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Evaluation of four different crossbreds developed for backyard poultry farming under intensive system

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ABSTRACT

In the present study, 4 new crosses, viz. PD1× PD4 (A), PD1 × PB2 (B), PD1x PD3 (C) and PD1 × IWI (D) were developed and evaluated under intensive system of rearing. Body weights, conformation traits were evaluated during starter and growing period and production performance were measured up to 72 weeks of age. Body weights at day 0, 2, 4, 6, 7 and 8 weeks of age in the starter period and at 10, 12, 14, 16, 18 and 20 weeks of age during growing period differed significantly between crosses in both male and female. Irrespective of age, cross B recorded higher body weight compared to other crosses. Shank length and keel length measured at 6, 8, 18 and 20 weeks of age in both the sexes differed significantly between the crosses. The maximum shank and keel lengths were achieved by 20 weeks of age. Feed conversion ratio (FCR) from 0–8 weeks of age was the best in B followed by A, C and D. The age at sexual maturity (ASM), weight at sexual maturity, body weight and shank length at 40 weeks of age, egg production up to 72 weeks of age differed significantly between different crosses. Egg weights measured at different weeks of age also differed significantly between the crosses. The egg production up to 72 weeks of age was the highest in C followed by D, A and B. Mortality % was lowest in D at different period. The results indicated that B may be useful for coloured meat type birds in rural areas whereas C and D cross may be useful for egg type as well as dual purpose backyard poultry. Cross A may be useful for dual type backyard poultry.

Key words: Body weight, Conformation traits, Crossbred, Egg production

Backyard poultry farming is popular in many countries in rural and tribal areas where the basic infrastructure for industrial poultry farming is difficult to practice. Generally, rural farmers rear indigenous/ *desi* birds under backyard farming. The production and growth potential of these birds are low but backyard farmers preferred these due to their adaptability to adverse environment, better survivability during lean period along with limited care, husbandry and housing facility requirements. So the requirement by the farmer is to rear a bird having desirable plumage colour with high performance compared to local indigenous birds with very little change in husbandry practices that is followed for the indigenous fowl. Improvement in genetic makeup can be achieved either by pure line selection or by crossbreeding to improve the desirable traits by exploiting heterosis or by a combination of both strategies. In addition to indigenous fowl, crossbreds were produced using exotic, and indigenous breeds are being utilized for backyard which poultry farming (Khan 2008, Padhi *et al.* 2012a, Padhi *et al*. 2014a). Different pure lines are being developed through selection and are being crossed to develop crossbreds for backyard poultry farming (Ayyagari 2008, Padhi *et al*. 2012a, Kundu *et al*. 2015). While developing different crosses for backyard poultry, the desirable features to be considered are colour plumage, meat/ egg dual purpose type, active, good stress tolerance, low input requirement, resistance to diseases and above all higher shank length. Though many crosses are being developed for backyard poultry farming, there is always scope to develop more crosses for the farmers to offer them wider choice. Further, before allowing the new crosses in the field their evaluation in the farm is important. Keeping this in view, four different crosses were developed using a single male parent and four female lines. The performances of male parent used for different traits are reported in literature (Padhi *et al.* 2012a, b; Padhi and Chatterjee 2012, Padhi *et al*. 2013). The four crosses were evaluated for different traits under intensive system of rearing.

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MATERIALS AND METHODS

Location of study: The experiment was conducted at Directorate of Poultry Research, Hyderabad, Telangana, India. It is located in Deccan plateau in the southern part of India, position between 17°23′ N and 78° 28′ E at a height of 500 m from sea level. The state experiences tropical climate with temperature ranging from 20°C in winter to 45°C in summer season. This experiment was approved by institute's animal ethics committee.

Experimental population: Vanaraja male line (PD1) was used as a male line for the production of 4 different crosses. PD1 is being developed from a low performing colour Cornish population (Ayyagari 2008). It was selected for higher shank length at 6 weeks of age since last 6 generations. The four lines used as female parents were PD3, PD4, PB2 and IWI. PD3 having red colour plumage and developed from Dahlem Red population and being selected for higher egg mass up to 40 weeks of age since last 2 generations. PD4 is an indigenous breed being developed from Aseel population (an indigenous breed of India) and selected for high body weight at 16 weeks of age since last two generations. PB2 is a multi coloured meat type synthetic population being improved for high juvenile body weight and egg production since last 20 generations. IWI is a white leghorn population being developed by selection for higher 64 weeks egg production since last 2 generations. Four crossbreds produced were PD1 × PD4 (A), PD1 × PB2 (B), PD1 × PD3 (C) and PD1 × IWI (D). In four different crosses, 625 chicks were produced in a single hatch. A and C cross have all red colour plumage birds whereas B have multicolor plumage and the D has dull white plumage with few red colour spots near neck region and wings.

Rearing and management practices: The chicks were wing banded and brooded on a deep litter system, with a decreasing temperature schedule from 33°C during first week to 23°C at the end of fifth week in an open-sided house with curtains hanging from outside during brooding period. The curtains were removed after 6 weeks of age. Floor space was given as per the standard requirements for medium meat type birds. All the chicks were reared under intensive system to study their performance. Chicks were provided *ad lib.* broiler starter ration (2,800 kcal/ kg of ME and 20% CP on calculated basis) up to 8 weeks of age. From 8 weeks onwards grower ration (2,600 kcal/ kg of ME and 16% CP on calculated basis) were provided up to 18 weeks of age. Due to lack of rearing space and for other purpose, 186 birds were removed at different weeks of growing period. A total of 242 females (A-62, B-64, C–48, D-68) were shifted to individual cages at 18 weeks of age and kept there up to 72 weeks of age. Male and extra females of D were kept in the floor up to 20 weeks of age. In A, C and D the grower ration were provided *ad lib.* as in all these crosses, one parent was either egg type or indigenous breed. However, in B quantitative feed restriction was practiced as in this cross both the parent used was meat type bird and the growth was more. This was done with aim to get the optimum weight of female for better egg production. The female of all the 4 crosses were provided with layer ration with CP 18% and ME 2,700 kcal/kg from 18 weeks on wards. Males were given grower ration (CP 16% and ME 2,600 kcal/kg on calculated basis) up to 20 weeks of age. A, C, D genetic groups fed layer ration *ad lib.* during laying period and B cross were provided 120 g feed/ bird/ day. The feed ingredients used in the ration formulations were corn (*Zea mays*), soybean meal, sunflower cake, deoiled rice bran, vitamin premix, salt, DL-methionine, lysine, trace minerals, shell grit and dicalcium phosphate. The layer ration was supplemented with extra shell grit so that the calcium content made up 3.5% of the ration. The chicks were vaccinated against Marek's disease, Newcastle disease, infectious bursal disease and fowl pox.

Traits measured: Body weight were measured at 0 day, 2, 4, 6, 7 and 8 weeks of age during starter period and at 10, 12, 14, 16,18 and 20 weeks of age during growing period in both the sexes. Shank and keel lengths were measured at 6, 8, 18 and 20 weeks of age in both the sexes. Feed consumption in each genetic group was recorded up to 8 weeks of age and the feed conversion ratios (FCR) were calculated from 0–7 and 0–8 weeks of age group wise. Mortality if any was recorded daily and mortality % in each genetic group was calculated from 0–8, 8–20 and 20–72 weeks of age. Egg production was recorded daily from start of lay of each bird up to 72 weeks of age. The bird survived up to 72 weeks of age were taken into consideration for calculation of egg production and other traits like age at sexual maturity, weight at sexual maturity, and body weight and shank length at 40 weeks of age. First egg weight and egg weight at 4 weeks interval starting from 28 weeks up to 72 weeks of age were recorded in all the 4 genetic groups.

Statistical analysis: Means and standard error of various traits were calculated using standard statistical methods (Snedecor and Cochran 1989). Data were subjected to analysis of variance (ANOVA). Single factor ANOVA model was used to assess the effect of genotype on different traits. When significant difference was observed, means were compared with Duncan's multiple range test. All statements of statistical difference were based on $P \leq 0.05$.

RESULTS AND DISCUSSION

Body weights: During starter period, there was significant difference ($P \leq 0.05$) between genetic groups for the body weights measured at 0, 2, 4, 6, 7 and 8 weeks of age in males. The weekly average highest weights differed amongst the four crosses with B being the heaviest until 8 weeks of age. The gain in body weight was highest from 4 to 6 weeks of age in all the four crosses during starter period. During growing period body weights amongst male were significant ($P \leq 0.05$) between different genetic groups irrespective the age of the birds. At 10 weeks of age, heaviest body weights was in B followed by A, C and D (Table 1). The highest gain between 2 weeks interval during growing period in male of A, B, C and D were from 12 to 14 week, 10 to 12 week, 10 to 12 week and 12 to 14 weeks, respectively. Body weights of female during starter, growing and laying period are presented in Table 2. Body weights of female differ significantly ($P \leq 0.05$) irrespective the age of measurement. The maximum gain of weight during growing period was observed during 12 to 16 week (264 g) in A, 10 to12 week (291 g) in B, 14 to 16 week (229 g) in C

Table 1. Body weight (mean±SE) of different crossbreds in male

Traits	A	B	C	D
No. of obs.	51	72	49	119
Starter				
BW0 (g)	32.45±0.35^{d}	43.07±0.42^{a}	36.91±0.55^{b}	34.61±0.26^{c}
BW2 (g)	92.75±2.51^{c}	188.09±2.98^{a}	100.63±2.68^{b}	107.11±1.61^{b}
BW4 (g)	221.76±7.68^{b}	461.44±8.41^{a}	197.10±7.21^{c}	216.49±4.45^{b}
BW6 (g)	443.22±14.33^{b}	999.21±16.04^{a}	426.92±13.24^{b}	441.55±10.73^{b}
BW7 (g)	622.02±17.90^{b}	1334.94±16.58^{a}	600.96±17.77^{b}	589.15±10.46^{b}
BW8 (g)	796.94±21.35^{b}	1625.25±17.79^{a}	780.00±18.21^{b}	749.89±11.54^{b}
Growing period				
BW10 (g)	1115±22.42^{b} (51)	2003±20.41^{a} (72)	1111±23.03^{b} (49)	965±14.49^{c} (118)
BW12 (g)	1410±24.45^{b} (42)	2390±35.31^{a} (38)	1420±28.68^{b} (39)	1258±26.11^{c} (46)
BW14 (g)	1770±30.17^{b} (42)	2518±32.62^{a} (38)	1671±39.93^{c} (39)	1613±31.00^{c} (46)
BW16 (g)	2055±33.44^{b} (42)	2671±41.77^{a} (30)	1957±33.86^{c} (36)	1866±33.03^{c} (43)
BW18 (g)	2255±37.72^{b} (42)	2815±44.64^{a} (28)	2178±42.31^{bc} (34)	2076±37.76^{c} (42)
BW20 (g)	2534±44.17^{b} (36)	3093±65.61^{a} (20)	2404±57.20^{bc} (22)	2323±46.81^{c} (34)

No. of obs., number of observations; PD1 × PD4, A; PD1 × PB2; B, PD1 × PD3; C and PD1 × IWI, D. Second row indicates number of observations up to 8 weeks of age in different crosses; BW, body weights, the number in first column following BW indicates age of measurement in weeks. Value in parenthesis indicates number of observation, average even with one common superscript in a row did not differ significantly (P≤0.05).

and 12 to14 week (228 g) in D. Weight at sexual maturity, body weights at 40 and 72 weeks of age differed significantly (P≤0.05) between the crosses (Table 2).

The results on juvenile body weights in both the sexes revealed that B having both the parents from meat type stocks, as expected recorded heaviest body weight. In A, C and D where female parents are of low body weights, the weight is low. The gain in body weight at different period in male and female suggest exploiting further for their use as growing purpose and subsequent use of male for meat purpose. From the body weight it was revealed that B may be used as a meat type colour population where there is market for coloured bird which command a premium price. Thus, this bird may be used for sale at 8 to 10 weeks of age for meat purpose. In the other 3 crosses, the male may be sold at 18 weeks of age as the body weight was above 2.0 kg. However, the performance of the bird has to be evaluated in backyard for any final conclusion.

Table 2. Body weight (mean±SE) of different crosses in female at different ages

Traits	A	B	C	D
No. of obs.	62	75	59	125
Starter				
BW0 (g)	32.67±0.34^{d}	43.48±0.49^{a}	36.43±0.50^{b}	34.50±0.29^{c}
BW2 (g)	97.98±2.22^{c}	178.97±2.77^{a}	100.41±2.07^{bc}	103.87±1.29^{b}
BW4 (g)	204.81±5.88^{b}	415.40±7.91^{a}	177.63±6.45^{c}	199.88±3.86^{b}
BW6 (g)	416.56±11.85^{b}	874.93±7.91^{a}	356.20±12.70^{c}	388.78±7.61^{bc}
BW7 (g)	554.6813.36^{b}	1133.43±17.33^{a}	489.61±15.88^{c}	504.92±9.41^{c}
BW8 (g)	721.73±15.20^{b}	1377.59±21.92^{a}	629.64±17.18^{c}	634.54±9.97^{c}
Growing period				
BW10 (g)	96816.9^{b} (62)	1711±22.88^{a} (75)	883±18.04^{c} (56)	796±10.76^{d} (124)
BW12 (g)	1208±17.61^{b} (62)	2002±25.00^{a} (74)	1090±22.18^{c} (55)	1023±11.34^{d} (119)
BW14 (g)	1472±21.16^{b} (62)	2123±22.45^{a} (74)	1286±24.81^{c} (54)	1306±12.67^{c} (119)
BW16 (g)	1610±18.16^{b} (62)	2244±21.75^{a} (71)	1515±19.58^{c} (50)	1486±14.71^{c} (119)
BW18 (g)	1767±16.23^{b} (62)	2389±25.27^{a} (64)	1647±26.07^{c} (48)	1625±17.67^{c} (116)
BW20 (g)	1946±19.87^{b} (62)	2581±28.15^{a} (64)	1781±24.11^{c} (48)	1773±19.16^{c} (104)
Laying period				
WASM (g)	2078±16^{b} (59)	2785±54^{a} (57)	2111±28^{b} (45)	1969±23^{c} (67)
BW 40 (g)	2227±25^{b} (59)	2844±40^{a} (57)	2237±23^{b} (45)	2071±25^{c} (67)
BW72 (g)	2410±41^{b} (59)	3194±71^{a} (57)	2561±60^{b} (45)	250444^{b} (67)

No. of obs., number of observations; PD1 × PD4, A; PD1 × PB2; B, PD1 × PD3; C and PD1 × IWI, D. Second row indicates number of observations up to 8 weeks of age in different crosses; BW, body weights, the number in first column followed BW indicates age of measurement in weeks. Value in parenthesis indicates number of observation, average even with one common superscript in a row did not differ significantly (P≤0.05).

Effect of egg weight on hatching weight of chicks was reported by Tona *et al.* (2004). Differences of crosses in respect to body weight are reported in literature which is in agreement with the present findings (Adeleke *et al.* 2011, Rajkumar *et al.* 2011, Kundu *et al*. 2015). The body weight observed in B was better than the report in Vanaraja, a backyard variety by Haunshi *et al.* (2009) and Kalita *et al.* (2012). A, C and D body weights observed in the present study was better than Gramapriya, a backyard variety as reported by Haunshi *et al.* (2009) and A cross in the field by Padhi *et al*. (2014a). The 20 weeks body weight obtained in the present study in A is comparable to the body weights of C1 cross, C and D 20 week body weight were better than Gramapriya as reported by Niranjan *et al*. (2008). Significant difference between different pure and crosses for WASM was reported by Padhi *et al.* (2001) in indigenous and meat type socks, which agree with the present findings. However, it is to be mentioned here that the parent used for development of these crosses are different and there was no reports on same germplasm being used in literature. The literatures used to compare the results are only for indicating the trends. A showed lowest body weight at 72 weeks, this may be due to low body weight of PD4 which was used as female parent in this cross.

Conformation traits: Shank and keel lengths measured at 6, 8, 18 and 20 weeks of age in both the sexes and 40 weeks shank length of female are presented in Table 3. Significant difference ($P \leq 0.05$) between different genetic groups were observed for both shank and keel length irrespective the age of measurement and sex. At 6 weeks of age in male, shank length of B was highest followed by D, A and C. In female, shank length was highest in B followed by A, D and C irrespective the age of measurement. Significant ($P \leq 0.05$) shank length between different crosses indicates the variation and use of parents affecting the crossbred's shank length at different weeks of age. As expected in B, shank length was highest indicating the effect of both the meat type parent. The increase in shank length was less during 18 to 20 weeks of age in all the four crosses irrespective of sex. Shank length recorded at 40 weeks of age showed significant ($P \leq 0.05$) difference between different crosses. Highest shank length was obtained in B followed by A, D and C. There was a decrease in shank length at 40 weeks of age compared to 20 weeks of age which may be due to at higher age more calcium might be utilized for the egg production thus reducing the shank length. Significant shank length between different genetic groups at different ages irrespective of sexes was available in literature (Padhi *et al.* 2012a, Kundu *et al*. 2015). Padhi and Chatterjee (2012) reported only 0.09 mm increase in shank length from 20 to 40 weeks of age in PD1 pure lines.

Keel length measured at 6 weeks of age in male showed highest value in B followed by D, A and C, However, at 18 and 20 weeks of age the trend from highest to lowest in respect to keel length was B, A, C and D. The gain in keel length from 18 to 20 weeks of age in all the genetic groups was very less in both male and female. Highest keel length in B may be due to effect of both meat type parents. The keel length of A was better during growing stage compared to C and D. The keel length observed in the present study at 8 and 20 weeks of age are higher to the keel length reported in 6 crosses by Adeleke *et al.* (2011). The gains in

Table 3. Conformation traits (mean±SE) in male and female of different genetic groups at different ages

Traits	PD1 × PD4 (A)	PD1 × PB2 (B)	PD1 × PD3 (C)	PD1 × IWI (D)
Male shank length				
SL6 (mm)	66.68 ± 1.06^{bc} (51)	85.84 ± 0.62^{a} (72)	65.95 ± 0.98^{c} (49)	67.04 ± 0.52^{b} (119)
SL 8 (mm)	86.22 ± 1.01^{b} (51)	105.37 ± 0.58^{a} (72)	84.72 ± 1.08^{b} (49)	84.21 ± 0.63^{b} (119)
SL18 (mm)	129.44 ± 1.17^{b} (38)	133.96 ± 1.01^{a} (28)	124.23 ± 1.13^{c} (34)	119.85 ± 1.60^{d} (42)
SL20 (mm)	131.63 ± 1.23^{b} (38)	135.64 ± 1.09^{a} (20)	125.69 ± 1.18^{c} (22)	123.17 ± 1.44^{c} (34)
Female shank length				
SL6 (mm)	63.83 ± 0.83^{b} (62)	80.81 ± 0.68^{a} (75)	59.01 ± 1.11^{c} (59)	63.40 ± 0.53^{b} (125)
SL 8 (mm)	81.89 ± 0.87^{b} (62)	96.52 ± 0.75^{a} (75)	75.28 ± 0.96^{d} (59)	78.29 ± 0.58^{c} (125)
SL18 (mm)	107.23 ± 0.59^{b} (62)	111.68 ± 0.72^{a} (64)	103.87 ± 0.50^{c} (48)	105.15 ± 0.76^{c} (116)
SL20 (mm)	107.32 ± 0.48^{b} (62)	112.78 ± 0.95^{a} (64)	102.55 ± 0.65^{d} (48)	105.18 ± 0.63^{c} (104)
SL40 (mm)	105.89 ± 0.42^{b} (59)	111.40 ± 0.53^{a} (57)	102.69 ± 0.62^{c} (45)	102.99 ± 0.53^{c} (67)
Male keel length				
KL6 (mm)	75.14 ± 1.18^{c} (51)	103.45 ± 0.86^{a} (72)	74.38 ± 1.07^{c} (49)	77.06 ± 0.72^{b} (119)
KL 8 (mm)	93.21 ± 1.13^{b} (51)	124.89 ± 0.83^{a} (72)	95.91 ± 0.98^{b} (49)	95.53 ± 0.71^{b} (119)
KL18 (mm)	151.89 ± 1.41^{b} (42)	168.68 ± 1.46^{a} (28)	145.78 ± 1.14^{c} (34)	145.56 ± 1.43^{c} (42)
KL20 (mm)	151.91 ± 1.08^{b} (36)	168.86 ± 2.28^{a} (20)	145.83 ± 1.45^{c} (22)	145.58 ± 1.49^{c} (49)
Female keel length				
KL6 (mm)	72.31 ± 1.01^{bc} (62)	97.20 ± 0.98^{a} (75)	70.25 ± 1.28^{c} (59)	73.24 ± 0.74^{b}(125)
KL 8 (mm)	89.84 ± 0.99^{b} (62)	118.15 ± 1.37^{a} (75)	88.80 ± 1.16^{b} (59)	89.98 ± 0.75^{b} (125)
KL18 (mm)	139.97 ± 0.93^{b} (62)	153.69 ± 11.13^{a} (64)	138.51 ± 0.82^{b} (48)	135.12 ± 0.81^{c} (116)
KL20 (mm)	139.99 ± 0.94^{c} (62)	153.70 ± 0.97^{a} (64)	138.55 ± 1.52^{c} (48)	135.14 ± 0.93^{b} (104)

SL, shank length; KL, keel length, the number followed after SL and KL indicates the age of measurements. Value in parenthesis indicates number of observation, average even with one common superscript in a row did not differ significantly ($P \leq 0.05$).

keel length in all the genetic groups slow down after 18 weeks of age which is in agreement with finding by Adeleke *et al.* (2011).

Feed conversion ratio (FCR) and mortality: The FCR measured from 0–7 and 0–8 weeks of age in A, B, C and D genetic groups were 2.78, 2.18, 2.93, 3.01 and 2.79, 2.29, 2.95, 3.06 respectively. The FCR revealed that B may be used for meat purpose and the FCR was better from 0–7 week than 0–8 weeks. All the crosses of the present study were recorded better FCR than the Gramapriya which is a layer type backyard variety as reported by Haunshi *et al.* (2009). Poor FCR for higher age was reported by Rama Rao *et al.* (2010) in Vanaraja. Mortality in A, B, C and D from 0–8 and 8–20 weeks of age were 2.56, 4.57, 10.74, 1.61% and 8.55, 2.61, 8.26, 3.23%, respectively. The mortality % in female from 20–72 weeks of age in female were 4.83, 12.50, 6.25 and 1.47%, in A, B, C and D, respectively. The mortality results indicated that B may be used for meat type birds than commercial backyard poultry for eggs. In C, the mortality is a problem in all the period. In A, mortality was in control except during growing period indicating the better adaptability of the birds. In all the 3 periods the mortality was low in D indicating the usefulness of this cross for egg production. The mortality in D obtained in the present study was better than the report of Kalita *et al.* (2012) in Vanaraja. Higher mortality in A was reported under field condition during laying period as reported by Padhi *et al.* (2014a).

Production performance: The averages of different production performance are presented in Table 4. The age at sexual maturity (ASM) was lowest in D followed by A, C and B. Significant ($P \leq 0.05$) difference between different crosses for ASM was observed. Lower ASM in D may be due to presence of White Leghorn as female parent. B being developed from meat type parents the ASM is highest. Significant ($P \leq 0.05$) difference between crosses for ASM is in agreement with the report of Niranjan *et al.* (2008) and Haunshi *et al.* (2009). Egg production upto 40 and 72 weeks of age showed significant ($P \leq 0.05$) difference between crosses. Significant difference in respect to egg production between different crosses is in agreement with the reports of Niranjan *et al.* (2008) and Haunshi *et al.* (2009). The lowest egg production in B rejects this cross to be used as dual type birds and only suitable for meat type birds. The A cross moderate egg production and better body weight compared to C and D during growing period and appearance like indigenous birds may be of use as a dual purpose birds in backyard system.

Table 4. Production performance (Mean±SE) of different crosses under intensive system

Traits	PD1×PD4 (A)	PD1×PB2 (B)	PD1×PD3 (C)	PD1×IWI (D)
No. of females	59	57	45	67
ASM (day)	157 ± 2.00^{a}	160 ± 1.79^{a}	158 ± 1.10^{a}	149 ± 0.64^{b}
Egg production up to 40 week (no.)	$70.50 \pm .44^{b}$	55.29 ± 2.18^{c}	88.78 ± 2.17^{a}	92.43 ± 1.45^{a}
Egg production up to 72 week (no.)	161.98 ± 4.36^{b}	113.49 ± 4.14^{c}	219.12 ± 5.27^{a}	212.58 ± 3.24^{a}

ASM, age at sexual maturity; means having different superscript differ significantly ($P \leq 0.05$).

Egg weight: Average egg weights for first egg and at four weeks interval from 28 to 72 weeks of age are presented in Table 5. The egg weights differed significantly ($P \leq 0.05$) between different crosses at all the ages of measurements except at1st egg and at 32, 36 and 48 weeks of age. At 36 weeks of age in all the crosses the egg weight was more than 53 g. The trend of egg weight between different crosses changes at different weeks of age and at 40 weeks highest egg weight was in B followed by A, D and C. Egg weight at 72 weeks of age was highest in B followed by D, A and C. As the age advances the egg weight increases in all the 4 crosses except at few ages egg weight was higher at early age in compare to later age. Niranjan *et al.* (2008) reported significant difference in respect to egg weight in different crosses. As the ages increases the egg weight increases, this was in agreement with the reports of Padhi *et al.* (2013) and Padhi *et al.* (2014b). However, in some genetic groups there was a decrease in egg weight at higher age compared to lower age, this may be due to better egg production during that period. Egg weight of B was highest may be due to higher body weight of the birds.

For backyard poultry farming there is always scope to develop more crosses for the farmers to offer them wider choice. Keeping this in view, 4 different crosses were developed using a single male parent and four female lines. The performance of PD1 × PD4 (A), PD1 × PB2 (B), PD1

Table 5. Egg weight (mean±SE) at 4 weeks interval in different crosses

Traits	PD1×PD4 (A)	PD1×PB2 (B)	PD1×PD3 (C)	PD1×IWI (D)
EW1	40.61 ± 0.82	42.00 ± 0.97	41.23 ± 0.81	39.64 ± 0.70
EW28	46.97 ± 0.42^{c}	51.01 ± 0.61^{a}	49.37 ± 0.57^{b}	48.58 ± 0.57^{bc}
EW32	50.60 ± 1.01	51.77 ± 0.85	49.88 ± 0.57	50.06 ± 0.45
EW36	53.11 ± 0.55	53.71 ± 0.65	53.91 ± 0.65	53.14 ± 0.51
EW40	54.52 ± 0.59^{b}	56.81 ± 0.60^{a}	53.82 ± 0.55^{b}	54.68 ± 0.59^{b}
EW44	55.21 ± 0.21^{b}	56.98 ± 0.20^{a}	53.28 ± 0.51^{c}	54.31 ± 0.35^{b}
EW48	59.74 ± 0.33	59.74 ± 0.45	60.37 ± 0.57	58.89 ± 0.81
EW52	56.38 ± 0.73^{b}	59.31 ± 0.51^{a}	57.70 ± 0.60^{ab}	58.79 ± 0.59^{a}
EW56	58.09 ± 0.74^{c}	59.95 ± 0.90^{ab}	59.30 ± 0.48^{bc}	61.10 ± 0.58^{a}
EW60	56.93 ± 0.91^{c}	61.03 ± 0.87^{a}	58.59 ± 0.71^{bc}	$60.20 \pm .072^{ab}$
EW64	58.43 ± 0.90^{b}	63.04 ± 0.62^{a}	59.22 ± 0.52^{b}	61.90 ± 0.66^{a}
EW68	57.61 ± 0.83^{c}	62.10 ± 0.90^{a}	59.29 ± 0.68^{bc}	$59.79 \pm .057^{b}$
EW72	59.10 ± 0.73^{b}	63.27 ± 0.85^{a}	58.92 ± 0.51^{b}	60.72 ± 0.70^{b}

EW1, first egg weight of birds; EW, egg weight, the number followed by EW in first column indicates the age of egg weight. Average even with one common superscript in a row did not differ significantly ($P \leq 0.05$).

× PD3 (C) and PD1 × IWI (D) revealed significant difference in respect to most of the traits starting form body weight and shank length during starter, grower and laying period. The overall performance based on various traits, viz. growth, conformation, FCR, mortality, egg production, egg weight and the plumage colour of the crosses, indicates that in hot and humid tropics areas where there is a market for colour broiler, cross B will be suitable colour meat type birds and can fetch premium price. A, C and D cross may be of great use for backyard poultry farming due to their egg production and better growth rate. The male of all three crosses may be sacrificed at 18 weeks of age for meat purpose. The female of C and D produce well under intensive system which may produce well in backyard system but the colour of C being red it may be more preferred compare to D. Where there is no preference of colour pattern of the backyard birds D may be useful. A having both exotic and native blood with red plumage colour and indigenous look may be of use for backyard poultry as a dual purpose birds. The higher shank length of this cross compared to C and D may help them escape from predators. Further, before releasing these crosses the field evaluation must be made.

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