



Performance evaluation and crossbreeding effects for body weight and conformation traits in different breeds of ducks

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ABSTRACT

A 3×3 full diallel experiment was carried out using 3 breeds of ducks, viz. Indigenous duck (D), Khaki Campbell (C) and White Pekin (P), to evaluate the juvenile body weights and conformation traits and to estimate different crossbreeding genetic parameters in 609 ducklings from nine genetic groups. Significant differences between different genetic groups were observed for all the traits measured. Direct genetic effects, maternal effects and heterosis were significant for all the traits studied. Heterosis was in desirable direction for all the traits. Overall results revealed that crossbreds performed significantly higher than the purebreds. C × P recorded highest body weight amongst the crossbreds at 8 weeks of age. Heterosis (%) estimates for 8 week body weight, shank length and keel length were positive. Since both additive and non-additive genetic effects are important for the juvenile traits, establishment of pure lines with specialized sire and dam lines followed by crossing is ideal for the production of different crosses for the commercial duck farming.

Key words: Body weight, Conformation traits, Crossbreeding, Diallel cross, Duck, Heterosis

Poultry species have contributed immensely as a source of animal protein after pork (FAO 2009). Duck occupies second position for the production of poultry meat after chicken in India. Crossbreeding is an important tool in ducks to exploit heterosis. Diallel cross is used for testing the population for different crossbreeding genetic parameters. It helps identify the best crossbred for a particular trait for exploiting heterosis. Crossbreeding experiments using local ducks from India were found in literature with respect to different traits (Nageswar *et al.* 2005, Padhi *et al.* 2009a,b,c, Padhi 2010, Padhi and Sahoo 2011). Wolf and Knizetova (1994) reported crossbreeding parameters in Pekin ducks. Maruyama *et al.* (1999) studied growth pattern and carcass development in male Pekin ducks selected for growth rate and observed that growth potential increased by selection. Growth performance of Pekin duck was also reported by Knizetova *et al.* (1991), Knizetova *et al.* (1994), Maruyama *et al.* (2001) and Schinckel *et al.* (2005) and different growth parameters were studied. However, diallel cross using different breeds of ducks are limited in literature. So the present study was undertaken to evaluate different crossbreeding genetic parameters using three breeds of ducks with respect to juvenile traits and to decide the selection methods to be used for the purebreds and to identify the best cross for commercial duckery for maximum returns.

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MATERIALS AND METHODS

Birds and management practices: Indigenous duck (D), Khaki Campbell (C) and White Pekin (P) breeds of ducks maintained at the CARI, Regional Station, Bhubaneswar under random mating with 40 sire and 200 dams for last 3 generations. Indigenous duck were collected from different parts of Odisha and are having different colour pattern. Khaki Campbell and White Pekin were brought from Central Poultry Development Organisation, Bengaluru and these ducks are from UK and Vietnam origin basically respectively. A 3C3 full diallel cross was carried out producing 3 purebreds (D, C, P), 3 crossbreds (D×C, D×P and C×P) and 3 reciprocals (C×D, P×D and P×C). In a single hatch 609 ducklings were produced with 30 sires and 150 dams and were reared on deep litter brooding with standard starter diet having 20% crude protein and 2800 kcal ME/kg along with standard management for 8 weeks. Each genetic group was kept separately and efforts were made to give sufficient floor space to each ducklings. No vaccination was given.

Traits measured: Body weights of individual ducklings were recorded at 2, 4, 6 and 8 weeks of age using a sensitive weighing scale balance with precision of 0.5 g. Gain in body weight during a period was calculated by subtracting from the average of the body weight at early age from the average body weight at higher age. Shank length and keel length were recorded at 8 weeks of age. Shank length and keel length were measured with the help of Vernier callipers in cm.

Distance between hock joint and tarsal joint was taken as the shank length and length of sternum as keel length. Heterosis for different crosses was calculated using formulae $\{(\text{Average of crossbred} - \text{average of the purebreds}) / \text{average of purebreds}\} \times 100$

Statistical analysis: Data were analysed using least square analysis of variance (Harvey 1966) and traits showing significant difference between genetic groups were used for estimation of different crossbreeding genetic parameters as per Dickerson (1969) model used for the analysis and crossbreeding parameters estimation.

$$Y_{ij} = \mu + 1/2g_i + m_j + \delta h_{ij} + e_{ij}$$

where μ , general mean, g_i , direct genetic effect of the i th parental population, m_j , maternal effect of j th parental population, h_{ij} , heterosis for the combination $i \times j$; e_{ij} , residual effect, δ , 0 for purebred and 1 for crossbreds. Restriction imposed on the parameters were $\sum_{i=1} g_i = \sum_{j=1} m_j = 0$, $h_{ij} - h_{ji} = 0$ for all i and j with $i=j$.

Duncan multiple range test (Duncan 1955) was used to make pair-wise comparison of means.

RESULTS AND DISCUSSION

Juvenile traits

Body weight: Body weights of all the nine genetic groups are presented in Table 1. Body weights measured at different ages of the 3 purebreds, viz. Indigenous duck (D), Khaki Campbell (K) and White Pekin (P), showed significant differences ($P < 0.05$) between the breeds. Indigenous duck body weight was significantly higher than the Khaki Campbell at 2 and 4 weeks of age. However, at 6 and 8 weeks of age Khaki Campbell body weights was significantly higher than D. In D ducks the growth was higher in early period and lower in later stages, which might be due to the genetic characteristics of this breed. Significant differences between genetic groups for body weight observed at different ages of

measurement were in agreement with the reports of Wolf and Knizetova (1994), Padhi *et al.* (2009a) and Padhi (2010). P body weight was highest amongst all the purebreds and crosses at 8 weeks of age. White Pekin (P), being a meat type breeds, shows significantly higher body weight amongst the purebreds. P recorded better gain as the age advances. Similar trends also reported during growing period by Padhi (2010). Body weight of P in the present study was lower than the report of Wolf and Knizetova (1994), Maruyama *et al.* (2001) and Schinckel *et al.* (2005). This may be due to different genetic make up of the breeds and origin. It is to be mentioned here that no selection being practised in this breed since last three generations. The gain in body weight during 4 to 6 and 6 to 8 weeks of age was lowest in D followed by C and P (Table 2). Higher early growth of D compared to C reported by Padhi *et al.* (2009a). Better early period growth in Pekin ducks than the present study were reported by Knizetova *et al.* (1991) and Maruyama *et al.* (1999).

Body weights in crosses revealed that D as male parent with other 2 breeds recorded higher 2 weeks body weights. However, at 4 weeks of age P as female parents shows higher body weight in crosses compared to the reciprocals showing the suitability of this breed as female parent. Similar trend was observed at 6 weeks of age. However, at 8 weeks of age PC recorded non-significant higher body weight than the DP. Both CD and DC recorded higher body weight than their parents irrespective the age of measurement except at 8 weeks in DC (Table 1) showing the presence of over-dominance which may be exploited for meat production as the extra male are being used for meat purpose in the village and the female are kept for egg production. At 6 and 8 weeks of age significantly higher body weight was recorded in P amongst all the nine genetic groups. It is observed that the gain in body weight was faster in crosses during early period in the DC and CD. However, when crosses having P as one parent,

Table 1. Body weight and conformation traits of different genetic groups at different ages

Genetic groups	Sample size (N)	2 nd wk (g)	4 th wk (g)	6 th wk (g)	8 th wk (g)	Shank length (cm)	Keel length (cm)
Purebreds							
Indigenous	52	260.87±7.63 ^{ef}	493.81±10.33 ^f	777.75±16.03 ^h	1120.15±21.62 ^f	6.00±0.05 ^c	9.81±0.10 ^f
Khaki Campbell	51	137.35±2.45 ^h	399.19±8.55 ^g	837.67±15.85 ^g	1249.18±18.24 ^e	5.77±0.04 ^d	10.82±0.09 ^e
White Pekin	41	289.61±5.59 ^{cd}	859.98±13.95 ^{bc}	1839.02±32.36 ^a	2462.05±38.39 ^a	6.86±0.06 ^a	14.12±0.14 ^a
Crossbreds							
DC	60	332.57±3.94 ^b	665.55±8.24 ^e	1047.92±12.69 ^f	1220.87±15.35 ^e	6.04±0.05 ^c	10.85±0.09 ^e
DP	66	361.82±4.60 ^a	1022.29±11.21 ^a	1501.07±19.89 ^c	1841.26±27.84 ^c	6.55±0.05 ^b	13.08±0.11 ^b
CD	50	272.98±4.49 ^{de}	720.42±9.06 ^d	1142.40±11.87 ^e	1341.04±13.91 ^d	6.19±0.03 ^c	11.64±0.08 ^d
CP	37	299.41±7.15 ^c	905.00±14.31 ^b	1567.65±30.31 ^b	2053.35±49.77 ^b	6.81±0.09 ^a	12.67±0.18 ^c
PD	119	176.87±3.96 ^g	684.37±13.83 ^e	1371.48±16.88 ^d	1799.55±17.19 ^c	6.56±0.03 ^b	12.35±0.06 ^c
PC	34	249.53±10.27 ^f	820.65±24.06 ^c	1345.38±30.17 ^d	1863.29±43.63 ^c	6.07±0.07 ^c	12.41±0.25 ^c

Means bearing even one common superscript in a column did not differ significantly ($p < 0.05$)

D Indigenous duck, C Khaki Campbell, P White Pekin, DC Indigenous Duck × Khaki Campbell, DP Indigenous Duck × White Pekin, CD Khaki Campbell × Indigenous Duck, CP Khaki Campbell × White Pekin, PD White Pekin × Indigenous Duck, PC White Pekin × Khaki Campbell.

Table 2. Body weight gain at different periods in different genetic groups

Genetic groups	2 to 4 weeks (g)	4 to 6 weeks (g)	6 to 8 weeks (g)
<i>Purebreds</i>			
D	232.94	283.94	342.40
C	261.84	438.48	411.51
P	570.37	979.04	623.03
<i>Crossbreds</i>			
DC	332.98	382.37	172.95
DP	660.47	478.78	340.19
CD	447.44	421.98	198.64
CP	605.59	692.65	485.7
PD	507.5	687.11	428.07
PC	571.02	524.73	517.91

D Indigenous duck, C Khaki Campbell, P White Pekin, DC Indigenous Duck × Khaki Campbell, DP Indigenous Duck × White Pekin, CD Khaki Campbell × Indigenous Duck, CP Khaki Campbell × White Pekin, PD White Pekin × Indigenous Duck, PC White Pekin × Khaki Campbell

the gain in body weight during later part of experiment continue to more (Table 2). It is also observed that the crossbred grow faster and attain mature body weight earlier than the purebreds. Overall all the crossbreds recorded lower gain in body weight during 6 to 8 weeks of age compared to 2- to 4- and 4- to 6- week period. Pingel (1990) and Schinckel *et al.* (2005) reported that ducks have reasonable rapid growth during the first few weeks of age which is evident in the present study as the gain in body weight in all the genetic groups except P were higher during early period. Better body weight in crossbreds using C and D were also reported by Nageswar *et al.* (2005) and Padhi *et al.* (2009a). All the crossbreds perform well in respect to body weight indicating the presence of heterosis for further exploitation. Better cross performance observed in the present study was in agreement

with the report of Wolf and Knizetova (1994) and Padhi (2010). Higher gain in body weight during early period reported by Maruyama *et al.* (1999) and Maruyama *et al.* (2001) in purebreds.

Conformation traits: Shank and keel length measured at 8 weeks of age are presented in Table 1. Amongst purebreds highest shank length was observed in P followed by D and C. Keel length was highest in P followed by C and D. The 2 traits showed significant difference ($P < 0.05$) between the genetic groups. Amongst the crosses shank length was better than the lower shank length parent breed and CD, DC recorded higher shank length than the parental breed. Similar trends were observed for keel length. DC and CD crosses recorded higher keel length than the parental population and other crosses recorded significantly higher keel length than the C and D purebreds. Shank length and Keel length was highest in P amongst all the genetic groups. Amongst crosses CP and DP recorded significantly higher shank length and keel length respectively. Significant difference between different genetic groups for conformation traits was in agreement with the reports of Goswami *et al.* (2000), Padhi *et al.* (2009a,b). Higher measurements for different crosses also reported by Padhi *et al.* (2009a,b). It was also evident that when the body weight of the birds higher the conformation traits measurements were more. However, shank length of C was lower than Indigenous duck even if the body weight was higher indicating breed difference. Similar observation also reported by Padhi *et al.* (2009a).

Crossbreeding genetic parameters

Body weight: Crossbreeding genetic parameters for body weight are presented in Table 3. General mean of the body weight showed that the gain in body weight was higher for the period from 4 to 6 weeks of age followed by the period from 6 to 8 weeks and 2 to 4 weeks. Direct genetic effects (DGE) of the parental population were significant ($P < 0.01$)

Table 3. Estimates of crossbreeding genetic parameters for body weight and conformation traits

Parameters	2 nd wk (g)	4 th wk (g)	6 th wk (g)	8 th wk (g)	SL (cm)	KL (cm)
m	229.28	584.33	1151.48	1610.33	6.21	11.58
DGE	**	**	**	**	*	**
g_1	113.11 ^a	3.83 ^b	-362.02	-516.67	-0.26	-1.79
g_2	-95.16 ^b	-138.73 ^c	-208.23 ^b	-250.00	-0.14	-0.41
g_3	-17.94 ^a	134.90 ^a	570.25	766.67	0.40	2.21
ME	**	**	**	**	*	**
m_1	-81.51 ^c	-94.35 ^a	-11.70 ^a	26.33	0.05	0.02
m_2	3.24 ^b	-46.41 ^b	-105.58	-111.33	-0.29	-0.35
m_3	78.28 ^b	140.76 ^a	117.28	85.00	0.24	0.33
Heterosis	**	**	**	**	*	**
h_{12}	103.66	246.49 ^b	287.45 ^c	96.50	0.23	0.93
h_{13}	-5.90 ^c	176.43 ^c	127.89 ^b	29.50	0.13	0.75
h_{23}	60.99 ^b	233.24 ^a	118.17	90.50	0.13	0.07

Estimates bearing different superscript in a column for a particular parameters did not differ significantly ($P < 0.05$). DGA, direct genetic effect; ME, maternal effect; ** significant at $P < 0.01$, *significant at $P < 0.05$. In first column 1 indicates indigenous duck, 2 indicates Khaki Campbell and 3 indicates White Pekin.

for body weights measured at different ages. Direct genetic effect (DGE) for body weight was higher in P, indicating the usefulness of this breed for crossbreeding amongst the three purebreds. Negative estimates of C shows the lower genetic effect on the crosses. DGE which also indicated part of general combining ability is also important in ducks as reported by Wolf and Knizetova (1994). Few reports are available in ducks on importance of general combining ability reported in body weight in chicken (Jakubec *et al.* 1987, Padhi *et al.* 1997, Rajkumar *et al.* 2011). Importance of DGE in quails was reported by Hyankova *et al.* (2002). Maternal effect (ME) was found significant ($P < 0.01$) for body weight at different ages of measurement. Maternal effect (ME) estimates was higher in P amongst purebreds, indicating the importance of this breeds as female parent. The magnitude of ME decreases as the age increases this is in agreement with the report of Hyankova *et al.* (2002) in quails. C as a female parent showed less advantages with P male parent. The results indicated that amongst all the breeds P as female parent combine well with other breeds and amongst C and D, D as female parents combine well with C for high 8-week body weight. Importance of maternal effect in chicken was also reported by Nath *et al.* (2007), Saadey *et al.* (2008) and Rajkumar *et al.* (2011). Barbato and Vasilators (1991) reported that the incidence of maternal ability in chicken was sporadic and generally have little importance after hatching. Maternal effect determine pre- and post-natal mothering ability of a line which is function of the genotype of a line rather than the genes transmitted to the male progeny of the line (Harvey 1966); the difference in egg size may be responsible for maternal effect at early ages which reduces as age advances.

Heterosis was significant ($P < 0.01$) for the body weight measured at different ages. Heterosis estimates were positive for all the cross irrespective age of measurements except for 2 weeks in cross combination using D and P. Positive heterosis effect estimates amongst crosses indicated the presence of dominance and over dominance. Estimates were higher for the D and C combination at all the ages of measurements. However, the magnitude of heterosis estimates decreases as the age advances after 4 weeks of age in the entire cross-combination. Heterosis estimates of the cross-combination D and P were lowest at 8 weeks of age. Heterosis% for the 8 weeks body weight showed that CD had highest heterosis followed by CP, DC, DP, PD and PC (Table 4). Highest heterosis% of CD at 8 weeks of age indicated the presence of over-dominance. Presence of heterosis for body weight in ducks and other avian species are reported in literature (Wolf and Knizetova 1994, Hyankova *et al.* 2002, Saaday *et al.* 2008, Padhi 2010, Shit *et al.* 2010, Rajkumar *et al.* 2011). Heterosis effect estimates decreases at 8 weeks of age compared to early ages. The age dependent change in heterosis was specific for each hybrid combination, which was reported by Hyankova *et al.* (2002)

Table 4. Heterosis (%) in different crosses for different traits

Traits	DC	CD	CP	PC	DP	PD
8 th wk (%)	3.06	13.20	10.66	0.41	2.80	0.47
8 th wk SL (%)	2.63	5.18	7.84	-3.88	1.87	2.02
8 th wk KL (%)	5.19	12.85	1.60	-0.48	9.32	3.22

DC Indigenous Duck × Khaki Campbell, DP Indigenous Duck × White Pekin, CD Khaki Campbell × Indigenous Duck, CP Khaki Campbell × White Pekin, PD White Pekin × Indigenous Duck, PC White Pekin × Khaki Campbell.

in quails. Marks (1995) reported over-dominance during early ages for heterosis in quails, which was also evident from the present study. Positive and negative heterosis was dependant on the choice of hybrid combination as well as on the age at which body weight was investigated. Heterosis accelerated during high weight gain period and then decreased during low body weight gain period towards the end of experiment, which is in agreement with the findings of Hyankova *et al.* (2002) and Marks (1995). Heterosis during early week may be caused by egg size of the maternal line in relation to the growth potential of the hybrids. It was also observed that the body weight was also influenced by maternal effect. Knizetova *et al.* (1991) reported similar observation in ducks. The estimates indicate the use of C as female parent with other 2 breeds is most suitable for higher body weight in crosses.

Conformation traits: Estimates for different crossbreeding genetic parameters are presented in Table 2. DGE was significant ($P < 0.05$) and negative estimates were obtained for C and D population both for shank length and keel length. P population showed positive estimates for both the traits. Lowest magnitude for DGE estimates was obtained in D population, indicating lower contribution of this breed for the two traits. ME was significant ($P < 0.01$) both for shank length and keel length and estimates were positive and highest in P population, indicating the usefulness of this breed as dam line for higher shank and keel length. ME estimates were negative for C population for both the traits. Lower estimates for C indicate that this line to be used as male parent with the other 2 line to exploit the maternal effect. Significant of maternal effect for conformation traits was reported in chicken (Padhi *et al.* 1997). Heterosis estimates were significant ($P < 0.05$) for both the traits and the estimates were positive for the entire cross-combination indicating the presence of non-additive gene effects. Both for shank length and keel length highest estimates of heterosis were observed for the cross-combination involving D and C population followed by D and P and C and P population. Heterosis% for shank length was highest in CP followed by CD, DC, PD, DP and PC (Table 4). Heterosis% for keel length was highest in CD followed by DP, DC, PD, CP and PC (Table 4). PC showed negative heterosis% for both the traits whereas, all other crossbreds showed positive estimates for both shank

and keel length. Heterosis% increased in the cross-combination having P as female parent compared to male parent, indicating the importance of this breed for dam lines for higher conformation traits. Amongst D and C, D as female parent performed better for both the traits. All the crosses showed positive heterosis% except PC indicating crossbreeding for improving the conformation traits. Padhi *et al.* (2009a) reported positive heterosis between crosses involving C and D for the conformation traits.

From the result it may be concluded that most of the crossbred performed better than the purebreds in respect to growth and conformation. The gain in body weight varied in different genetic groups and as the age advanced the weight gain decreased. Significant differences between the genetic groups were observed. DGE, ME and heterosis were significant for all the traits studied. ME estimates tended to decrease as the age increased. Further, as both additive and non additive genetic effects are important, establishment of pure lines with specialised sire and dam lines followed by crossing is of importance for the production of different crosses for commercial exploitation. Maternal estimates suggested to use P as female parent amongst the 3 breeds and between C and D, later to be used as female parent. Heterosis was positive for all the crosses for body weights. CP may be used for meat purpose amongst crossbreds.

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