



Comparative performance of Kuzi Ducks (*Anas platyrhynchos*) and its crosses with Khaki Campbell with respect to growth, phenotypic parameters and carcass quality

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ABSTRACT

To develop a suitable duck variety for egg type, one pilot study was undertaken to know the cross performance of Kuzi ducks with exotic duck breeds available in India. In the present study, comparative performance of Kuzi ducks and its two crosses with Khaki Campbell viz Kuzi × Khaki Campbell (DK) and Khaki Campbell × Kuzi (KD) were carried out with respect to juvenile growth, conformation, body colour and carcass quality. It was observed that significant differences exist between different genetic groups for body weights and Kuzi Ducks recorded higher body weights than its two crosses. The weight gain was more during two to seven weeks of age in all the three genetic groups irrespective of sex. Gain in body weight showed maximum gain during four to six weeks of age. This may be exploited in the future breeding programme. Multicolour plumage was dominant in all the three genetic groups. Shank colours were brown in most of the birds in DK and KD whereas pink in Kuzi. The study revealed that male ducks may be slaughtered at 12 weeks of age for meat purpose as thereafter they were not gain any significant body weight. It was found that the crosses of Kuzi and Khaki Campbell recorded lower body weight than Kuzi.

Keywords: Body weight, Carcass quality, Cross, Kuzi duck, Plumage colour, Weight gain

Duck is the second most important species in poultry after chicken in many countries and contributing both egg and meat to the consumers. These are most important food source in rural areas in Asia particularly Southeast Asia. Of the 1.15 billion ducks (*Anas* spp.) kept in 2020, 1.0 billion (89%) were in Asia. The largest duck population is found in China, Vietnam, Bangladesh and Indonesia (FAO 2022). In India, duck is the second most important species after chicken and as per the 20th livestock census (2020), total duck population in the country was 33.51 million and 87% of them are being reared under backyard and most of the duck populations are indigenous in origin.

Different aspects with respect to the growth of indigenous ducks in India were reported (Cyriac *et al.* 2020a, Padhi *et al.* 2022). Cross performance of indigenous ducks with exotic ducks like Khaki Campbell as well as other exotic breeds like White Pekin are available in the literature (Padhi and Sahoo 2012, Padhi *et al.* 2019). The cross performance of the indigenous ducks with exotic one were positive and better than the indigenous ducks (Padhi *et al.* 2019). However, further study is of importance to periodically assess the cross performance of indigenous ducks with exotic breeds with respect to various traits and its comparison with indigenous ducks. Further, for

the development of duck variety, evaluation of crosses are important and the introduction of indigenous duck inheritance in crosses are of importance for its climatic adaptation. Keeping this in view, the present study was being undertaken to study the comparative performance of Kuzi ducks (one indigenous ducks of Odisha state in India) and its two crossbreds with exotic Khaki Campbell with respect to various, growth, conformation, phenotypic characteristics and carcass quality traits.

MATERIALS AND METHODS

Experimental ducks: Kuzi ducks used for the present study are being maintained in the Regional centre of ICAR-Central Avian Research Institute presently Regional station of ICAR-Directorate of Poultry Research, Bhubaneswar, Odisha, India. The ducks collected from the field and the ducks available in the centre form the base population, and then the breed is being maintained as a pedigree population. The S1 generation was produced by using 40 sires and 160 dams after selection of the S0 generation stock with higher eight week body weight. Same selection criterion was followed for the production of the second generation. Male and female Kuzi ducks of S1 generation and Khaki Campbell breeds are available in the centre as none pedigreed stocks were used to produce two crosses. Along with the crosses, pure Kuzi ducklings were hatched for the comparative performance of crosses with pure Kuzi. The number of fertile egg set in Kuzi, Khaki Campbell × Kuzi

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(KD) and Kuzi × Khaki Campbell (DK) were 274, 175 and 193 eggs, respectively. Out of the total 479 ducklings hatched, a total of 178 Kuzi ducklings, 145 DK and 147 KD ducklings were used for the present study.

Management and feeding: The ducklings hatched were wing banded, weighed and reared under a deep litter system with standard brooding, feeding and health care management system. All the survived ducklings were reared up to 12 weeks of age. Ducklings were provided wheat based starter ration from start to eight weeks of age, and then grower feed from nine weeks onwards. Ducklings were fed with a diet containing 21% CP and 2800 kcal/kg ME up to eight weeks of age and then followed by a diet containing 17 % CP and 2500 kcal/kg ME. Drinking water and feed were provided *ad lib.* throughout the experiment up to 16 weeks of age.

Data collected: Body weights were recorded at day old and then at weekly interval up to eight weeks of age. Then the growing period body weights were recorded at 10, 12 and 16 weeks of age. Sexing of the ducklings were made at eight weeks of age and the ducklings which were wing band were used for the analysis of data for male and female up to eight weeks of age. Weight gains were calculated from the mean body weight data of male and female of each genetic group. Conformation traits such as shank length (SL), Keel length (KL) and Bill length (BL) were recorded at eight weeks of age. Plumage colour, skin colour, shank colour and bill colour of all the ducklings were observed visually and recorded at eight weeks of age in all the three genetic groups. Mortality if any were recorded daily and the mortality % from day old to eight weeks of age were calculated for each genetic group.

At 12 weeks of age, three male and three female birds each from all the three genetic groups were sacrificed to study the carcass quality. Carcass qualities were recorded as per Padhi *et al.* (2010). Two prime cuts leg and breast were deboned and the weight of skin, meat and bone of these two prime cuts were recorded. The meat and bone ratio of two prime cuts breast and leg were calculated along with ratio of meat plus skin and bone.

Statistical analysis: The mean and SE for various traits were calculated according to standard statistical procedures (Snedecor and Cochran 1994). Significant differences between the genetic groups for various growth, conformation and carcass quality traits were tested by one-way ANOVA. Duncan (1955) Multiple Range Test was used to test the differences between the means of the traits studied.

RESULTS AND DISCUSSION

Body weights: It is evident that from one to four week of age except in male irrespective of sexes, the body weight of Kuzi × Khaki Campbell (DK) and Khaki Campbell × Kuzi (KD) were significantly ($p < 0.05$) higher than Kuzi and at three weeks, DK recorded significantly ($P < 0.05$) higher body weight than its reciprocal cross in female and straight run ducklings (Table 1). It was observed sexual dimorphism

with respect to body weights was more pronounced in DK from seven week onwards, whereas in Kuzi there was not much difference was observed (Table 1). The body weight recorded in Kuzi in the present study at six and eight weeks of age were higher than the report of Padhi *et al.* (2022) in the same stock in S1 generation. The body weight recorded in the Kuzi ducks comparable to the selected Kuttanad ducks of Kerala by Cyriac *et al.* (2020a,b). The increase may be due to the effect of selection in the stock. The crossbred body weight observed in the present study up to four weeks of age showed that the crosses recorded better body weight than the Kuzi which were in agreement with the findings of Padhi and Sahoo (2011), Padhi *et al.* (2019). However, after four weeks onwards, the Kuzi recorded higher body weight than the crosses. This may be due to

Table 1. Juvenile period body weight (g) in different genetic groups in different sexes

Male			
Age	Kuzi (84)	DK (68)	KD (69)
Day old	41.52±0.46	40.27±0.38	40.48±0.40
1 WK	95.97±1.65 ^b	102.74±1.71 ^a	103.78±1.74 ^a
2 WK	232.29±3.91 ^b	250.27±4.49 ^a	260.70±4.13 ^a
3 WK	431.57±7.13 ^b	492.06±7.60 ^a	472.17±7.03 ^a
4 WK	673.61±8.12	698.32±9.73	684.59±7.52
5 WK	942.22±10.95 ^a	964.06±11.99 ^a	829.44±7.22 ^b
6 WK	1167.30±11.56 ^{ab}	1192.28±14.26 ^a	1141.32±14.41 ^b
7 WK	1333.78±16.23 ^{ab}	1302.34±13.16 ^b	1279.90±14.22 ^b
8 WK	1445.68±19.04	1404.12±15.59	1417.49±14.15
10 WK			
Female			
	Kuzi (86)	DK (74)	KD (70)
Day old	40.58±0.37 ^a	39.50±0.36 ^b	40.44±0.43 ^{ab}
1 WK	97.22±1.52 ^b	105.89±1.57 ^a	101.82±1.24 ^a
2 WK	227.00±3.18 ^b	250.22±4.10 ^a	254.46±4.21 ^a
3 WK	421.16±6.72 ^c	499.10±7.08 ^a	463.97±6.81 ^b
4 WK	644.99±8.76 ^b	687.05±8.12 ^a	686.93±7.49 ^a
5 WK	928.09±10.45 ^b	967.77±13.16 ^a	825.15±8.29 ^c
6 WK	1119.62±10.91	1141.20±13.99	1132.08±13.50
7 WK	1280.87±12.85 ^a	1222.60±13.28 ^b	1254.00±14.96 ^{ab}
8 WK	1428.57±15.36 ^a	1313.73±15.06 ^b	1398.99±14.37 ^a
Male and female combined			
	Kuzi (170)	DK (142)	KD (139)
Day old	41.05±0.29 ^a	39.85±0.26 ^b	40.46±0.29 ^{ab}
1 WK	96.60±1.12 ^b	104.38±1.16 ^a	102.82±1.08 ^a
2 WK	229.61±2.51 ^b	250.24±3.02 ^a	257.65±2.94 ^a
3 WK	426.30±4.90 ^c	495.73±5.17 ^a	468.16±4.84 ^b
4 WK	659.12±6.06 ^b	692.45±6.29 ^a	685.73±5.29 ^a
5 WK	935.04±7.56 ^b	965.99±8.92 ^a	827.35±5.47 ^c
6 WK	1143.15±8.14 ^{ab}	1165.66±10.18 ^a	1136.81±9.86 ^b
7 WK	1306.99±10.51 ^a	1260.78±9.91 ^b	1267.23±10.33 ^b
8 WK	1437.01±12.18 ^a	1357.01±11.44 ^c	1408.44±10.08 ^a

Means having one superscript in common in a row for a particular sex did not differ significantly ($P \leq 0.05$). In first column, WK indicates week. DK, Kuzi × Khaki Campbell; KD, Khaki Campbell X Kuzi. Figures in parenthesis are no. of observations.

the higher body weight of Kuzi in the present study and the stock being subjected to a selection programme where as the stock used by the author earlier was not selected.

The growing period body weights are presented in Supplementary Table 1. It is evident that significant difference ($p < 0.05$) between genetic groups were recorded in both the sexes irrespective of age of body weight measured. The results indicates that the males almost achieved the adult body weight at 12 weeks of age. However, in female in all the three genetic group, the body weight increased at 16 weeks of age significantly ($p < 0.05$), indicating the weight gain in female continued up to 16 weeks of age and this may be due to gain in weight before starts of lay. The body weight during the growing period was higher than the report in all the genetic groups compared to the available literature in Desi ducks of Odisha and its crosses with Khaki Campbell (Padhi 2010). This may be due to the higher body weight of Kuzi which is being subject to selection for higher eight week body weight. Lower 12 week body weight than the present study was also reported by Cyriac *et al.* (2020a) in Kuttanad ducks of Kerala both male and female.

Weight gain: The gain in weight for a different period in all the three genetic groups in male and female are presented in Supplementary Table 2. From the table, it is evident that in all the three genetic groups irrespective of sex, the weight gains accelerate from one week onwards and reaches peaks between four to six weeks of age and then decreases and after eight weeks of age, the weight gain

reduced to a great extent. The weekly body weight gain obtained in the present study was better than the reports of Islam *et al.* (2012) in Khaki Campbell, Jinding and Deshi ducks in Bangladesh. This may be due to difference in the genetic makeup of the genetic groups studied.

Confirmation traits: Conformation traits recorded at eight weeks of age in the three genetic groups are presented in Supplementary Table 3 both for male and female. The results indicated that significant ($p < 0.05$) differences between genetic groups were recorded for shank length in both sexes. Bill length differed significantly ($p < 0.05$) only in male between genetic groups. It is evident from the data that female recorded lower measurement compared to their male counterpart in each genetic group for the conformation traits. The results obtained in the present study were higher than the report of Padhi *et al.* (2022) in Kuzi ducks. This may be due to the selection effect of the stock at a higher eight week body weight. Lower shank length than the present study was reported by Kamal *et al.* (2019) in indigenous duck of Odisha. Lower bill length in Maithili duck than the present findings was also reported by Kamal *et al.* (2020a) in indigenous duck of Odisha. The higher value in the present study may be due to higher shank length of Kuzi ducks which was being selected for higher body weight thus there may be correlated increase of conformation traits and when crosses with Khaki Campbell the traits shows higher value in crosses also.

Colour pattern (phenotypic): The different colour pattern of plumage, bill, and shank are presented in Table 2.

Table 2. Colour (external) and their % at 8 weeks of age in different genetic groups

Description of part	Colour description	Kuzi (N=170) (%)	DK (N=142) (%)	KD (N=139) (%)
Plumage colour	Ash	0.25	0	0
	Black and Pink	8.48	0	4.35
	Black and White	0.74	0	0
	Brown	1.25	0	0
	Fawn	1.25	1.72	1.09
	Khaki	1.25	12.07	22.82
	Multicolour	85.79	86.21	69.57
	White	1	0	2.70
Bill colour	Black	6.58	6.90	17.39
	Black with Pink	1.57	15.52	1.09
	Blue	2.89	13.79	41.30
	Blue with pink	1.51	48.28	8.70
	Brown	50.10	1.72	3.26
	Multicolour	0.78	5.17	0
	Pink	34.17	5.17	22.83
	Spotted	2.51	0	5.44
Shank colour	Black	2.63	0	6.59
	Black with pink	0.50	0	1.10
	Blue	0.25	1.72	1.10
	Brown	43.93	82.76	61.54
	Pink	45.13	3.79	23.08
	Spotted	0.75	1.72	1.10
	Yellow	5.68	0	5.50

K D, Khaki Campbell × Kuzi; DK, Kuzi × Khaki Campbell.

Table 3. Carcass quality traits at 12 weeks of age in Kuzi duck of Odisha and its two crosses with Khaki Campbell in pooled sex

Parameter	Kuzi	KD	DK
Pre fasting BW(g)	1616±122	1528±61	1422±64
BW before slaughter (g)	1532±112	1467±60	1367±62
<i>Traits as % of live wt</i>			
Fasting loss (%)	5.17±0.42 ^a	3.99±0.39 ^b	3.89±0.17 ^b
Blood (%)	4.08±0.41	4.86±0.36	4.47±0.48
Feather (%)	5.15±0.35	4.63±0.12	4.54±0.34
Head (%)	6.07±0.43	5.67±0.12	6.27±0.12
Shank+feet (%)	2.75±0.07	2.91±0.06	2.93±0.09
Liver (%)	1.81±0.12	1.63±0.09	1.81±0.09
Gizzard (%)	3.19±0.06 ^a	2.95±0.08 ^b	2.86±0.07 ^b
Heart (%)	0.91±0.07 ^a	0.75±0.03 ^b	0.83±0.02 ^{ab}
Eviscerated yield (%)	72.17±0.72	71.88±1.18	69.95±0.72
Giblet %	5.91±0.15 ^a	5.32±0.09 ^b	5.49±0.11 ^{ab}
<i>Cut up parts as % of eviscerated carcass weight</i>			
Leg (%)	18.46±0.64	19.60±0.72	19.87±0.40
Breast (%)	26.01±0.25	25.54±0.61	26.41±0.34
Back (%)	29.41±0.40 ^a	29.54±0.34 ^a	27.86±0.41 ^b
Neck (%)	12.00±0.52	12.09±0.25	11.83±0.53
Wing (%)	13.60±0.56	12.75±0.35	13.60±0.54
Cutting loss (%)	0.57±0.26	0.47±0.16	0.48±0.17
<i>Meat and bone ratio of prime cuts</i>			
Breast	3.57±0.32	4.21±0.41	3.43±0.31
Leg	4.05±0.32	4.12±0.26	3.92±0.09
<i>Meat + Skin: Bone of prime cuts</i>			
Breast	4.68±0.43	5.29±0.52	4.65±0.36
Leg	5.22±0.43	5.22±0.43	5.35±0.15

KD= Kuzi × Khaki Campbell DK= Kuzi × Khaki Campbell. BW=Body weight. Means having one common superscript in a row did not differ significantly ($P \leq 0.05$).

The photographs of the flocks of Kuzi ducks are presented in Fig. 1 and that of DK and KD are presented in Fig. 2 and 3, respectively. The plumage colour as observed at eight weeks of age in a straight run ducklings of Kuzi, DK and KD showed that multicolour (more than one colour) was dominant amongst all and DK recorded higher percentage of multicolour followed by Kuzi and KD. Khaki plumages were more in KD followed by DK. More colour variations were observed in Kuzi compared to other two crosses. More multicolour plumage in Kuzi was reported by Padhi *et al.* (2022). However, plumage colour reported in crosses using indigenous with Khaki Campbell is limited in the literature.

Higher % of brown and pink Kuzi bill colour was reported by Padhi *et al.* (2022) in same stock. Dark brown to black bill was reported by Kamal *et al.* (2020a) in Maithili duck of Bihar. Higher % of pink and brown shank recorded in Kuzi ducks whereas brown shank was dominant in DK and KD. Similar observation in Kuzi ducks was reported by Padhi *et al.* (2022) in Kuzi ducks. Yellow and orange shank was reported by Kamal *et al.* (2019) in indigenous duck of Odisha this may be due to the difference in population. Reports of bill colour in



Fig. 1. Kuzi flock.



Fig. 2. Kuzi × Khaki Campbell flock.



Fig. 3. Khaki × Kuzi flock.

crosses of Kuzi with Khaki Campbell is lacking in the literature. The phenotypic colour variation in Kuzi ducks indicates if required different variety may be developed on plumage pattern or colour basis. Further, the crossbreds produced using Khaki Campbell may be of use as it has different colour variation and may be use for rearing where indigenous ducks are popular.

Carcass quality: The carcass quality measured in the three genetic groups at 12 weeks of age in straight run ducklings are presented in Table 3. The result indicates that there was a significant ($p < 0.05$) higher fasting loss of body weight in Kuzi compared to other two crosses. Significant difference ($p < 0.05$) between the genetic groups were observed for the gizzard, heart and giblet %. Whereas, in other traits, no significant ($p < 0.05$) difference were observed. The % observed in the present study was higher than the report of Padhi *et al.* (2022) measured at 20 week of age except blood loss % and feather %. This may be due low age of slaughter. Significant ($p < 0.05$) difference between different genetic groups for different carcass quality traits was reported in Desi ducks of Odisha and its

crosses with other exotic groups which was in agreement with the present finding (Padhi *et al.* 2010); however the experiment was conducted at eight weeks of age whereas the present study was conducted at 12 weeks of age. The results revealed that the males may be discarded at 12 weeks of age for better slaughter yield. Further, the eviscerated yield % in the present study was better than the reports of Padhi *et al.* (2010), and though it was not significant ($p < 0.05$) in the present study numerically the eviscerated yield % was best in Desi followed by KD and DK as observed in the cited report.

Cut-up parts expressed as % of eviscerated carcass weight showed significant ($p < 0.05$) difference between genetic groups only for back %. Irrespective of genetic groups, highest % of cut up parts observed in back cut followed by breast, leg, wing and neck. Similar trend was observed in Kuzi ducks by Padhi *et al.* (2022). Meat bone ratio of two prime cuts breast and legs showed better yield in KD followed by Kuzi and DK. However, no significant ($p < 0.05$) difference were observed between genetic groups.

Mortality: The mortality % observed in different genetic groups at day old to eight weeks of age and eight to 16 weeks of age are presented in Supplementary Table 4. Mortality observed during brooding periods in different genetic groups were below 5%. However, during growing periods Kuzi and DK recorded lower mortality than KD. Higher mortality % in the farmer's field was also reported by Kamal *et al.* (2020b) in indigenous duck of Jharkhand, Odisha and Chhattisgarh in day old to two months of age. The mortality indicates the superiority of cross DK over other genetic groups studied.

Different phenotypic, growth and carcass quality parameters were studied in Kuzi and its two crosses with Khaki Campbell and are presented in this paper. The Kuzi ducks was found to be better with respect to juvenile growth compared to KD and DK. The weight gain was found to be higher between two to six weeks of age in all the three genetic groups. This may be exploited in the future breeding programme for maximum weight gain. The study revealed that male ducks may be slaughtered at 12 weeks of age for meat purpose as thereafter they were not gaining any significant weight. The study suggested that for meat purpose if crossbred are to be used than KD is the preferred one than DK.

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