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ESTIMATION OF GENETIC PARAMETERS AMONG CARCASS CHARACTERISTICS IN TWO STRAINS OF JAPANESE QUAILS

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Abstract: The data on carcass characteristics of 370 black and 336 brown Japanese quails under selection for high 4- week body weights over four generations was subjected to least squares analysis to study the effect of strain, generation, sex and hatch. The effects of strain generation and hatch were significant on majority of the traits under study, while sex had significant effect on BW6, DW, Giblets but not on carcass cuts. The overall least squares means for BW6, DW, Giblets, heart, liver, gizzard were 221.61, 137.75, 11.77, 1.85, 5.10 and 4.81g, respectively, where as the least squares means for wings, neck, legs, breast, back and SFV are 12.38, 5.91, 33.15, 56.47, 29.84 g and 1.84 kg, respectively. Black Japanese quails are significantly ($P<0.01$) heavier than brown Japanese quails for all carcass traits. Generation 7 and hatch 5 recorded highest means for almost all the carcass traits. Heritability estimates for BW6, giblets and carcass cuts are medium to high in magnitude. Genetic association of BW6 and DW with other internal organs and carcass cuts ranged from -0.77 to 0.97 among the strains. Phenotypic correlation of BW6 with giblets and carcass cuts varied from low to high, while moderate to high association with positive direction was recorded for DW with other organs. Environmental correlation of BW6 with other carcass traits are medium to high (-0.51 to 0.80) in range with inconsistency in direction.

Keywords: Carcass traits, Correlations, Heritability, Japanese quail.

Introduction

Poultry industry played a major role in the development of livestock sector in India. The total poultry population in India was 729.2 millions and poultry meat contributes 27.11% of total meat production of world (19th Livestock census, 2012)[1]. Growth rate in poultry industry has been further enhanced by introduction of other species such as quails, turkey, ducks, emu and ostrich etc. Among the other species of poultry, quail meat is well accepted by the consumers and India ranks VI in the world in respect of quail meat production. Poultry meat is white meat, however quail meat resembles more with red meat and known for delicacy. The present study was under taken to study the carcass characteristics of two strains Japanese quails that are under selection for high 4 week body weight.

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Materials and methods

A total of 370 Black and 336 Brown Japanese quails belonging to 5, 6 and 7th generations maintained at Poultry experimental station, Rajendranagar, Hyderabad were utilized for the present study. A random sample of two males and two females from each sire family in fifth generation and three males and three females from each sire family in 6thand 7th generations were slaughtered at 6th week of age by Halal method. The quails were fasted for 12 hours. Individual quail was sacrificed by severing the jugular vein and carotid artery and allowed to bleed completely. The data on Pre-slaughter weight (BW6), Dressed weight (DW), Giblets (heart, liver and gizzard), Carcass cuts (wings, neck, legs, thighs, drumsticks, breast and back) and Warner – Bratzler Shear force values (Reddy *et al.*,1984)[2] was subjected to least squares analysis (Harvey, 1979)[3] to resolve the effect of strain, generation, sex and hatch on carcass traits. The data adjusted for generation and hatch effects was utilized for estimation of genetic parameters (Becker, 1985)[4].

Results and discussion

The least squares analysis of variance of carcass traits revealed that the strains, generations and hatches had a significant effect on majority of carcass traits with the exception on liver and shear force values (SFV) for effect of strain, on shear force values for effect of generation and on the weight of drumsticks for effect of hatch, while significant influence of sex was noticed on pre-slaughter weight (BW 6), dressed weight (DW) and giblets (heart, liver and gizzard), but not on carcass cuts. These results were in harmony with the findings of Oguz *et al.* (1999)[5], Dhaliwal *et al.*(2004)[6], Vali *et al.* (2005)[7], Banerjee *et al.* (2010)[8] and Alkan *et al.* (2013)[9].

The overall least squares means for BW6, DW, Giblets, Heart, Liver and Gizzard were 221.61, 137.75, 11.77, 1.85, 5.10 and 4.81g, respectively, where as the least squares means for wings, neck, legs, breast, back and SFV are 12.38, 5.91, 33.15, 56.47, 29.84 g and 1.84 kg, respectively (Table 1).The overall least squares means for DW(137.75 g) and the mean SFV (1.84 kg) in the present investigation were much higher than the means reported by Turkmut *et al.,* 1999[10]; Dhaliwal *et al.,*2004[6]; Vali *et al.,* 2005[7]; Narinc *et al.,* 2010[11]. The means reported for various carcass traits in the present study were within the range of means reported by earlier research workers[8,9]. Among the carcass cuts studied, the mean weights for breast found to be higher in both Black (58.80 $\pm$ 0.61 g) and Brown (52.96 $\pm$ 0.53 g) Japanese quails followed by legs (33.66 $\pm$ 0.34 and 32.64 $\pm$ 0.34g) and back (30.84 $\pm$ 0.34 and 28.95 $\pm$ 0.34 g). Black Japanese quails were significantly ($P<0.01$) heavier than the Brown Japanese quails for mean body weights at all the ages and similar trend was reflected at 6-weeks of age for pre-slaughter weight and further resulted in higher means for carcass traits in Black Japanese quails.

The overall least squares mean for BW 6 in 5th, 6th and 7th generations were 212.71, 217.94 and 234.17 g, respectively and the corresponding means for DW were 130.59, 138.02 and 144.64 g. The chicks of 7th generation recorded highest BW6 followed by those of generations 6 and 5.The means for other carcass traits also followed similar trend. The mean weights of giblets varied from 11.45 to 12.29 g among the generations. Among the carcass cuts, the mean weights for breast was highest in Generation 7 (58.23 g) followed by 6 (55.90 g) and 5 (52.68 g), which were in agreement with the earlier reports of Oguz *et al.* (1996)[12], Dhaliwal *et al.* (2004)[6] and Vali *et al.* (2005)[7] that selection for high 4-week body weight has resulted in correlated genetic response in growth pattern and tend to increase the weight of carcass and components of carcass.

The least squares means were significantly (P<0.01) higher in females than in males for BW6, DW, Giblets, Liver and Gizzard. The mean shear force values in males and females were 1.79 and 1.88 kg, respectively. Significant effect of sex on all the carcass traits with an exception for carcass cuts in the present study further confirmed the findings of Kirmizibayrak and Altinel (2001)[13], Vali *et al.* (2005)[7] and Banerjee (2010)[8]for BW6, DW, weight of liver, but contradictory to the findings of Taboada *et al*. (1998) [14] El-full (2000)[15] and Tavaniello *et al.,* 2014[16] for pre-slaughter weight. Non significant effect of sex on carcass cuts observed in the present study was coincided with the findings of Ozcelik *et al*. (1998)[17], but, not with vali *et al.*(2005)[7] for weights of breast and thighs.

The chicks of 5th hatch recorded (P<0.01) highest BW6 (236.66 g), DW (147.36 g) and giblets (12.45 g), whereas the lowest means for the above traits with an exception for giblets (186.34, 110.99 and 12.19 g) were noticed in the chicks of 7th hatch. Among the carcass cuts, highest means were observed for breast in all the seven hatches with the means ranging from 41.79 to 60.60 g followed by legs (27.44 to 36.71 g) and back (26.46 to 31.20 g). The mean weight of wings among the seven hatches varied from 10.50 to 13.69 and the means for neck ranged from 4.80 to 6.44 g. Similarly, the mean weights for thighs ranged from 15.61 to 21.72 g and that of the drumsticks varied from 11.83 to 14.99 g (Table 1). Significant effect of hatch was found on almost all the carcass traits studied, which was in consistent with the report of Vali *et al.*(2005)[7]. The significant differences among the hatches for carcass traits could be attributable to the environmental fluctuations.

Genetic parameters

Genetic parameters estimated for traits under study are presented in Table 2.

Heritability: The heritability estimates for BW6 in males and females of Black strain are 0.34 and 0.90. Heritability estimates for DW across the strains varied from 0.18 to 0.95 and the estimates for giblets are 0.21 in Black males and 0.23 in females, while the estimates are 0.59 and 0.67 in Brown males and females, respectively. Heritability estimates for carcass cuts varied from 0.10 to 0.33 in black and 0.15 to 0.83 in brown males, while the estimates varied from 0.19 to 0.49 in black and 0.19 to 0.90 in brown females. The heritability estimate for BW6 in both the strains are medium to high in magnitude exhibiting the presence of considerable amount of genetic variance and offers scope for further improvement by selective breeding. Kawahara and Saito (1976)[18], Toelle *et al.* (1991)[19] and Daikwo *et al.* (2012)[20] also reported low to high heritability estimates for various carcass traits in their studies on Japanese quails.

Correlations: The genetic correlation of BW 6 with DW, internal organs (giblets, heart, liver and gizzard) and carcass cuts in the present study varied from 0.10 to 0.99, while the phenotypic correlations ranged from 0.01 to 0.93 across the strains. The genetic (0.47 to 0.91) and phenotypic (0.16 to 0.47) correlations of BW 6 with various internal organs were positive and medium to high in magnitude in Brown females, while the magnitude of environmental correlations across the strains varied from -0.51 to 0.98 with positive direction in Black males and inconsistent in direction in case of Black and Brown females.

The estimates of correlation coefficients of DW with other organs were low to high at genetic level in Black females (-0.77 to 0.95) and Brown females (0.12 to 0.48).The corresponding estimates at phenotypic level were low to high (0.21 to 0.71 and 0.11 to 0.33) in magnitude with positive association. The genetic correlation of DW with other organs in Black and Brown males were 0.15 to 0.43 and 0.20 to 0.98, respectively. The corresponding estimates at phenotypic level were 0.08 to 0.24 and 0.11 to 0.33.

Medium to high genetic correlations were noticed for giblets with various internal organs and carcass cuts in Black (-0.26 to 0.89) and Brown (0.19 to 0.27) strains, whereas phenotypic correlations were moderate to high in magnitude in Black (0.16 to 0.77) and low to high (0.01 to 0.74) in Brown Japanese quails. Wide range of estimates (-0.91 to 0.98) were observed for environmental correlations with inconsistency in direction. The genetic and phenotypic correlation of heart with other organs varied from -0.47 to 0.37 and -0.05 to 0.28 in Black strain. Low to medium genetic and phenotypic correlations observed for liver with other organs among the strains. The environmental correlations ranged from -0.45 to 0.34. Phenotypic association of gizzard with carcass cuts was moderate in magnitude.

The phenotypic correlation coefficients of wings with the other carcass cuts varied from 0.32 to 0.53, while the environmental correlations are ranged from -0.59 to 0.08 in Brown males and the genetic correlation of wings with breast was 0.73, whereas low to medium estimates were observed for neck with other carcass cuts at phenotypic (0.01 to 0.29) and environmental (-0.38 to 0.69) levels. The genetic correlation of neck with drumsticks was 0.15 in Brown males. High positive association was observed for phenotypic correlations of legs with other carcass cuts in both Black and Brown Strains. The environmental correlations were high in magnitude in Black and medium to high in Brown. Genetic and phenotypic correlations obtained in the present study among the various carcass traits were in harmony with those reported by Toelle *et al.*(1991)[19],Vali *et al.*(2005)[7]; Daikwo *et al*. (2013)[20]; Lofti *et al.* (2011)[21] and Momah *et al.* (2014)[22].

The genetic and phenotypic correlations of shear force values with dressed carcass was -0.20 and 0.32 respectively and wide range of estimates noticed for genetic, phenotypic and environmental correlations of shear force values with other internal organs and carcass cuts. Results of the present study indicated that all carcass traits were basically same on genetic and phenotypic scales and selection of quails for high body weight is expected to bring about positive and correlated improvement in all the associated carcass traits. The shear force value, which is an inverse measure of tenderness of the muscle fibres was generally negatively correlated with the dressed weight (-0.20) in Brown Japanese quails, which revealed that selection of birds for high 4 week body weight resulted in higher pre-slaughter weight in turn more tender musculature, besides the improvement in various carcass cuts.

The genetic parameters obtained in the present study for some of the traits were outside the normal range which could be due to smaller number of progeny per sire (*Brah et al.,* 1998[23] and Prado Gonzalez *et al.,* 2003[24]).

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Table 1. Least squares means (g) of carcass traits of Japanese quails

	Overall (n = 706)		Black (n = 370)		Brown (n = 336)		Generation5 (n = 164)		Generation6 (n = 283)		Generation7 (n = 259)		Males (n = 374)		Females (n = 332)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Pre-slaughter weight	221.61	1.43	231.15[b]	1.65	212.07[a]	1.64	212.71[a]	2.20	217.94[b]	1.66	234.17[c]	1.83	217.97[a]	1.66	225.25[b]	1.64
Dressed carcass weight	137.75	0.95	142.92[b]	1.10	132.58[a]	1.09	130.59[a]	1.46	138.02[b]	1.10	144.64[c]	1.22	136.61[a]	1.11	138.89[b]	1.09
Total Giblets**:**	11.77	0.13	12.06[b]	0.15	11.47[a]	0.15	11.55[a]	0.20	11.45[a]	0.15	12.29[b]	0.17	11.52[a]	0.15	12.01[b]	0.15
Heart	1.85	0.04	1.92[b]	0.04	1.78[a]	0.04	1.86[b]	0.05	1.70[a]	0.04	2.00[c]	0.05	1.90[b]	0.04	1.81[a]	0.04
Liver	5.10	0.08	5.09	0.09	5.12	0.09	5.06[a]	0.12	4.86[a]	0.09	5.39[b]	0.10	4.93[a]	0.09	5.28[b]	0.09
Gizzard	4.81	0.07	5.05[b]	0.08	4.56[a]	0.08	4.62[a]	0.11	4.90[b]	0.08	4.90[b]	0.09	4.70[a]	0.08	4.92[b]	0.08
Carcass cuts:																
Wings	12.38	0.14	13.10[b]	0.16	12.19[a]	0.16	11.98[a]	0.22	12.96[b]	0.16	13.20[b]	0.18	12.78	0.16	12.99	0.16
Neck	5.91	0.07	6.52[b]	0.09	5.81[a]	0.08	5.88[a]	0.11	6.06[b]	0.09	6.19[b]	0.09	5.90	0.09	5.92	0.08
Legs	33.15	0.29	33.66[b]	0.34	32.64[a]	0.34	31.56[a]	0.45	33.36[b]	0.34	35.73[c]	0.38	33.17	0.34	33.32	0.34
Thighs	19.63	0.19	19.91[b]	0.22	19.25[a]	0.22	18.66[a]	0.29	19.83[b]	0.22	21.08[c]	0.25	19.57	0.22	19.70	0.22
Drumsticks	13.61	0.12	13.81[b]	0.14	13.41[a]	0.14	12.90[a]	0.19	13.57[b]	0.15	14.65[c]	0.16	13.60	0.15	13.62	0.14
Breast	56.47	0.53	58.80[b]	0.61	52.96[a]	0.53	52.68[a]	0.81	55.90[b]	0.61	58.23[c]	0.68	54.96	0.62	56.28	0.61
Back	29.84	0.30	30.84[b]	0.34	28.95[a]	0.34	28.49[a]	0.46	29.74[b]	0.34	31.29[b]	0.38	29.80	0.35	30.36	0.34
Shear force values	1.84	0.03	1.82	0.04	1.86	0.04	1.89	0.05	1.83	0.04	1.79	0.04	1.79[a]	0.04	1.88[b]	0.04

Means followed by the same superscript(s) in a row do not differ significantly (P<0.05)

Table Cont.

	Hatch 1 (n = 114)		Hatch 2 (n = 117)		Hatch 3 (n = 154)		Hatch 4 (n = 156)		Hatch 5 (n = 100)		Hatch 6 (n = 58)		Hatch 7 (n = 7)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Pre-slaughter weight	227.87[c]	2.16	231.93[cd]	2.14	225.70[c]	1.77	217.12[b]	1.78	236.66[d]	2.19	225.64[c]	2.87	186.34[a]	8.33
Dressed carcass weight	138.83[b]	1.44	143.05[c]	1.42	144.00[c]	1.18	141.46[b]	1.18	147.36[d]	1.45	135.45[b]	1.91	110.99[a]	5.54
Total Giblets	11.06[a]	0.20	11.62[ab]	0.19	11.86[b]	0.16	11.61[ab]	0.16	12.45[c]	0.20	11.56[ab]	0.26	12.19[bc]	0.76
Heart	1.81[a]	0.05	1.95[a]	0.05	1.91[a]	0.04	1.96[a]	0.04	2.09[b]	0.05	1.77[a]	0.07	1.49[a]	0.21
Liver	5.01[ab]	0.12	4.77[a]	0.12	4.97[ab]	0.10	4.84[a]	0.10	5.23[b]	0.12	5.03[ab]	0.15	5.88[b]	0.45
Gizzard	4.24[a]	0.11	4.90[b]	0.11	4.98[b]	0.09	4.81[b]	0.09	5.14[a]	0.11	4.76[b]	0.14	4.83[b]	0.41
Carcass cuts:														
Wings	12.33[bc]	0.21	12.61[cd]	0.21	13.14[cd]	0.17	12.81[cd]	0.18	13.69[d]	0.22	11.86[ab]	0.28	10.50[a]	0.82
Neck	5.88[b]	0.11	6.06[bc]	0.11	6.32[c]	0.09	6.28[c]	0.09	6.44[c]	0.11	5.99[bc]	0.15	4.80[a]	0.43
Legs	33.60[c]	0.45	34.50[cd]	0.44	35.02[d]	0.37	34.27[cd]	0.37	36.71[d]	0.45	33.36[b]	0.59	27.44[a]	1.72
Thighs	19.95[b]	0.29	20.70[bc]	0.29	20.87[c]	0.24	20.36[bc]	0.24	21.72[c]	0.29	19.48[b]	0.38	15.61[a]	1.12
Drumsticks	13.66	0.19	13.83	0.19	14.14	0.15	13.93	0.16	14.99	0.19	13.88	0.25	11.83	0.73
Breast	57.46[cd]	0.80	58.65[cd]	0.79	58.54[d]	0.65	57.17[cd]	0.66	60.60[d]	0.81	54.22[b]	1.06	41.79[a]	3.08
Back	29.56[a]	0.45	31.20[b]	0.44	30.97[b]	0.37	30.95[b]	0.37	29.91[ab]	0.45	30.03[ab]	0.60	26.46[a]	1.73
Shear force values	1.73[a]	0.05	1.85[ab]	0.05	1.85[ab]	0.05	1.94[b]	0.04	2.00[b]	0.05	1.92[b]	0.06	1.56[a]	0.04

Means followed by the same superscript(s) in a row do not differ significantly ($P<0.05$)

Table 2: Estimates of heritabilities, genetic, phenotypic and environmental correlations among carcass traits in black and brown Japanese quails

	BW6	DW	Giblets	Heart	Liver	Gizzard	Wings	Legs	Drumstick	Breast	SFV
Black Males											
BW6	0.34	0.16	0.34	0.42	0.45	0.14	0.18	0.26	0.30	0.57	
DW	0.49 (0.31)	0.86	0.21	0.15	0.17	0.23	0.23$	0.31	0.28	0.43	
Giblets	0.38 (0.40)	0.24(0.09)	0.21	-0.26	0.51	0.17	0.19	0.23	0.27	0.38	
Heart	0.01 (0.18)	0.21(0.16)	0.34 ($)	0.37	0.33	-0.27	0.18	0.16	0.23	-0.30	
Liver	0.05 (0.25)	0.17(0.14)	0.70 (0.80)	-0.05 (0.85)	0.80	-0.28	0.09	0.13	0.21	0.23	
Gizzard	0.18 (0.51)	0.23(0.05)	0.77 (0.51)	+0.12 ($)	0.33 (-0.26)	0.10	0.11	0.18	0.22	0.75	
Wings	0.06 ($)	0.19(0.08)	0.42(0.23)	0.05(0.13)	0.19(0.11)	0.18(0.13)	0.33	0.29	0.17	0.43	
Legs	0.18 (0.31)	0.08($)	0.35(0.17)	0.10(0.16)	0.22(0.07)	0.19(0.07)	0.29(0.15)	0.44	0.33	0.28	
Drumstick	0.23 ($)	0.16(0.04)	0.19(0.10)	0.19(0.07)	0.13(0.10)	0.08($)	0.23(0.21)	0.33(0.21)	0.24	0.35	
Breast	0.93 (0.71)	$	0.25 (0.23)	0.05 (0.32)	0.42(0.19)	0.26 (0.11)	0.16(0.12)	0.28(0.15)	0.32(0.19)	0.10	
Black Females											0.18
BW6	0.90	0.11	0.82	0.10	0.18	0.78	0.99	0.12	0.87	0.75	
DW	0.87 ($)	0.18	0.95	-0.77	0.19	0.09	0.30	0.94	0.65	0.25	
Giblets	0.05 (-0.51)	0.45 (0.24)	0.23	0.77	0.86	0.34	0.85	0.26	0.89	0.48	
Heart	0.01 (0.61)	0.21 (0.50)	0.39 (0.11)	0.68	0.13	0.37	-0.47	0.19	-0.09	-0.22	
Liver	0.08 (-0.34)	0.24 (0.07)	0.71 (0.60)	0.17 (-0.15)	0.28	0.14	0.01	0.08	0.11	-0.44	
Gizzard	0.03 (-0.42)	0.71 (-0.01)	0.72 (0.37)	0.07 (-0.08)	0.08 (-0.45)	0.16	0.09	0.13	0.18	0.14	
Wings	0.23 (0.50)	0.10 (0.54)	0.38 (0.15)	0.10 (0.27)	0.21 (0.23)	0.35 (-0.23)	0.19	0.21	0.28	0.31	
Legs	0.32 (0.24)	0.60 (0.98)	0.30 (0.35)	0.23 (0.50)	0.23 (-0.04)	0.41 (0.24)	0.57 (0.44)	0.49	0.33	0.25	
Drumstick	0.25 (0.80)	0.54 (0.85)	0.21 (0.03)	0.14 (0.38)	0.21 (-0.11)	0.36 (-0.05)	0.50 (0.24)	0.85 (0.77)	0.34	0.94	
Breast	0.33 (0.19)	0.42 (0.78)	0.16 (0.28)	0.28 (0.38)	0.73 (0.34)	0.32 (-0.24)	0.46 (0.12)	0.67 (0.58)	0.61 (0.43)	0.37	
Brown males											0.54
BW6	0.35	0.42	0.18	0.21	0.11	0.17	0.25	0.34	0.36	0.41	
DW	0.27 (0.11)	0.95	0.68	0.16	0.74	0.21	0.97	0.94	0.23	0.95	-0.20
Giblets	0.07 (0.23)	0.36 (0.27)	0.59	0.23	0.27	0.14	0.19	0.22	0.09	0.21	-0.75
Heart	0.18 (0.07)	$	$	0.22	0.16	0.19	0.23	0.18	0.14	0.19	$
Liver	0.10(0.15)	0.26 (-0.95)	0.74 (0.45)	$	0.29	0.23$	0.43	0.86	0.13	0.50	-0.60

Gizzard	0.07(0.11)	0.23(0.18)		$	0.	0.35	0.12	0.24	0.19	0.21	$
Wings	0.18(0.21)	0.55(-0.57)	0.40 (0.10)	$	0.30 (0.220	$	0.46	0.31	0.23	0.73	0.56
Legs	0.21(0.11)	0.29(0.31)	0.38 (0.20)	$	0.25 (-0.12)	$	0.53 (0.3)	0.15	0.34	0.27	$
Drumstick	0.32(0.14)	0.16 (0.08)	0.40 (-0.18)	$	0.21 (-0.19)	$	0.32 (-0.17)	0.78 (0.59)	0.20	0.25	0.
Breast	0.25(0.28)	0.28 (0.66)	$ (0.49)	$	0.66 (-0.27)	$	0.33 (0.38)	0.60 (0.07)	$	0.83	-0.13
SFV		0.32	0.01 (0.50)		0.01 (0.61)		0.01 (-0.59)	0.10 (0.72)	0.04 (0.55)		0.62
Brown Females											
BW6	0.96	0.31	0.91	0.47	0.14	0.18	0.78	0.41	0.35	0.64	
DW	0.47 ($)	0.25	0.34	0.21	0.19	0.12	0.38	0.44	0.45	0.48	
Giblets	0.13(0.01)	0.14(0.05)	0.67	0.26	0.31	0.22	0.27	0.19	0.22	0.31	
Heart	0.24 (0.07)	0.19(0.11)	0.01 (-0.08)	0.48	0.23	0.27	0.84	0.11	0.07	0.14	
Liver	0.12(0.18)	0.21(0.15)	0.19(-0.09)	0.11($)	0.24	0.19	0.17	0.21	0.16	0.11	
Gizzard	0.18(0.07	0.11(0.09)	0.20(0.11)	0.12($)	$(0.11)	0.32	0.21	0.16	0.18	0.09	
Wings	0.28 ($)	0.33(0.14)	0.03(0.12)	0.19(0.12)	$(0.12)	0.11($)	0.90	0.25	0.29	0.21	
Legs	0.22(0.16)	0.15(0.12)	0.14(0.11)	0.09(0.10)	0.07(0.14)	0.18(-0.07)	0.25(-0.11)	0.59	0.41	0.31	
Drumstick	0.25(0.13)	0.21(0.18)	0.18(0.12)	$0.14(0.12)	0.15(0.11)	0.09($)	0.33(-0.21)	$	0.38	0.23	
Breast	0.18 (-0.02)	0.28(0.16)	0.35 (-0.91)	0.03 (0.25)	0.17(0.09)	$0.07($)	0.45 (-0.05)	$	$	0.74	

Diagonal figures indicate heritability estimates, Above the diagonal indicate genetic correlations, Below the diagonal indicate phenotypic and environmental (figures in parenthesis) correlations ,$ beyond biological limits