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Comparative studies on feed efficiency and body conformation characteristics in RIR chicken and its crosses

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ABSTRACT

The feed efficiency and body conformation characteristics were evaluated in 457 chicks of RIR-selected, control and white strains, CARI-Sonali and CARI-Debendra crossbred chicken maintained at ICAR-Central Avian Research Institute. The least squares means of live body weight gain, feed consumption, FCR, shank length, keel length and breast angle were estimated at various periods of ages. CARI-Debendra recorded significantly the highest live weight gains and FCRs than the other genotypes studied, though RIR-white strain outperformed CARI-Debendra in terms of FCRs at 8th and 16th week of age. CARI-Sonali significantly followed CARI-Debendra in attaining live weight gain up to 8th week of age and thereafter, RIR-selected strain exhibited better weight gain than the CARI-Sonali. CARI-Debendra demonstrated better FCRs throughout the ages excepting 8th and 16th week-estimates where RIR-white strain performed the best. RIR-control strain had the least weight gains and non-beneficial FCRs throughout the ages. The male birds had more live weight gains than the females throughout the ages. The best body conformation estimates were found in CARI-Debendra followed by RIR-selected strain/ CARI-Sonali, RIR-white and RIR-control strain. The body conformation estimates of CARI-Sonali were better than that of RIR-selected strain up to 8th week of age, and were found better in males than the females throughout the ages. The findings on genotypic variation in feed efficacy and body conformation characteristics of the birds could be important to the farmers for selection of genotypes for rearing as per their preference of the traits.

Keywords: Breast angle, FCR, RIR chicken, Shank and keel lengths, Weight gain

A dual purpose chicken population of exotic Rhode Island Red (RIR) genetically improved through selective breeding at Central Avian Research Institute (CARI), Izatnagar is being maintained as selected population since 1980. A random-bred control population of RIR is being maintained since then (Das *et al.* 2020). A rare white plumage strain of RIR evolved at this Institute as RIR-white strain. This Institute also developed two crossbreds by mating its RIR female line with (i) males of IWH line of White Leghorn chicken to develop CARI-Sonali, a layer purpose chicken, and (ii) males of coloured synthetic male line of broiler chicken to develop CARI-Debendra, a multi-coloured dual purpose chicken (Das *et al.* 2013). Selection was practiced in the RIR-selected population based on 40-weeks part-period egg production along with an independent culling level for egg weight at 28th week of age (Das *et al.* 2020). These traits are related to the feed efficiency along with its genetic background, and improvement in these traits would also be expected to improve feed efficiency (Niranjan and Kataria 2008). Consumers usually prefer a plump-breasted bird and the preference for breast meat is reflected back to the breeder, with the avowed intervention of increasing breast-plumpness (Das *et al*. 2014a, 2015a, 2015b). Again, body dimensions can predict either conformation or percentage meat yield of the carcass if suitable correlation can be demonstrated (Reid *et al*. 1984, Das *et al*. 2014a, 2015a). In this context, the present investigation was carried out to assess feed efficiency and body conformation characteristics in RIR chicken and its crosses maintained at this Institute.

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MATERIALS AND METHODS

Experimental birds and husbandry adopted: In the present study, a total of 457 chicks of single hatch representing RIR-selected, control and white strains, CARI-Sonali and CARI-Debendra crossbred chicken were evaluated at the Experimental Layer Farm of ICAR-Central Avian Research Institute (CARI), Izatnagar. The chicks were wing banded and dubbed on day one age. As soon as they attained four weeks of age at separate battery brooders with standard floor space and brooding temperature (Das *et al*. 2014a, 2014b, 2015a), the chicks were shifted into separate new brooder houses for 16 weeks of age. *Ad lib.* freshwater and feed were provided twice daily. Chick mash with 20.65% CP, 2694.64 kcal/kg ME, 1.02% Ca, 0.45% P, 1.05% Lys and 0.41% Met was utilized for feeding birds up to 0-8 weeks of age, and grower mash with 16.78% CP, 2536.00 kcal/kg ME, 1.15% Ca, 0.40% P, 0.76% Lys and 0.37% Met for feeding birds at 9-16 weeks of age. The birds were vaccinated following standard vaccination schedule (Das *et al*. 2014a, 2014b, 2015a).

Feeding trials: The feeding trials (*ad lib.*) were conducted from day-1 to 16th week of age. The birds were provided with weighed quantity of standard ration. The feed residue was weighed after each recording period, followed by notice of any mortality on specific date, if any, the dead bird's wing band number(s) and weight(s) were date-wise recorded, and the amount of feed consumed by individual birds per day was calculated.

Traits investigated: The chick weight, live body weight, shank length, keel length and breast angle were recorded at 4, 6, 8, 12 and 16th week of age. Body weights were measured using digital balance (capacity-0.5 g to 3 kg with accuracy of 1 mg), shank and keel lengths were measured using vernier calipers, and breast angle was measured using goniometer. Feed consumption efficiency was expressed as feed consumption (g), live body weight gain (g) and feed conversion ratio (FCR) (g feed intake per g weight gain) in different periods of age.

Statistical analysis: Data were analyzed by the least squares analysis of variance (Harvey 1990) taking genotype and sex as fixed effects along with genotype*sex interaction effect in the statistical model:

$$Y_{njk} = \mu + G_n + S_j + (GS)_{nj} + e_{njk}$$

where Y_{njk}, value of a trait measured on kth individual of jth sex in nth genotype; μ, population mean; G_n, fixed effect of nth genotype; S_j, fixed effect of jth sex; $(GS)_{nj}$, interaction effect of jth sex with nth genotype; and e_{njk}, random error associated with mean zero and variance σ^2.

Critical Difference (CD) test at the 5% level of probability of significance was performed for assessing critical differences among the least squares means.

RESULTS AND DISCUSSION

Feed efficiency characteristics: The estimated least squares means of live weight gain (WG), feed consumption (FC) and feed conversion ratio (FCR) measured at periods of 1-4, 5-6, 7-8, 9-12 and 13-16 weeks of age of all the chickens studied are presented in Table 1. The present estimates of feed efficiency traits, i.e. live weight gain, feed consumption and feed conversion ratio of different chicken genotypes were in accordance to the previous reports on RIR chicken (Das *et al.* 2014a, 2015a, 2015b) and its crosses (Das *et al.* 2016a, 2016b). The CARI-Debendra recorded significantly (P<0.05) the highest live weight gains and FCRs in compromise of more consumption of feed as compared to the other genotypes studied. In some periods (at 8th and 16th weeks of age), RIR-white strain demonstrated better (P<0.05) FCRs consuming lesser amount of feed than the CARI-Debendra crossbred. The CARI-Sonali crossbred significantly (P<0.05) followed the CARI-Debendra in attaining live weight gain upto 8th week of age and thereafter, the RIR-selected strain significantly (P<0.05) exhibited better weight gain than the CARI-Sonali. The RIR-selected strain demonstrated better (P<0.05) FCRs than the CARI-Sonali throughout the ages excepting 6th and 8th week-estimates. The CARI-Debendra demonstrated the best (P<0.05) FCRs than the other genotypes throughout the ages excepting 8th and 16th week-estimates where the RIR-white strain performed the best (P<0.05), and at 4th week of age, both the genotypes demonstrated statistically (P>0.05) the same FCR. The RIR-control strain had the least (P<0.05) weight gains and non-beneficial FCRs throughout the ages. The attributed differential performance in terms of feed efficiency might be due to their genetic makeup as other environmental factors were constant throughout the feeding trial. Mahrous *et al.* (2008) reported also comparable estimates in four genetic groups of feathered, frizzled, naked neck and naked neck-frizzled chickens. Mengesha (2012) reviewed corresponding 8th and 12th week's average FCRs as 7.0 and 4.2 in intensive rearing system, and 3.04 and 5.6 in semi-intensive rearing system in some indigenous chicken in the tropical countries of Africa. A study on different dietary practices at farmers' field for raising RIR layer chickens in deep litter brooding system recorded comparable estimates of live body weight gains and FCRs at different periods of 0-4, 4-6 and 6-8 weeks of age (Das *et al.* 2019). The attributed differences with different reported findings might be due to the strain, line or breed difference, and different facets of management practices as well as rearing system.

It is evident in the Table 1 that the sex of the birds pooled over genotypes demonstrated a significant (P<0.05) role in live weight gains throughout the ages and in FCRs at 8th and 16th weeks of age, the males gained more live weight than the females in agreement with the earlier reports on RIR chickens (Das *et al.* 2014a, 2015a, 2015b, Rahim *et al.* 2019) and its crosses (Das *et al.* 2016a, 2016b). The genotype*sex interaction component of variance (Table 1) elucidates significant variation in the estimates of live weight gains at 8th week of age onwards and for FCR only at 16th week of age. Feed consumption by birds could not be affected by sex at any age as reported earlier (Das *et al*. 2014a, 2015a, 2015b, 2016a, 2016b).

Body conformation traits: The estimated least squares means of body conformation indices, i.e. shank length, keel length and breast angle measured at 4th, 6th, 8th, 12th and 16th weeks of age of different chicken genotypes are presented in Table 2. The present estimates of these chicken body

Table 1. Estimated least squares means (± standard errors) with genetic and non-genetic factors of feed efficiency characteristics in RIR chicken and its crosses

Factor	Obs.	WG4 (g)	FC4 (g)	FCR4	WG6 (g)	FC6 (g)	FCR6	WG8 (g)	FC8 (g)	FCR8	WG12 (g)	FC12 (g)	FCR12	WG16 (g)	FC16 (g)	FCR16
Genotype (G) component of variance	457	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
RIR selected strain	98	165.29^{c} ±3.81	525.29^{b} ±3.31	3.32^{b} ±0.13	126.45^{c} ±4.45	659.85^{d} ±3.85	5.61^{c} ±0.23	167.35^{c} ±6.67	1202.97^{c} ±4.31	7.71^{c} ±0.26	448.86^{b} ±13.61	2107.18^{c} ±5.25	5.08^{b} ±0.41	440.95^{b} ±15.04	2398.51^{c} ±6.09	6.17^{b} ±0.24
RIR control strain	99	148.85^{d} ±3.69	517.89^{b} ±3.21	3.88^{c} ±0.13	91.04^{d} ±4.31	630.02^{c} ±3.73	7.88^{d} ±0.22	124.39^{d} ±6.46	1152.56^{b} ±4.17	10.36^{d} ±0.25	332.14^{d} ±13.18	2041.99^{b} ±5.09	6.77^{c} ±0.40	304.18^{d} ±14.57	1968.71^{b} ±5.90	7.52^{d} ±0.23
RIR white strain	68	153.10^{d} ±4.46	421.58^{a} ±3.87	2.88^{a} ±0.16	133.22^{bc} ±5.20	529.24^{a} ±4.50	4.36^{b} ±0.27	157.33^{c} ±7.80	629.35^{a} ±5.04	4.62^{a} ±0.30	346.97^{cd} ±15.90	1658.24^{a} ±6.14	6.27^{c} ±0.48	382.35^{c} ±17.57	1794.05^{a} ±7.12	5.15^{a} ±0.28
CARI- Sonali	95	176.43^{b} ±3.76	695.19^{c} ±3.26	4.05^{c} ±0.13	140.23^{b} ±4.39	610.54^{b} ±3.80	4.60^{b} ±0.22	203.73^{b} ±6.58	1363.00^{d} ±4.25	7.25^{c} ±0.26	379.74^{c} ±13.42	2045.04^{b} ±5.18	6.04^{c} ±0.40	399.90^{c} ±14.83	2490.29^{d} ±6.01	6.90^{c} ±0.24
CARI-Debendra	97	266.96^{a} ±3.75	742.65^{d} ±3.25	2.89^{a} ±0.13	282.13^{a} ±4.38	967.06^{e} ±3.79	3.74^{a} ±0.22	377.21^{a} ±6.56	1850.68^{e} ±4.24	5.44^{b} ±0.25	916.40^{a} ±13.38	3453.02^{d} ±5.16	4.05^{a} ±0.40	651.29^{a} ±14.79	3394.26^{e} ±5.99	6.10^{b} ±0.24
Sex (S) component of variance	457	*	ns	ns	***	ns	ns	***	ns	***	***	ns	ns	***	ns	***
Male pooled over genotypes	252	186.22^{a} ±2.34	581.57 ±2.03	3.31 ±0.08	161.71^{a} ±2.73	680.68 ±2.37	5.13 ±0.14	221.97^{a} ±4.10	1241.67 ±2.65	6.62^{a} ±0.16	534.48^{a} ±8.36	2262.75 ±3.22	5.38 ±0.25	494.93^{a} ±9.23	2413.24 ±3.74	5.63^{a} ±0.15
Female pooled over genotypes	205	178.03^{b} ±2.59	579.47 ±2.25	3.50 ±0.09	147.52^{b} ±3.02	678.00 ±2.62	5.35 ±0.15	190.04^{b} ±4.53	1237.76 ±2.93	7.53^{b} ±0.18	435.16^{b} ±9.25	2259.43 ±3.57	5.91 ±0.28	376.54^{b} ±10.22	2405.09 ±4.14	7.11^{b} ±0.16
G×S interaction component of variance	457	ns	ns	ns	ns	ns	ns	*	ns	ns	***	ns	ns	***	ns	**
RIR selected strain																
Male	61	170.98 ±4.69	527.20 ±4.07	3.21 ±0.16	134.73 ±5.47	661.73 ±4.74	5.35 ±0.28	185.42^{d} ±8.20	1204.33 ±5.30	6.93 ±0.32	493.34^{c} ±16.72	2109.86 ±6.45	4.70 ±0.50	510.08^{b} ±18.48	2400.12 ±7.49	5.18^{b} ±0.30
Female	37	159.59 ±6.02	523.38 ±5.22	3.43 ±0.21	118.18 ±7.02	657.98 ±6.08	5.88 ±0.36	149.28^{e} ±10.53	1201.61 ±6.80	8.49 ±0.41	404.38^{d} ±21.47	2104.51 ±8.29	5.47 ±0.64	371.81^{ce} ±23.73	2396.90 ±9.62	7.16^{de} ±0.38
RIR control strain																
Male	54	151.76 ±4.98	520.12 ±4.32	3.66 ±0.17	91.28 ±5.81	633.39 ±5.03	7.99 ±0.30	123.90^{gh} ±8.72	1155.24 ±5.63	10.29 ±0.34	344.63^{fhi} ±17.77	2039.61 ±6.86	6.54 ±0.53	300.63^{g} ±19.64	1971.83 ±7.96	7.48^{e} ±.32
Female	45	145.93 ±5.46	515.65 ±4.73	4.10 ±0.19	90.81 ±6.37	626.64 ±5.51	7.78 ±0.33	124.88^{fg} ±9.55	1149.88 ±6.17	10.44 ±0.37	319.64^{gh} ±19.47	2044.37 ±7.51	6.99 ±0.58	307.73^{f} ±21.52	1965.60 ±8.72	7.56^{e} ±0.35
RIR white strain																
Male	37	157.92 ±6.02	421.75 ±5.22	2.82 ±0.21	137.88 ±7.02	529.44 ±6.08	4.23 ±0.36	175.46^{d} ±10.53	631.26 ±6.80	4.04 ±0.41	376.49^{cef} ±21.47	1664.08 ±8.29	6.68 ±0.64	450.54^{d} ±23.73	1808.32 ±9.62	4.28^{a} ±0.38
Female	31	148.29 ±6.57	421.41 ±5.70	2.95 ±0.23	128.56 ±7.67	529.05 ±6.64	4.50 ±0.39	139.19^{efh} ±11.50	627.44 ±7.43	5.20 ±0.45	317.45^{gi} ±23.46	1652.39 ±9.05	5.87 ±0.70	314.16^{efg} ±25.92	1779.79 ±10.51	6.03^{c} ±0.42

Table 1 *(Contd...)*

Table 1. (*Concluded...*)

Factor	Obs.	WG4 (g)	FC4 (g)	FCR4	WG6 (g)	FC6 (g)	FCR6	WG8 (g)	FC8 (g)	FCR8	WG12 (g)	FC12 (g)	FCR12	WG16 (g)	FC16 (g)	FCR16
CARI-Sonali																
Male	45	181.37 ±5.46	693.42 ±4.73	3.95 ±0.19	149.07 ±6.37	609.15 ±5.51	4.38 ±0.33	217.02[c] ±9.55	1362.66 ±6.17	6.90 ±0.37	422.67[de] ±19.47	2043.88 ±7.51	5.43 ±0.58	439.69[d] ±21.52	2488.58 ±8.72	6.42[cd] ±0.35
Female	50	171.49 ±5.18	696.96 ±4.49	4.14 ±0.18	131.39 ±6.04	611.92 ±5.23	4.82 ±0.31	190.44[d] ±9.06	1363.34 ±5.85	7.60 ±0.35	336.82[fg] ±18.47	2046.20 ±7.13	6.65 ±0.55	360.12[e] ±20.41	2492.00 ±8.27	7.38[e] ±0.33
CARI-Debendra																
Male	55	269.08 ±4.94	745.36 ±4.28	2.91 ±0.17	295.60 ±5.76	969.70 ±4.99	3.69 ±0.29	408.03[a] ±8.64	1854.85 ±5.58	4.96 ±0.34	1035.29[a] ±17.61	3456.33 ±6.80	3.53 ±0.52	773.69[a] ±19.46	3397.36 ±7.89	4.78[ab] ±0.31
Female	42	264.83 ±5.65	739.94 ±4.90	2.87 ±0.20	268.65 ±6.59	964.43 ±5.71	3.80 ±0.34	346.39[b] ±9.88	1846.52 ±6.38	5.92 ±0.38	797.50[b] ±20.15	3449.70 ±7.78	4.57 ±0.61	528.88[bc] ±22.27	3391.16 ±9.03	7.42[e] ±0.36

*P<0.05, **P<0.01, ***P<0.001, ns: non-significant; WG, FC and FCR denote live body weight gain in grams, feed consumption in grams and feed conversion ratio at different periods of ages in weeks, respectively; Means within a same variance component factor and same column having at least one common superscript, do not have significant difference (P<0.05).

conformation indices were in consistence with the previous reports on RIR chickens (Das *et al.* 2014a, 2015a, 2015b) and its crosses (Das *et al.* 2016a, 2016b). Kalita and Talukdar (2022) reported the estimates of 6.13±0.29 cm, 5.39±0.28 cm and 63.80±2.50° for the shank length, keel length and breast angle, respectively at 5th week of age in Dahlem red chicken under intensive system of management. The present estimates witnessed the best (P<0.05) body conformation of the CARI-Debendra crossbred followed by the CARI-Sonali crossbred/ RIR-selected, RIR-white and RIR-control strain. The best attributes of body conformation of the CARI-Debendra crossbred might be due to its sire (broiler male line) inheritance. The present findings could indicate that carcass of the CARI-Debendra could produce more percentage of meat yield with more breast meat. The RIR-selected strain performed based on its genetic potentiality. The CARI-Sonali crossbred had its parental RIR and White Leghorn layer inheritance, hence its body conformation was found as good as RIR-selected strain as the results (Table 2) evidenced its better estimates upto 8th week of age than the RIR-selected strain and thereafter, a reverse trend was observed. Significant (P<0.05) variation in their body conformation indices was observed in most of the cases as reflected in the Table 2, same was recorded also for the RIR-white and RIR-control strain, as well. The attributed body conformation difference might be due to their different genetic makeup, and the attributed better conformation of the present RIR-crosses was due to their genetic potentiality that might have received through their parental inheritance. It was also noticed that the CARI-Sonali which was considered the best layer crossbred strain (Das *et al.* 2014b), when goes towards maturity, gets declining trend of body conformation indices as compared to the dual-purpose RIR-selected strain.

The least squares analysis of variance (Table 2) elucidates that sex played a significant (P<0.05) role on body conformation of the birds as it grows, males attaining faster growth in shank, keel and breast than the females throughout the ages. Significant genotype*sex interaction component of variance (Table 2) obtained at 8th weeks of age onwards could indicate that the birds attaining maturity achieve differential growth in body conformation traits as per their genotypic potentiality along with prevailing physiological function of sex, whereas difference at initial stage (as obtained in the shank and keel lengths at 4th week of age) might be due to their only genotypic potentiality. A significant sex-differentiation was reported earlier in RIR chickens (Das *et al*. 2014b, 2015a, 2015b), CARI-Sonali (Das *et al*. 2016a) and CARI-Debendra crossbred chicken (Das *et al*. 2016b). The higher estimates of shank and keel lengths, and breast angle at 8th week of age in male birds were also reported in the CARI-Devendra chicken (Singh and Jilani 2005). El-Safty (2012) reported that males had significantly greater values for keel and shank lengths of Libyan native chickens at different ages when compared with female counterparts. Lariviere *et al.* (2009) also reported that keel angle and keel length were all greater in

Table 2. Estimated least squares means (± standard errors) with genetic and non-genetic factors of body conformation traits in RIR chicken and its crosses

Factor	Obs.	4th week			6th week			8th week			12th week			16th week		
		SL (cm)	KL (cm)	BA (°)	SL (cm)	KL (cm)	BA (°)	SL (cm)	KL (cm)	BA(°)	SL (cm)	KL (cm)	BA (°)	SL (cm)	KL (cm)	BA (°)
Genotype (G) component of variance		***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
RIR selected strain	81	4.43^{c} ± 0.05 (51)	4.61^{c} ± 0.05 (51)	39.11^{c} ± 0.29 (51)	5.78^{c} ± 0.04	5.88^{c} ± 0.05	44.85^{b} ± 0.31	6.89^{c} ± 0.06	7.37^{b} ± 0.06	50.52^{b} ± 0.35	8.79^{b} ± 0.07	9.00^{b} ± 0.07	57.40^{b} ± 0.38	10.02^{b} ± 0.08	10.51^{b} ± 0.08	61.33^{b} ± 0.39
RIR control strain	93	4.18^{d} ± 0.05 (53)	4.51^{cd} ± 0.05 (53)	35.55^{e} ± 0.28 (53)	5.51^{d} ± 0.04	5.61^{d} ± 0.05	39.23^{d} ± 0.29	6.34^{e} ± 0.05	6.49^{d} ± 0.05	46.90^{d} ± 0.33	7.85^{d} ± 0.06	7.90^{d} ± 0.06	50.25^{e} ± 0.35	9.17^{d} ± 0.08	9.19^{d} ± 0.08	52.05^{e} ± 0.38
RIR white strain	68	4.23^{d} ± 0.05 (44)	4.48^{d} ± 0.05 (44)	36.43^{d} ± 0.31 (44)	5.75^{c} ± 0.05	5.84^{c} ± 0.05	41.40^{c} ± 0.34	6.64^{d} ± 0.06	7.00^{c} ± 0.06	49.65^{c} ± 0.39	8.39^{c} ± 0.07	8.50^{c} ± 0.07	52.75^{d} ± 0.41	9.70^{c} ± 0.09	9.85^{c} ± 0.09	55.76^{d} ± 0.42
CARI-Sonali cross	81	4.55^{b} ± 0.05 (45)	4.86^{b} ± 0.05 (45)	40.14^{b} ± 0.31 (45)	6.16^{b} ± 0.04	6.35^{b} ± 0.05	45.10^{b} ± 0.31	7.18^{b} ± 0.06	7.48^{b} ± 0.06	51.12^{b} ± 0.35	8.72^{b} ± 0.07	8.85^{b} ± 0.07	56.53^{c} ± 0.37	10.04^{b} ± 0.08	10.50^{b} ± 0.08	59.63^{c} ± 0.38
CARI-Debendra cross	89	5.30^{a} ± 0.05 (47)	5.67^{a} ± 0.05 (47)	47.46^{a} ± 0.30 (47)	6.90^{a} ± 0.04	7.32^{a} ± 0.05	50.76^{a} ± 0.30	8.21^{a} ± 0.05	8.86^{a} ± 0.06	58.31^{a} ± 0.34	10.78^{a} ± 0.06	11.46^{a} ± 0.07	67.19^{a} ± 0.36	11.36^{a} ± 0.08	12.70^{a} ± 0.08	71.82^{a} ± 0.36
Sex (S) component of variance		ns	*	**	***	***	***	***	***	***	***	***	***	***	***	***
Male	220	4.58 ± 0.03 (129)	4.88^{a} ± 0.03(129)	40.16^{a} ± 0.18(129)	6.11^{a} ± 0.03	6.29^{a} ± 0.03	44.76^{a} ± 0.19	7.20^{a} ± 0.03	7.57^{a} ± 0.04	52.07^{a} ± 0.22	9.24^{a} ± 0.04	9.38^{a} ± 0.04	58.19^{a} ± 0.23	10.67^{a} ± 0.05	10.90^{a} ± 0.05	61.91^{a} ± 0.23
Female	192	4.50 ± 0.03 (111)	4.77^{b} ± 0.03(111)	39.31^{b} ± 0.20(111)	5.93^{b} ± 0.03	6.11^{b} ± 0.03	43.78^{b} ± 0.20	6.91^{b} ± 0.04	7.29^{b} ± 0.04	50.53^{b} ± 0.23	8.57^{b} ± 0.04	8.90^{b} ± 0.05	55.46^{b} ± 0.24	9.45^{b} ± 0.05	10.20^{b} ± 0.05	58.32^{b} ± 0.25
G×S interaction component of variance		*	*	ns	ns	ns	ns	*	*	*	***	*	***	***	*	***
RIR selected strain																
Male	48	4.55^{cd} ± 0.06 (29)	4.76^{c} ± 0.06 (29)	40.09 ± 0.38 (29)	5.90 ± 0.7	5.98 ± 0.07	45.52 ± 0.52	7.06^{d} ± 0.07	7.54^{c} ± 0.08	51.46^{cd} ± 0.46	9.10^{c} ± 0.09	9.26^{c} ± 0.09	59.14^{c} ± 0.48	10.64^{b} ± 0.10	10.86^{c} ± 0.10	63.40^{c} ± 0.49
Female	33	4.28^{e} ± 0.07 (22)	4.43^{d} ± 0.07 (22)	37.95 ± 0.43 (22)	5.56 ± 0.08	5.69 ± 0.09	43.36 ± 0.60	6.72^{e} ± 0.09	7.18^{d} ± 0.09	49.50^{ef} ± 0.55	8.49^{de} ± 0.11	8.74^{d} ± 0.11	55.67^{d} ± 0.58	9.40^{de} ± 0.13	10.16^{d} ± 0.13	59.27^{e} ± 0.60
RIR control strain																
Male	52	4.21^{e} ± 0.06 (35)	4.54^{d} ± 0.06 (35)	36.06 ± 0.34 (35)	5.62 ± 0.06	5.67 ± 0.07	39.23 ± 0.48	6.38^{f} ± 0.07	6.53^{f} ± 0.07	47.16^{g} ± 0.44	8.04^{f} ± 0.08	8.01^{f} ± 0.09	50.51^{fg} ± 0.46	9.49^{d} ± 0.10	9.40^{e} ± 0.10	52.32^{h} ± 0.47
Female	41	4.17^{e} ± 0.08 (18)	4.49^{d} ± 0.08 (18)	34.97 ± 0.48 (18)	5.32 ± 0.09	5.46 ± 0.09	38.28 ± 0.67	6.32^{f} ± 0.08	6.48^{f} ± 0.08	46.77^{g} ± 0.50	7.66^{g} ± 0.09	7.80^{g} ± 0.10	50.00^{g} ± 0.52	8.86^{f} ± 0.11	8.97^{f} ± 0.11	51.78^{h} ± 0.53
RIR white strain																
Male	37	4.24^{e} ± 0.07 (24)	4.50^{d} ± 0.07 (24)	36.60 ± 0.41 (24)	5.83 ± 0.08	5.97 ± 0.08	42.10 ± 0.58	6.78^{e} ± 0.08	7.15^{d} ± 0.09	50.55^{de} ± 0.52	8.64^{d} ± 0.10	8.72^{d} ± 0.10	53.84^{e} ± 0.55	10.25^{c} ± 0.12	10.19^{d} ± 0.12	57.35^{f} ± 0.56
Female	31	4.23^{e} ± 0.07 (20)	4.48^{d} ± 0.07 (20)	36.30 ± 0.45 (20)	5.77 ± 0.08	5.74 ± 0.09	41.03 ± 0.63	6.49^{f} ± 0.09	6.84^{e} ± 0.09	48.71^{f} ± 0.57	8.15^{f} ± 0.11	8.27^{e} ± 0.11	51.66^{f} ± 0.60	9.16^{e} ± 0.13	9.52^{e} ± 0.13	54.16^{g} ± 0.62
CARI-Sonali cross																
Male	36	4.47^{d} ± 0.07 (21)	4.81^{c} ± 0.07 (21)	40.40 ± 0.44 (21)	6.17 ± 0.08	6.30 ± 0.9	45.05 ± 0.62	7.38^{c} ± 0.08	7.60^{c} ± 0.09	51.99^{c} ± 0.53	9.05^{c} ± 0.10	9.10^{c} ± 0.10	57.94^{c} ± 0.56	10.65^{b} ± 0.12	10.81^{c} ± 0.12	61.43^{d} ± 0.57

Table 2 *(Contd...)*

Table 2. *(Concluded...)*

Factor	Obs.	4th week			6th week			8th week			12th week			16th week		
		SL (cm)	KL (cm)	BA (°)	SL (cm)	KL (cm)	BA (°)	SL (cm)	KL (cm)	BA (°)	SL (cm)	KL (cm)	BA (°)	SL (cm)	KL (cm)	BA (°)
Female	45	4.63^{c} ± 0.07 (24)	4.89^{c} ± 0.07 (24)	39.85 ± 0.41 (24)	6.09 ± 0.08	6.34 ± 0.08	44.40 ± 0.58	6.99^{d} ± 0.08	7.32^{d} ± 0.08	50.28^{e} ± 0.47	8.38^{e} ± 0.09	8.60^{d} ± 0.09	55.12^{d} ± 0.50	9.44^{d} ± 0.12	$10.1\ 9^{d}$ ± 0.12	57.83^{f} ± 0.51
CARI-Debendra cross																
Male	47	5.40^{a} ± 0.07 (20)	5.76^{a} ± 0.07 (20)	47.43 ± 0.45 (20)	7.19 ± 0.08	7.64 ± 0.09	52.23 ± 0.63	8.42^{a} ± 0.07	9.07^{a} ± 0.08	59.28^{a} ± 0.46	11.37^{a} ± 0.09	11.83^{a} ± 0.09	69.52^{a} ± 0.49	12.32^{a} ± 0.11	13.25^{a} ± 0.10	75.06^{a} ± 0.50
Female	42	5.22^{b} ± 0.06 (27)	5.59^{b} ± 0.06 (27)	47.37 ± 0.39 (27)	6.80 ± 0.07	7.23 ± 0.08	50.63 ± 0.54	8.00^{b} ± 0.08	8.63^{b} ± 0.08	57.32^{b} ± 0.49	10.19^{b} ± 0.09	11.10^{b} ± 0.09	64.86^{b} ± 0.52	10.40^{bc} ± 0.11	12.15^{b} ± 0.11	68.57^{b} ± 0.53

SL, shank length in centimeter; KL, keel bone length in centimeter; and BA, breast angle in degree. *, P<0.05; **, P<0.01; ***, P<0.001; ns, non-significant. Figures within parenthesis denote the number of observation. Means within the same variance component factor and same column with at least one common letter, do not have significant difference (P>0.05).

males and significantly different between sexes (P<0.001) at 85 days in Ardennaise chicken. Adebambo *et al.* (2006) observed that body conformation traits, viz. breast girth, shank length and keel length not to be all significantly affected by sex excepting shank length for 12th, 15th and 18th weeks of age in Giriraja, Indian WLH, and Nigerian improved indigenous chicken genotypes (F_1, F_2 and B-α chickens). Thus, the chicken body conformation is not sex-independent. In addition, the body conformation traits were also reported highly correlated with birds' live body weights (Das *et al*. 2014b, 2015a, 2015b, 2016a, 2016b) and could therefore be used to predict either conformation or percentage meat yield of the carcass.

The study could conclude that the CARI-Debendra crossbred chicken performed the best in live weight gains and FCRs as compared to the other genotypes studied. In some periods (at 8th and 16th weeks of age), RIR-white strain demonstrated better (P<0.05) FCRs consuming lesser amount of feed than the CARI-Debendra genotype. CARI-Sonali significantly (P<0.05) followed the CARI-Debendra in attaining live weight gain upto 8th week of age and thereafter, the RIR-selected strain significantly (P<0.05) exhibited better weight gain than the CARI-Sonali. RIR-selected strain demonstrated better (P<0.05) FCRs than the CARI-Sonali throughout the ages excepting 6th and 8th week-estimates. The CARI-Debendra demonstrated the best (P<0.05) FCRs than the other genotypes throughout the ages excepting 8th and 16th week-estimates where the RIR-white strain performed the best (P<0.05), and at 4th week of age, both the chicken genotypes demonstrated statistically (P>0.05) the same FCR. RIR-control strain had the least (P<0.05) weight gains and non-beneficial FCRs throughout the ages. The CARI-Debendra could be the best plump-breasted crossbred variety of chicken among the chicken genotypes studied. The CARI-Sonali was initially better than the RIR-selected strain followed by the RIR-white strain which was better than the RIR-control strain in terms of the body conformation indices. The male birds gained more live weight and body conformation estimates throughout the ages along with better FCRs at 8th and 16th week of age than the females and the traits were not sex-independent. The findings on genotypic variation in body conformation and feed efficacy characteristics of the birds could provide an idea to the farmers for selection of genotypes for rearing as per their preference of the traits.

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