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Heterosis and Heritability Estimates of Body Weight in Turkeys

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ABSTRACT. Two commercial strains of turkeys, the Black Bronze (BB), and the White Ross (RR) were used in this study. The study lasted two years and different matings produced parental strains, F_1 crosses as well as backcrosses to both parents. Results revealed that mean 12–, and 16-week body weights were higher for RR than BB. Mean body weight for F_1 crosses at these two ages was intermediate to the parental strains. Heterosis was evident for only 12-week body weight. Average heritability estimates for 12-week body weight were 0.62, 0.74 and 0.68 as based on sire, dam and sire plus dam components, respectively. The corresponding estimates for 16-week body weight were 0.55, 1.06 and 0.80, respectively. The estimates of maternal effects were 0.03 and 0.13 for 12- and 16-week body weights, respectively.

Results of previous studies on the effects of crossing strains and varieties of turkeys on body weight have been inconsistent. Heterosis was evident in some crosses but not in others. The superiority of specific strain crosses of turkeys, with respect to 12-week body weight was shown by Asmundson and Pun (1954), Jerome *et al.* (1960), McCartney and Chamberlin (1961) and Friars *et al.* (1963). Conversely, Friars *et al.* (1963) and Nestor (1971) found no heterotic effect on 16-week body weight.

Numerous estimates of the heritability for body weight of turkeys at different ages have been reported. Mukherjee and Friars (1970) reported that heritability estimate based on sire plus dam components of 12-week body weight was 0.49 for both males and females of the Large White strain turkey. The estimates of heritability for 16-week body weight varied widely ranging from 0.23 (McCartney 1955) to 0.83 (Johanson and Asmundson 1957). Heritability estimates from dam component were larger than those from sire component (Bumgardner and Shaffner 1954, and Goodman *et al.* 1954).

The purpose of this study was to estimate the heritability of body weight at different ages and to study the effect of heterosis on body weight of two strains of turkeys.

Material and Methods

This study was based on body weight measurements on the turkey flock at the Poultry Research Center, University of Alexandria. The turkey stock consisted of, two commercial strains, the Black Bronze (BB) and the White Ross (RR).

In the first season (1978-1979), crosses consisting of the two strains, were made to provide parental strains (BB and RR) and reciprocal cross strains (RR x BB and BB x RR). Twelve breeding pens, were used. Each pen had three poults of each strain. Half of these pens were sired by RR males and the other half had BB males. In the second season (1979-1980) the hens and toms which had been produced in the previous season were crossed in different combinations to produce parental strains, F_1 crosses and backcrosses to RR and BB strains. The hens and toms were divided at random and natural mating was used throughout the experimental seasons.

The birds hatched in 1980 were given approximately similar conditions to those hatched in 1979. The ration and water were provided *ad libitum*. At hatching, milk and chopped boiled eggs were supplied to attract the chicks to eat. From hatching time to 8 weeks of age, the chicks were on a starting ration containing about 25% protein. Turkey growing ration containing about 19% protein was supplied from 8 weeks to sexual maturity, and breeding ration of 17% protein was supplied afterwards. The composition of these diets used is shown in Table 1.

Nine weekly hatches were secured, in each season, starting in March. The poults were hatched in April and May. They were wingbanded at hatching and recorded in the siredam records. All poults of each hatch were raised to 3 weeks of age at the density of 11 birds per sq m in an electric battery brooder supplied with artificial light for 14 hours daily. Then they were transferred randomly to the floor brooding at the density of 8 birds per sq m until 8 weeks of age. After that they were transferred to rearing houses at the density of 4 birds per sq m until the age of sexual maturity. Table 2 shows temperature variation during the experimental periods.

Body weight was measured in grams at 12 and 16 weeks of age for each individual, in the two seasons, and at sexual maturity for each hen, only in the first season. Sexual maturity was estimated as the age in days at first egg laid.

Percentage hecterosis was estimated by the following formula

$$\% \text{ heterosis} = \frac{\text{mean of cross} - \text{mean of parental strains}}{\text{mean of parental strains}} \times 100$$

Data were corrected for hatch effect by adjusting each individual's records by the deviation of the unweighted hatch mean from the strain or cross mean. Heritability estimates were obtained by means of variance component analysis (Becker 1968) on the data of Black Bronze. The standard errors of these heritabilities were calculated according to Becker (1968).

Results and Discussion

1. *Body weight at 12- and 16-weeks of age*

The males were significantly ($P<0.05$) heavier than the females in the different matings (Tables 3,4 and 5). These results are in general agreement with those reviewed by McCartney (1952) and Perenyi *et al.* (1978).

The birds of RR strain had significantly heavier body weights at 12- and 16-weeks of age than those of BB strain (Table 3). The F_1 progeny resulted from the BB x RR mating were heavier than those from the reciprocal mating. Statistical analysis of bird weights (Table 3) showed no differences in 12-week body weight between F_1 crosses while body weight at 16-weeks of age was significantly different.

Similar variations in body weights in different populations of turkey were reported by Mukherjee and Friars (1970) and Perenyi *et al.* (1978).

There were considerable differences in percent of heterosis for 12- and 16-week body weight among the different crosses. It is evident from Tables 3,4 and 5 that 12- and 16-week weights were heaviest for backcrosses to RR strain followed by the backcrosses to BB strain and F_1 crosses.

In general, these results are in agreement with those reported by Asmundson and Pun (1954), Jerome *et al.* (1960), McCartney and Chamberlin (1961) and Friars *et al.* (1963) who found heterosis in body weight at 12-weeks of age. Conversely, Friars *et al.* (1963) and Nestor (1971) found no heterotic effect on 16-week body weight.

The estimates of heritability and maternal effect for each season are shown in Table 6. Heritability estimates of 12-week body weight for adjusted data for sex differences varied from 0.55 to 0.73. The average estimates of the two seasons were 0.62, 0.74 and 0.68 as based on sire, dam and sire plus dam components, respectively.

The estimates were considerably greater than those reported by Mukherjee and Friars (1970), Krueger *et al.* (1972), Nestor (1977) and Popescu-Vifor and Puscatu (1980). However, the estimates of these authers were computed from unadjusted data for sex.

Heritability estimates of 16-weeks body weight for adjusted data were 0.81 and 0.79 for the first and second seasons, respectively, as based on sire plus dam components. The average estimates of the two seasons were 0.55, 1.06 and 0.80 as based on sire, dam and sire plus dam components, respectively. The over unity estimates for dam component found here was due to, in most cases, the experimental error. These estimates were in the same range with those reported by Johanson and Asmundaon (1957) for body weight at 16-weeks. However, they were considerably greater than those reported by Mukherjee and Friars (1970), Krueger *et al.* (1972), Nestor (1977) and Popescu-Vifor and Puscatu (1980). The differences in the heritability estimates of these authers were primarily due to the effect of the genetic make up of the populations and/or the environmental variations between farms.

It was evident from the data presented in Table 6, that the heritability estimates from the dam component were considerably higher than those from sire contribution. These results disagree with those reported by Krueger *et al.* (1972). However, Bumgardner and Shaffner (1954) and Goodman *et al.* (1954) found that dam component gave considerably higher estimate of heritability than the sire component of variance. As pointed out by Lerner (1950), discrepancies between these two estimates may be due to non-additive gene action, maternal effect and sex linked effects.

Maternal effects for body weight at 12- and 16-weeks of age were estimated as 3 and 13 percent, respectively. Experiments utilizing diallel matings would show the presence and magnitude of such maternal influences much better than the design which has been used in this study.

2. *Body weight at sexual maturity*

Body weight average at sexual maturity are shown in Table 7. The RR strain has significantly heavier body weight than that of the BB strain. These results are in agreement with those reported by Friaris *et al.* (1963) and Grigoriev *et al.* (1977) who found significant differences for body weight of mature age between varieties in turkey.

Comparing F_1 crosses, the progeny of RR x BB cross were equal in mature weight to progeny of the reciprocal cross. The overall average of heterosis estimates was -3.78 percent, which was not significantly different from zero. This result indicated that there was no heterotic effect on body weight at sexual maturity. In crosses of Broad Breasted Bronze and Beltsville Small White, Knox and Marsden (1944) observed the F_1 to be intermediate in mature weight between the parental strains but more closely approaching the smaller parent weight. In chickens, Pease and Dudley (1954) found negative heterosis estimate for body weight at sexual maturity. Negative heterotic effect for body weight at sexual maturity may be explained in terms of non-additive gene action, dominance and/or epistasis.

The estimates of heritability for body weight at sexual maturity were 0.27, −0.30 and −0.01 as based on sire, dam and sire plus dam components, respectively, (Table 6). In contrast, these estimates were somewhat lower than those reported by Cook *et al.* (1962), Krueger *et al.* (1972) and Kunev *et al.* (1977) on different varieties of turkey.

The results indicated that the estimate obtained from sire component was higher than that obtained from dam component. Krueger *et al.* (1972) came to the same conclusion, however Cook *et al.* (1962) found that the estimate calculated by dam component was higher than that obtained by sire component.

Maternal effect on body weight at sexual maturity was −0.14.

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Table 1. The composition of the diets used

Ingredients	Starting ration %	Growing ration %	Breeding ration %
Ground yellow corn	40.0	52.0	63.7
Rice polishing	8.7	13.0	4.0
Beans meal	20.0	11.0	8.0
Cottonseed meal	9.0	11.0	7.5
Fish meal	11.0	5.0	5.0
Blood meal	6.0	2.4	4.0
Dried yeast	3.0	1.0	—
Bone meal	0.7	2.0	3.0
Ground limestone	1.0	2.0	4.0
Mineral mixture[1]	0.4	0.4	0.5
Vitamin $(A+D_3)$[2]	0.1	0.1	0.2
Terramycin	0.1	0.1	0.1

1 Mineral mixture supplemented the following: NaCL4436 gm, $MgSO_4$ 750 gm, $MnSO_4$ 170 gm, $FeCl_2$ 50 gm, $CuSO_4$ 4.5 gm, H_2O 10 gm, KI 2 gm, and NaMo 2 gm (per ton).

2 Vitamin $(A+D_3)$ each gram contained 500 I.U. of Vitamin A and 500 I.U. of Vitamin D_3.

Table 2. Average temperature (C°) during the experimental seasons

Months	1979		1980	
	Minimum	Maximum	Minimum	Maximum
March	11.04	20.92	11.73	21.81
April	15.53	26.43	14.20	25.68
May	18.82	27.40	17.71	28.50
June	18.70	29.18	19.17	29.92
July	22.04	32.82	21.33	30.41
August	23.29	30.36	23.08	31.69

Table 3. Mean ($\bar{X}$), standard error (S.E.) and heterosis of 12- and 16-week body weights (g) in the first season (1978-1979)

Population: Group	Population: Mating (Sire Dam)	n	Male X ± S.E.	n	Female X ± S.E.	n	Adjusted for sex[1] X ± S.E.	Adjusted for sex[1] Heterosis
					12-week body weight			
Parental strain	RR x RR	24	2388 ± 124	19	2055 ± 169	43	2386 ± 105a[2]	
	BB x BB	149	1821 ± 44	167	1414 ± 28	316	1823 ± 28c	
			2105		1735		2105	
F_1 cross	RR x BB	22	2094 ± 99	26	1588 ± 68	48	2123 ± 72b	0.86
	BB x RR	25	2097 ± 71	24	1703 ± 65	49	2096 ± 53b	−0.43
			2096		1646		2110	0.22
					16-week body weight			
Parental strain	RR x RR	20	3762 ± 263	17	3042 ± 308	37	3766 ± 213a[2]	
	BB x BB	146	3035 ± 63	151	2254 ± 40	297	3020 ± 43c	
			3399		2648		3393	
F_1 cross	RR x BB	20	3093 ± 144	23	2433 ± 104	43	3091 ± 105a	−8.90
	BB x RR	21	3405 ± 118	22	2685 ± 138	43	3808 ± 105b	0.44
			3249		2559		3250	−4.23

(1) Female weights were adjusted to their equivalent male weights.
(2) Means with different superscripts differ ($P < 0.05$).

Table 4. Mean ($\bar{X}$), standard error (S.E.) and heterosis of 12-week body weight (g) in the second season (1979-1980)

Population			Male		Female		Adjusted for sex[1]	
Group	Mating Sire Dam	n	X ± S.E.	n	X ± S.E.	n	X ± S.E.	Heterosis
Parental strain	RR x RR	22	2294 ± 150	24	1727 ± 280	46	2295 ± 135[2]de	
	BB x BB	133	2033 ± 68	147	1581 ± 47	280	2039 ± 95e	
			2164		1654		2167	
Back cross to RR strain	RB x RR	17	2735 ± 59	13	4160 ± 510	40	2795 ± 90a	28.99
	BR x RR	13	2643 ± 113	15	2007 ± 85	28	2110 ± 68de	−2.63
	RR x RB	18	2685 ± 130	23	2024 ± 81	41	2685 ± 82ab	23.90
	RR x BR	12	2510 ± 437	13	1912 ± 345	25	2506 ± 319abc	15.64
			2643		2525		2524	16.48
Back cross to BB strain	RB x BB	12	2401 ± 108	21	1792 ± 92	33	2401 ± 87abc	10.80
	BR x BB	13	2323 ± 119	19	2034 ± 63	32	2321 ± 53cd	7.11
	BB x RB	14	1988 ± 80	16	1401 ± 54	30	1989 ± 55e	−8.21
	BB x BR	13	2327 ± 92	13	1624 ± 87	26	2365 ± 80bcd	9.14
			2260		1713		2269	4.71

(1) Female weights were adjusted to their equivalent male weights.
(2) Means with different superscripts differ ($P < 0.05$)

Table 5. Mean ($\bar{X}$), standard error (S.E.) and heterosis of 16-week body weight (g) in the second season (1979-1980)

Population			Male		Female		Adjusted for sex[1]	
Group	Mating Sire Dam	n	$\bar{X}$ ± S.E.	n	$\bar{X}$ ± S.E.	n	$\bar{X}$ ± S.E.	Heterosis
Parental strain	RR x RR	19	3215 ± 226	22	2088 ± 222	41	3170 ± 43de	
	BB x BB	129	3838 ± 86	140	2369 ± 56	269	3243 ± 57cd	
			3527		2229		3207	
Back cross to RR strain	RB x RR	17	3977 ± 123	13	3090 ± 709	30	3977 ± 179ab[2]	24.01
	BR x RR	13	3306 ± 542	14	2873 ± 143	27	2953 ± 155e	−7.92
	RR x RB	19	3940 ± 214	17	3064 ± 87	36	3941 ± 102ab	22.89
	RR x BR			13	2608 ± 339	13	2867 ± 470e	−10.60
			3708		2909		3435	7.10
Back cross to BB strain	RB x BB	19	3603 ± 142	20	2640 ± 126	39	3612 ± 125bc	12.63
	BR x BB	10	3389 ± 88	19	2900 ± 82	29	3392 ± 69cd	5.77
	BB x RB	11	3138 ± 110	14	2152 ± 70	25	3140 ± 74de	−2.09
	BB x BR	10	3522 ± 117	18	2525 ± 115	28	3578 ± 93bc	11.57
			3413		2554		3431	6.97

(1) Female weights were adjusted to their equivalent male weights

(2) Means with different superscripts differ ($P < 0.05$)

Table 6. Heritability estimates of 12- and 16-week body weight for each season

Season	h^2_S ± S.E.	h^2_D ± S.E.	h^2_{S+D} ± S.E.	Maternal effect
		12-week		
1978/79	0.69 ± 0.42	0.73 ± 0.29	0.71 ± 0.23	0.01
1979/80	0.55 ± 0.29	0.75 ± 0.22	0.65 ± 0.17	0.05
Mean	0.62	0.74	0.68	0.03
		16-week		
1978/79	0.39 ± 0.12	1.23 ± 0.38	0.81 ± 0.13	0.21
1979/80	0.70 ± 0.38	0.88 ± 0.27	0.79 ± 0.22	0.04
Mean	0.55	1.06	0.80	0.13
		Body weight at sexual maturity		
1978/79	0.27 ± 0.15	−0.30 ± 0.16	−0.01 ± 0.09	−0.14

Table 7. Mean ($\bar{X}$), standard error (S.E.) and heterosis of body weight at sexual maturity

Population			n	$\bar{X}$ ± S.E.	Heterosis
Group	Mating				
	Sire	Dam			
Parental strain	RR	RR	12	5475 ± 305a[1]	
	BB	BB	34	4282 ± 83c	
	Mean			4879	
F_1 cross	RR	BB	21	4821 ± 210b	−1.19
	BB	RR	23	4567 ± 190bc	−6.39
	Mean			4694	−3.79

(1) Means with different superscripts differ (P<0.05)

قوة الخلط والمكافىء الوراثي لوزن الجسم في الرومي

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استخدم في هذه الدراسة سلالتان تجاريتان من الرومي : البرونز الأسود والرومي الأبيض، وأجريت تزاوجات مختلفة في سنتين متتاليتين للحصول على السلالتين الأبويتين وخلطات الجيل الأول بالإضافة إلى الخلطات الرجعية لكل من السلالتين الأبويتين.

وأظهرت النتائج أن متوسط وزن الجسم عند عمر ١٢ و١٦ أسبوع كان مرتفعاً في سلالة الرومي الأبيض عنه في البرونز الأسود. وكان متوسط خلطات الجيل الأول في الوسط بين السلالتين الأبويتين، ووجد أن هناك تأثيراً لقوة الخلط فقط على وزن الجسم عند عمر ١٢ أسبوع.

وكان متوسط تقديرات المكافىء الوراثي لوزن الجسم عند عمر ١٢ أسبوع ٠,٦٢ و٠,٧٤ و٠,٦٨ مقدراً عن طريق مكونات التباين الأبوية والأمومية على التوالي. بينما كانت التقديرات المناظرة لوزن الجسم عند عمر ١٦ أسبوع ٠,٥٥ و١,٠٦ و٠,٨٠ على التوالي. وكانت تقديرات التأثيرات الأمومية ٠,٠٣ و٠,١٣ لأوزان الجسم عند عمر ١٢ و ١٦ أسبوع على التوالي.