferred to Ankara University. The hens were weighed again a week after their arrival at the university, and the average weight of the females placed to each group was determined to be 3919

g. For each female, 1 feeder and 1 nipple drinker were arranged per cage, and there was a specific code based on the rooster on the front of their cages. Individual cages measured 55x45x40.

2.3. Egg production period

Males and females were randomly distributed in cages on floors and rows, thus ensuring that males and females belonging to each group were present in every part of the house. A total of 25 cocks and 220 hens were placed in individual cages and the production period continued. At the bird level, the house temperature was tried to be kept between 24-26 ºC. Plastic wire mesh (chick carpet) was laid on the cage floor wire to minimize foot-leg, breast and eggshell problems due to the heavy weight of the broiler parents. The diagram of the males and females assigned to them at the beginning of egg-laying period, determined as 5 cocks in each group and 44 hens per cock group (Figure 1).

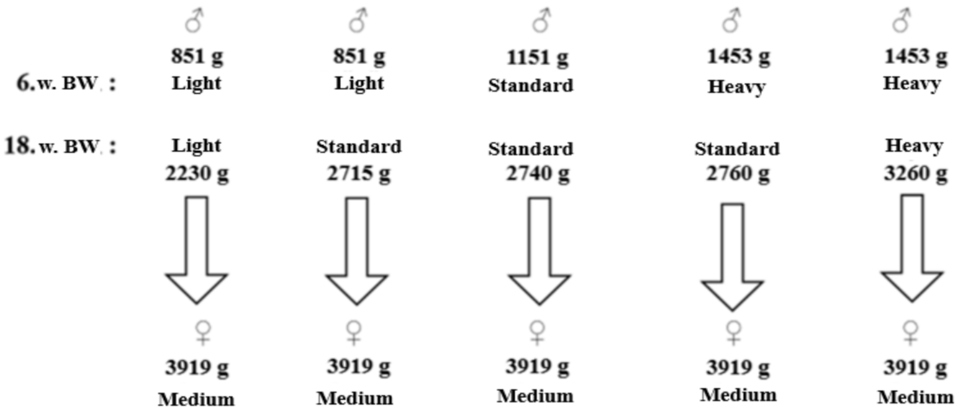

Figure 1- Group of cockerels and scheme of given hens

A total of 3 broiler studies were conducted according to the age groups of the sires (young, prime and old). In the first broiler experiment, chicks obtained from 24-week-old males and 47-week-old females were used. In the second and last broiler experiments, 35 and 48-week-old males with 58 and 71-week-old females were used, respectively.

2.4. Lighting and feeding program

The 8-hour daily lighting period applied to the roosters during the growing period was continued after they were transferred to the house. In males, first light stimulation was increased to 10 hours per week on 21st and that week it was increased to 12 hours. When the cocks were 22 weeks old, the hens were brought to the house and the lighting was fixed at 14 hours/daily this week. A homogeneous lighting of 60-80 lux was provided at bird level.

Feedig of the parents was carried out once a day between 8-9 am (once a week after insemination around 7 pm). Feed prepared in granule form, obtained from a commercial company, with a content of 2800 kcal/kg ME, 14% CP and 3.2% Ca, was provided throughout the entire production period. Considering that the birds were reared in cages, less feed quantity was calculated compared to when reared them on the floor. This calculation was made by following the egg production and BW gains.

2.5. Preparation of the males and artificial insemination

The males were accustomed to the massage method for ejaculate within 3 weeks of their arrival at the Poultry House. In order to obtain clean semen, feed was not provided on the morning of the insemination day and cloaca circumference of males were shaved. Artificial insemination was carried out once a week between 17:30-19:00 pm. The semen obtained from 5 cocks in each group was mixed undiluted and calculated according to the number of hens per group.

2.6. Storage and hatching of eggs

Eggs were collected 4 times a day (at 9, 12 a.m. and 3, 6 p.m.). After the hen and cock group code were permanently noted on the eggs, they were kept in two storage cabinets (Çimuka, Turkey) with a total capacity of 1400 eggs. These cabinets were adjusted to 18 ºC temperature and 70% relative humidity (RH), and eggs were stored for a maximum 10 d. The incubation was carried out in 2 fully automatic Çimuka (T960C) combined type incubators, each of which can hold 882 eggs.

During the incubation, the machine temperature value was arranged according to the shell temperature. For this purpose, the shell temperatures of 10 eggs from different layers were measured at the same time every day with a thermometer (Braun, ThermoScan 5), and the machine temperature set value was adjusted so that the average shell temperature was 100.0 ºF (37.8 ºC). The eggs were arranged in a mixed order according to the groups in order to eliminate the differences that may occur between the floors, especially the temperature, in the storage and development machines. In the hatch machine, each group was placed in their own baskets separately. During the incubation, the humidity was set at 50-55% RH in the machines. Turning was performed once an hour at a 45 º angle during the 18 d setter machine. On the 18^{th} d of incubation, the eggs that were found to be infertile or the embryos were dead by candling were separated and the eggs with continued development were transferred to the hatching baskets. A total of 3 incubations were carried out for broiler trials. Approximately 1300, 1450 and 1100 eggs were used for each of the 3 incubations.

2.7. Determination of broiler performance

In order to minimize the effect of incubation time in broiler experiments, chicks hatched between 490-500 hours of incubation period were used. After the gender of chicks were determined, they were weighed and raised separately according to the sire groups. The weighed chicks were then reared in the Broiler Research House at the university, with equal numbers of male and female chicks per pen. The house had a total area of 120 m^2 (10x12 m), and the required number of 1 m^2 pens were prepared according to the number of groups and replications in the trials (Table 2).

Table 2- Number of pens and chicks used in broiler experiments

Experiments	*Pens per group*	*Total Number of Pens*	*Broilers per Pen*	*Broilers per Group*	*Total Number of Broilers*
1	7	35	14	98	490
2	9	45	14	126	630
3	5	25	16	80	400

During the broiler rearing period, 55 lux light intensity illumination was provided in the chicken coop 24 hours a day. Starter feed (3,000 kcal ME/kg and 23.5% CP) was provided between days 0-10 and grower feed (3,200 kcal ME/kg and 22.0% CP) was offered between days 11-28. Finisher feed (3,300 kcal ME/kg and 20.0% CP) was provided between 29 and 35 days. Feeds were formulated to meet National Research Council (1994) recommendations. Feed and water were ad libitum offered to the chickens during all rearing periods. Water was provided to broilers in each pen via a nipple drinker line (3 nipples per pen). For the first 4 days, enough graph paper was laid to cover 2/3 of the pen, and a chick feeder was used until weight measurement in the first week. After the first week of the experiment, a hanging feeder (15 kg capacity) was used in each pen. The average feed intake (FI) per pen was calculated by adding weighed feed in front of each pen, and by weighing the remaining feed in the feeders weekly (with a scale with a sensitivity of 2 g). Feed conversion ratio (FCR) was also calculated from the sum of feed intake per pen and live weight per pen. The chicks were weighed in a scale with an accuracy of 0.01 g on the first day they were placed in the pen, and the average body weight (BW) was determined by weighing them individually with an accuracy of 2 g on the 7^{th}, 14^{th}, 21^{st}, 28^{th} and 35^{th} days.

2.8. Statistical analyses

In the trials, feed intake per broiler (FI), feed conversion ratio (FCR; dead broiler weights were also taken into account when calculating FCR), mortality rate (MR), liveability (LV) and European Production Efficiency Index (EPEI) were calculated. EPEI group averages were also calculated, allowing broiler performance criteria such as BW, FCR and LV to be evaluated together.

The data were stored and organized in the MS Excel program, and randomness was taken into consideration in the design of the experiments. Variation between paternal half-siblings was used to calculate heritability levels. While the SAS (2015) package program was used to calculate heritability levels, the relevant procedures of the SPSS (2011) 20.0 package program were used for all other statistical analyses. Differences between groups were analyzed by DUNCAN multiple comparison test, and statements of statistical significance were based on P≤0.05 unless otherwise stated.

According to the body weight averages of each of the 5 males in the sire groups (5 males in each group were considered as a single male because they were inseminated by mixing the semen of the males), the heritability degree was calculated from the weights of 568 broilers (276 females + 292 males). The model was arranged according to gender and weight of the chicks at the time of placement in the house. The effect of the storage day of the eggs and the pen in which the animals were reared were not included in the model because they were not significant.

Heritability estimates were obtained for each trait separately using within group correlation (dams nested within sires) by *Proc Mixed* procedure with REML algorithm in SAS (2015). Model included Sire, Dam (Sire) and residual as Random effects. After obtaining variance component estimates, heritability was estimated as:

$$\boldsymbol{h^2 = 4\frac{\sigma^2_{sire}}{\sigma^2_{Total}}}$$

3. Results

3.1. Body weight

Average BW of 0, 7, 14, 21, 28 and 35 d of broiler experiments are shown in Table 3.

Table 3- Broiler BW Averages according to Sire BW Groups in 3 Experiments

Experiments / Sire Ages	*Broiler Rearing Days*					
	0	*7*	*14*	*21*	*28*	*35*
Experiment 1 / Young	-------------------------- g ----------------------------					
Light Light (LL)	46.0^{ab}	196.6^{b}	530.8^{cd}	1091.4^{cd}	1799.2^{b}	2456.7^{b}
Light Standard (LS)	45.6^{b}	200.4^{ab}	523.1^{d}	1070.4^{d}	1744.7^{c}	2396.7^{c}
Standard Standard (SS)	44.8^{c}	200.8^{ab}	538.0^{bc}	1105.1^{bc}	1817.2^{b}	2489.8^{b}
Heavy Standard (HS)	45.8^{b}	203.8^{a}	552.3^{a}	1122.8^{ab}	1870.3^{a}	2562.2^{a}
Heavy Heavy (HH)	46.5^{a}	197.8^{b}	547.5^{ab}	1131.8^{a}	1875.6^{a}	2578.1^{a}
SEM	*0.23*	*1.76*	*4.11*	*8.24*	*11.23*	*13.75*
Experiment 2 / Prime	-------------------------- g ----------------------------					
Light Light (LL)	46.9^{a}	155.9^{c}	433.4^{b}	923.9^{b}	1566.4^{bc}	2126.4^{b}
Light Standard (LS)	45.8^{b}	158.0^{c}	418.3^{c}	867.9^{c}	1502.7^{d}	2029.0^{c}
Standard Standard (SS)	45.3^{b}	163.1^{b}	441.9^{b}	931.9^{b}	1576.2^{b}	2127.7^{b}
Heavy Standard (HS)	45.6^{b}	163.4^{b}	442.2^{b}	927.9^{b}	1563.8^{c}	2125.3^{b}
Heavy Heavy (HH)	47.0^{a}	168.7^{a}	453.6^{a}	966.5^{a}	1644.4^{a}	2256.3^{a}
SEM	*0.32*	*1.43*	*3.53*	*7.56*	*11.21*	*15.73*
Experiment 3 / Old	-------------------------- g ----------------------------					
Light Light (LL)	45.8^{c}	159.6	432.1^{b}	946.3^{b}	1653.2^{a}	2395.3^{b}
Light Standard (LS)	47.5^{ab}	161.3	437.0^{b}	949.0^{b}	1622.4^{ab}	2431.5^{b}
Standard Standard (SS)	48.4^{a}	163.3	430.4^{b}	944.5^{b}	1641.4^{a}	2409.2^{b}
Heavy Standard (HS)	46.5^{bc}	161.4	440.7^{b}	950.0^{b}	1611.4^{b}	2386.0^{b}
Heavy Heavy (HH)	48.1^{a}	167.2	462.7^{a}	1012.5^{a}	1703.5^{a}	2523.4^{a}
SEM	*0.39*	*3.19*	*5.45*	*10.45*	*32.59*	*23.06*

a,b: According to Duncan's test, there is a difference between means with different letters in the same column (P<0.05)

Experiment 1: Although the lightest group was HH in the first week, the heaviest chick weight was also measured in this group at the end (P<0.05). In detail, in the following week, HH group chicks accelerated their live weight gain and reached the highest weight in the 3rd week. When an average of live weight for the last two weeks is considered, it is observed that the LS group had the lowest, the SS and LL groups had the middle, and the HH and HS groups had the highest live weight (P<0.05).

Experiment 2: HH and LL group chicks had a higher weight than the other groups on the first day. In the first week, the HH group was followed by the SS and HS groups, while the LL and LS groups remained at the lowest average. After the seventh day, the LL group reached a similar weight with the SS and HS groups in terms of live weight gain. The highest live weight average was found in the HH group, while the lowest average was determined in the LS group (P<0.05). Similar to the first experiment, the LS group had the lowest mean, while the LL, SS and HS groups had a medium level and the HH group had the highest mean. In general, the reason why the live weight was lower in this trial compared to the 1st and 3rd trials was that it was carried out in the hot summer months. Because the cooling systems in the house in the university research unit did not work effectively during this extremely hot period.

Experiment 3: In terms of live weight on the first day, HH and SS groups reached the highest average, followed by LS and HS, while the LL group had the lowest live weight average (P<0.05). While there was no difference between the groups in the first week (P>0.05), it was determined that the HH group was 90 g heavier than the closest group and the other groups had similar averages (P<0.05).

3.2. Feed conversion ratio

The averages of FCR between 0-7, 0-14, 0-21, 0-28 and 0-35 d in the broiler studies are presented in Table 4.

Table 4- Broiler FCR Averages according to Sire BW Groups in 3 Experiments

Experiments / Sire Ages	*Broiler Rearing Days*				
	0 - 7	*0 - 14*	*0 - 21*	*0 - 28*	*0 - 35*
Experiment 1 / Young	--------------------------- g / g -----------------------------				
Light Light (LL)	1.018	1.165^{ab}	1.241^{b}	1.327^{b}	1.459^{ab}
Light Standard (LS)	1.006	1.160^{b}	1.237^{b}	1.353^{ab}	1.472^{ab}
Standard Standard (SS)	1.044	1.184^{a}	1.266^{a}	1.357^{a}	1.454^{ab}
Heavy Standard (HS)	1.045	1.173^{ab}	1.259^{a}	1.360^{a}	1.486^{a}
Heavy Heavy (HH)	1.004	1.153^{b}	1.243^{b}	1.330^{b}	1.438^{b}
SEM	*0.014*	*0.007*	*0.005*	*0.009*	*0.013*
Experiment 2 / Prime	--------------------------- g / g -----------------------------				
Light Light (LL)	1.213	1.269^{a}	1.337	1.390	1.563^{bc}
Light Standard (LS)	1.199	1.233^{c}	1.333	1.400	1.572^{bc}
Standard Standard (SS)	1.159	1.253^{abc}	1.338	1.410	1.579^{ab}
Heavy Standard (HS)	1.204	1.264^{ab}	1.325	1.414	1.611^{a}
Heavy Heavy (HH)	1.194	1.237^{bc}	1.314	1.383	1.540^{c}
SEM	*0.019*	*0.009*	*0.009*	*0.009*	*0.012*
Experiment 3 / Old	--------------------------- g / g -----------------------------				
Light Light (LL)	1.180	1.319	1.358	1.417	1.510
Light Standard (LS)	1.119	1.270	1.324	1.403	1.486
Standard Standard (SS)	1.176	1.325	1.363	1.431	1.500
Heavy Standard (HS)	1.205	1.320	1.360	1.449	1.513
Heavy Heavy (HH)	1.120	1.329	1.345	1.425	1.510
SEM	*0.031*	*0.029*	*0.024*	*0.012*	*0.016*

a, b: According to Duncan's test, there is a difference between means with different letters in the same column (P<0.05)

Experiment 1: While there was no significant difference in the first week, a difference began to emerge between the groups after the 2nd week, and it was determined that the SS group, which had low values until the last week, showed improvement in the last week, while the HS group had the worst average (P<0.05).

Experiment 2: While a difference was observed among groups in the second week of the experiment, there was no significant difference among them in the 1st, 3rd and 4th week. While the HS group had the worst feed conversion ratio in the last week, the HH group reached the best value (P<0.05).

Experiment 3: Differences among groups were not significant in any week of the trial (P>0.05).

3.3. Mortality

The mean mortality rates between d 0-7, 0-14, 0-21, 0-28 and 0-35 in the broiler studies are provided in Table 5.

Experiment 1: SS, LS and HS groups had a higher mean than LL and HH groups. The increase in mortality rate in the broiler chicken groups whose sires later reached the standard weight was higher than in the SS group whose sires always reached the standard weight (P<0.05).

Experiment 2: Mortality rate at week 2 in the SS group was significantly different compared to the other groups (P<0.05). In other weeks, there were only numerical differences.

Experiment 3: Although the mortality rates in the HS group were significantly higher (P<0.05) than the other groups in the 2nd, 3rd and 4th weeks of the trial, this difference was not significant in the whole period (P>0.05).

General Evaluation

In terms of sire body weights (Table 6), while the HS group approached the HH group at the age of 48 weeks, broilers belonging to the HH group had the heaviest live weight in all periods (P<0.05).

Table 5- Broiler Mortality Rate Means according to Sire BW Groups in 3 Experiments

Experiments / Sire Ages	*Broiler Rearing Days*				
	0 - 7	*0 - 14*	*0 - 21*	*0 - 28*	*0 - 35*
Experiment 1 / Young	-------------------------- % ----------------------------				
Light Light (LL)	0.00	0.00	0.00[b]	0.00[b]	1.02[b]
Light Standard (LS)	1.02	1.02	1.02[b]	2.04[b]	5.10[a]
Standard Standard (SS)	0.00	1.02	1.02[b]	2.04[b]	4.08[ab]
Heavy Standard (HS)	1.02	2.04	3.06[a]	5.10[a]	6.12[a]
Heavy Heavy (HH)	0.00	0.00	0.00[b]	0.00[b]	0.00[b]
SEM	*0.47*	*0.64*	*0.67*	*0.94*	*1.65*
Experiment 2 / Prime	-------------------------- % ----------------------------				
Light Light (LL)	2.38	2.38[ab]	2.38	2.38	2.38
Light Standard (LS)	0.00	0.00[b]	1.58	1.58	1.58
Standard Standard (SS)	3.17	4.76[a]	4.76	4.76	4.76
Heavy Standard (HS)	0.79	1.58[b]	2.38	2.38	3.17
Heavy Heavy (HH)	0.00	1.58[b]	1.58	2.38	2.38
SEM	*1.13*	*1.27*	*1.33*	*1.35*	*1.35*
Experiment 3 / Old	-------------------------- % ----------------------------				
Light Light (LL)	0.00	0.00[b]	0.00[b]	0.00[b]	1.25
Light Standard (LS)	0.00	0.00[b]	0.00[b]	0.00[b]	1.25
Standard Standard (SS)	0.00	0.00[b]	0.00[b]	0.00[b]	1.25
Heavy Standard (HS)	2.50	3.75[a]	5.00[a]	5.00[a]	5.00
Heavy Heavy (HH)	1.25	1.25[b]	1.25[b]	1.25[b]	3.75
SEM	*0.94*	*0.96*	*0.98*	*0.98*	*1.35*

a, b: According to Duncan's test, there is a difference between means with different letters in the same column (P<0.05)

Table 6- Sire Body Weight Averages (selection and insemination weeks for broiler studies)

Sires BW Groups	*Periods and Weeks*				
	Rearing		*Production*		
	Beginning	*Finish*	*Young*	*Prime*	*Old*
	6	*18*	*24*	*35*	*48*
	---------------------- g ----------------------				
Light Light (LL)	851[c]	2230[c]	3321[c]	4781[b]	5268[b]
Light Standard (LS)	851[c]	2715[b]	3742[b]	4782[b]	5566[b]
Standard Standard (SS)	1151[b]	2740[b]	3733[b]	4765[b]	5460[b]
Heavy Standard (HS)	1453[a]	2760[b]	3698[b]	4789[b]	5675[b]
Heavy Heavy (HH)	1453[a]	3260[a]	4134[a]	5253[a]	6174[a]
SEM	*2.06*	*18.53*	*24.19*	*63.69*	*104.22*

a,b: According to Duncan's test, there is a difference between means with different letters in the same column (P<0.05)

While the LL, SS and HS groups had similar averages in all periods in terms of the 35th day live weight of the broilers, the lowest average was weighed in the LS group and the highest average was weighed in the HH group (Table 7). In the whole experiment's average, 35[th] d BW of the LL, LS, SS, HS and HH groups were 2320, 2250, 2320, 2319 and 2431 g, respectively (Table 7).

Table 7- Average 35th d BW of Broilers according to Sire BW Groups 3 Experiments

BW Groups	*Sire Ages (Week) / Experiments*			
	Young (24)	*Prime (35)*	*Old (48)*	*Average*
	1	*2*	*3*	
	------------------ g ------------------			
Light Light (LL)	2465[b]	2126[b]	2395[b]	2320[b]
Light Standard (LS)	2397[c]	2029[c]	2432[b]	2250[c]
Standard Standard (SS)	2492[b]	2128[b]	2409[b]	2320[b]
Heavy Standard (HS)	2562[a]	2125[b]	2386[b]	2319[b]
Heavy Heavy (HH)	2574[a]	2256[a]	2523[a]	2431[a]
SEM	*13.75*	*15.73*	*23.06*	*18.65*

a, b: According to Duncan's test, there is a difference between means with different letters in the same column (P<0.05)

In terms of the FCR, a better performance had been achieved than the current catalogue values of the breeding companies (Cobb 2018; Aviagen 2019a; Aviagen 2019b). As indicated in Table 8, the HH group has sufficient values not only for live weight but also for feed conversion ratio.

Table 8- Average 0-35th d FCR in Broilers according to Sire BW Groups 3 Experiments

BW Groups	*Sire Ages (Week) / Experiments*			
	Young (24)	*Prime (35)*	*Old (48)*	*Average*
	1	*2*	*3*	
	------------------ *g/g* ------------------			
Light Light (LL)	1.459[ab]	1.563[bc]	1.510	1.511[b]
Light Standard (LS)	1.472[ab]	1.572[bc]	1.486	1.510[b]
Standard Standard (SS)	1.454[ab]	1.579[ab]	1.500	1.511[b]
Heavy Standard (HS)	1.486[a]	1.611[a]	1.513	1.537[a]
Heavy Heavy (HH)	1.438[b]	1.540[c]	1.510	1.496[c]
SEM	*0.013*	*0.012*	*0.016*	*0.008*

a, b: According to Duncan's test, there is a difference between means with different letters in the same column (P<0.05)

In the whole experiment's average, 35th d mortality of the LL, LS, SS, HS and HH was 1.71, 3.05, 3.88, 5.30 and 2.25%, respectively (Table 9). Only the differences between the first study results were significant (P<0.05), while the differences in terms of other studies and overall mean remained numerical.

Table 9- Average 0-35th d Mortality in Broilers according to Sire BW Groups 3 Experiments

BW Groups	*Sire Ages (Week) / Experiments*			
	Young (24)	*Prime (35)*	*Old (48)*	*Average*
	1	*2*	*3*	
	------------------ % ------------------			
Light Light (LL)	1.02[b]	2.38	1.25	1.71
Light Standard (LS)	5.10[a]	1.58	1.25	3.05
Standard Standard (SS)	4.08[ab]	4.76	1.25	3.88
Heavy Standard (HS)	6.12[a]	3.17	5.00	5.30
Heavy Heavy (HH)	0.00[b]	2.38	3.75	2.25
SEM	*1.65*	*1.35*	*1.35*	*1.306*

a, b: According to Duncan's test, there is a difference between means with different letters in the same column (P<0.05)

In the first experiment, the LS group had the lowest and the HH group had the highest index in terms of EPEI ($P<0.05$). In the second experiment, while all groups except HH had similar averages, the HH group again reached the highest average ($P<0.05$). In the last experiment, the LS group had the greatest value, followed by the HH, LL and SS groups, and the HS group had the lowest index value ($P<0.05$). In the average of 3 broiler experiments, the mean EPEI values of the LL, LS, SS, HS and HH groups were found to be 434, 423, 429, 422 and 460, respectively ($P<0.05$). When we consider the differences in these values in the general average, it can be concluded that the HH group reached the highest EPEI, while the other groups had values close to each other (Table 10).

Table 10- Average 35th d EPEI in Broilers according to Sire BW Groups 3 Experiments

BW Groups	*Sire Ages (Week) / Experiments*			
	Young (24)	*Prime (35)*	*Old (48)*	*Average*
	1	*2*	*3*	
	-------------------------- EPEI --------------------------			
Light Light (LL)	476^{ab}	382^{b}	447^{ab}	434^{b}
Light Standard (LS)	445^{d}	363^{b}	464^{a}	423^{b}
Standard Standard (SS)	470^{cd}	363^{b}	453^{ab}	429^{b}
Heavy Standard (HS)	472^{bc}	363^{b}	425^{b}	422^{b}
Heavy Heavy (HH)	513^{a}	409^{a}	449^{ab}	460^{a}
SEM	*8.93*	*6.65*	*9.12*	*4.79*

a, b: According to Duncan's test, there is a difference between means with different letters in the same column ($P<0.05$)

According to the calculations, the heritability for the body weight trait was found as $h^2 = 0.18$ for the 7th day, $h^2 = 0.21$ for the 14th day, $h^2 = 0.31$ for the 21st day, $h^2 = 0.30$ for the 28th day and $h^2 = 0.37$ for the 35th day.

4. Discussion

According to the experiments conducted, it has been reported that the share of genetics rather than environmental conditions in improving broiler performance characteristics is higher and this rate is approximately 85% (Havenstein et al. 2003a; Havenstein et al. 2003b). FCR, breast meat ratio and slaughter weight come to the fore compared to reproductive traits in terms of contributing to the profit increase rate of integrated firms (Emmerson 2003). However, the basis of the factors affecting the profit increase of companies is the broiler meat production per parent (Decuypere et al. 2010). Generally, studies have shown that the broiler performance of the offspring of heavy and light male parents varies (Van Wambeke et al. 1979; Van Wambeke et al. 1981; Leeson & Summers 2010). Our experiments differ from other trials due to the comparison of groups consisting of both heavy and light sires as a result of standard weighting during the rearing period.

In broiler experiments, HH group had the highest body weight in terms of placement time. In the first two trials, LL group approached the HH group, while in the last trial it had the lowest weight. The SS group, on the other hand, showed the opposite result of LL group. In order to eliminate the effect of hatching time (Özlü et al. 2018), chicks obtained between 490-500 h of hatch were used. There was no difference between egg weight averages of hens according to the cock groups. However, there was a difference between the groups in terms of placement time weight. As reported by Tahir et al. (2011) despite the high positive relationship between egg and chick weights, and between chick and slaughter weight, our results indicate that the first-day BW of groups, except for the HH group, were not reflected in the final weight means.

It has been reported that there is a low but significant relationship between the 3-week and 20-week age weights of male parents, and the 3-week-old weights have a positive, albeit low, relationship with the broiler performance of their offspring (Van Wambeke et al. 1979). In another study, a positive and significant correlation of 0.42 was calculated between the BW of male parents at 5 and 20 weeks of age ($P<0.01$). In this study, the 6th week BW performance of heavy ones and the offspring from other sires at the ages of 31, 41 and 51 weeks were 1671 and 1605 g, 1688 and 1573 g and 1727 and 1636 g, respectively, and the average of the whole period was determined as 1695 and 1604 g. In conclusion, heavy sires were reported to have approximately 90 g heavier progenies (Van Wambeke et al. 1981). When we consider the differences with the HH group and others, the results of the latter study are similar to our results. As a result of selection of male individuals in terms of body weight at the pure line level, variation in the performance characteristics of their offspring continues (Sarica et al. 2021). When selection is made at the parental level, serious variations are observed in the performance of the offspring, as in our study.

In our study, the levels of muscle and fat ratios in body of males were not measured. The extra feed given to the light pen after grading may have increased the fat ratio of LS group males after the 6th week of rearing period (Lin 1981; Leenstra 1986). It has been reported that there is a high positive relationship between abdominal fat and carcass fat and a negative effect on FCR. It is also reported that the heritability of abdominal fat is as high as 0.40-0.82 (Griffiths et al. 1978; Becker et al. 1981; Cahaner

& Nitsan 1985; Leenstra & Pit 1988; Gaya et al. 2006). It is considered that this factor may be effective in the low performance of the offspring of the LS group.

Van Emous (2015) showed that the growth period BW values influence broiler performance, as indicated in our study, while body composition at the end of the rearing period has a direct effect on hatchability results and broiler performance. Control of BW of male parents is very important in broiler strains (Türkoğlu & Sarıca 2018a). However, it has been demonstrated by our results that these practices should be questioned and different breeding strategies should be applied. It is thought that BW is very important not only during rearing period but also during the production period. According to the results of the present study, it was determined that bringing the standard weight in both heavy and light pens negatively affected broiler performance. In order to obtain positive results, standard weighting process can be slower or instead of bringing it to standard weight, it can be ensured that each pen is on its own average weight. Looking at the 1, 2, 3 and general averages in terms of live weight in the last week, it is observed that the HH group is ahead of the average of the other four groups by 88, 129, 92 g and 111 g, respectively. According to Leeson & Summers (2010), selecting the heaviest 20% or the heaviest 50% of the sires at the age of 3-4 weeks will increase the broiler performance by approximately 2 and 1%, respectively. If we take the 2320 g value after the HH group as a basis in the general averages, the difference of 111 g in the BB group reaches a higher value by about 5%.

Assuming that the breeding companies have completed selection, the integrated firms select the cockerels to be sent from rearing houses to the production houses phenotypically according to their general appearance. However, as stated similarly to our findings, the individual genetic variations of the prospective parent cocks are still at a level to allow selection (Leeson & Summers 2010). If we take into account 15% of female parent chicks given by the breeding companies to the integrated companies, half of them will be used during the production period. Therefore, it may be possible to select the heavier 50% of male parents. In broiler parents, hatching eggs are generally obtained from natural mating flocks (Pollock 1999). However, artificial insemination may be a more effective application as the BW of the genotypes increase further in the following years as a result of reduced success of cocks in natural mating (as in the commercial turkey parents). In addition, artificial insemination provides effective use of heavier sires (Brillard 2001). Considering body condition and composition, and male body weight (Leeson & Summers 2010; Van Emous 2015), rearing and feeding practices should be preferred to ensure success in natural mating. Since artificial insemination was used in our study, the results of this study obtained through natural mating are also important, since in a study comparing broiler chickens obtained by natural mating and artificial insemination, those with artificial insemination showed worse results in terms of both performance and immunity-related characteristics (Shaheen et al. 2020).

Body weight of the broiler parents at maturity affects carcass composition and carcass protein ratio (Salas et al. 2019). Not only body weight differences but also broiler parents' nutritional differences during the rearing period can affect the broiler performance of their offspring (Araújo et al. 2019; Moraes et al. 2019).

Since artificial insemination in roosters could not be followed individually, it was not possible to calculate heritability separately for groups. In our study, the calculated heritability of body weight between 1 and 5 weeks of age was 0.18-0.37, similar to some studies reported in the literature (Leenstra & Pit 1988; Koerhuis & Thompson 1997), but it seems to be lower than generally reported (Leenstra & Pit 1988; Mignon-Grasteau 1999; Gaya et al. 2006; Leeson & Summers 2010; Türkoğlu & Sarıca 2018b).

While it is aimed to maintain high fertility in production by reaching the standard weight, the effect of male parent BW on broiler performance is offen overlooked. Although reproductive performance is important, it is known that the main profit of integrated companies is the characteristics related to BW as the final product. Therefore, the aim is to achieve BW gain in the most effective way. The HH group had the highest mean in regards of EPEI (EPEI is a formula in which the most important parameters in broiler production such as BW, Liveability and FCR are evaluated together).

Contrary to the belief that standard weight roosters will perform better, the HH group comes to the fore when more and economical meat production is aimed. However, in order to make clearer interpretations, there is a need for studies to reveal the economic analysis of the productivity parameters of the offspring obtained from all groups of roosters. While higher meat production could be made from HH cocks, lower body weight gain was not achieved in the LL group compared to the others, and this was achieved more effectively with less feed.

Leeson & Summers (2010) stated that the most active cocks in the flock are those with standart weights. Although higher performance was obtained from the HH group, the reproductive performance of these heavy roosters under natural mating conditions is another subject worth investigating. Social relations between cocks are also a very important factor in flocks (Ottinger 1983; Ottinger 1989). In some studies, it has been reported that the frequency of the offspring of the cocks in the flock is variable and as a matter of fact, the indiviaual genetic contribution of the cocks to broilers can vary between 7 and 77% (Jones & Mench 1991; Bilcik et al. 2005).

5. Conclusions

In conclusion, it has been determined that breeding parentstock (PS) cannot be selected only based on 6th week rooster weight. It was determined that the performance of the offspring of these roosters decreased when they reached standard weight at 18 weeks. Especially when light cocks at 6 weeks of age reached the standard weight at 18 weeks, the broiler performance of their offspring was at its lowest level. In summary, it was determined that the offspring of roosters with high live weights at both 6 and 18 weeks of age showed the best broiler performance. In other words, it was determined that changes in body weight after the 6th week did not have a positive effect. Considering the EPEI formula, which includes feed conversion ratio and livability as well as live weight, HH group roosters should be preferred for heavier and more economical broiler production**.**

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