한국가금학회지 제 48권 제 2호, 59~67 (2021)
Korean J. Poult. Sci. Vol.48, No.2, 59~67 (2021)
https://doi.org/10.5536/KJPS.2021.48.2.59

Morphology, Morphometry, Growth Performance and Carcass Characteristics of Pekin, Nageswari and Their F_1 Crossbred Ducks under Intensive Management

Md. Tanvir Ahmad[1], Drishti Nandita[1], Tanvir Mohammad Maruf[1], Mohammad Hasanuzzaman Pabitra[1], Sabrina Islam Mony[1], Md. Shawkat Ali[2], Md. Sarwar Ahmed[3] and Mohammad Shamsul Alam Bhuiyan[1†]

[1]*Student, Department of Animal Breeding and Genetics, Bangladesh Agricultural University, Mymensingh, 2202, Bangladesh*
[2]*Professor, Department of Poultry Science, Bangladesh Agricultural University, Mymensingh, 2202, Bangladesh*
[3]*Senior Assistant Director, Govt. Regional Duck Breeding Farm, Khagdohar, Mymensingh, 2200, Bangladesh*

ABSTRACT This study investigated the morphological features, growth, and meat yield performance of Pekin (P), Nageswari (N), and their reciprocal F_1 crossbreds (P♂×N♀ and N♂×P♀). A total of 301-day-old ducklings were reared in four different pens up to 20 weeks of age under intensive management conditions. Feeding and management practices were similar for all individuals throughout the experimental period. The morphology and plumage pattern of F_1 crossbreds were similar to those of indigenous Nageswari ducks because of the dominant inheritance of the extended Black allele (E locus). Genotype had significant differences (P<0.05) among the four genotypes in morphometric measurements, except wing and shank length. Growth performance was highly significant among the four genotypes (P<0.001) from one-day to 12 weeks of age. The average live weights of P, N, P♂×N♀ and N♂×P♀ crossbred genotypes at 12 weeks of age were 2038.35±29.74, 1542.44±33.61, 1851.85±28.59 and 1691.08±27.80 g, respectively. Meat yield parameters varied significantly (P<0.05) among the different genotypes for all studied traits, except for liver and gizzard weight. Moreover, no significant differences (P>0.05) were observed between P and P♂×N♀ crossbred for important meat yield traits such as hot carcass weight, dressing%, back half weight, drumstick with thigh weight and breast meat weight. Remarkably, the P♂×N♀ crossbreed possesses 50% native inheritance, which contributes to better adaptation in a hot-humid environment. Our results revealed that the P♂×N♀ genotype could be suitable for higher meat production with better adaptability in the agro-climatic conditions of Bangladesh.

(Key words: morphology, meat yield characteristics, growth, crossbreeding, duck)

INTRODUCTION

Duck rearing is an integral part of poultry production in Bangladesh and is considered as the second important poultry species used for egg and meat purposes. Duck population of Bangladesh is estimated to be 57.75 million (DLS, 2019). This is the 5th largest duck population in the world (FAOSTAT, 2019) whereas 90% of them are non-descript indigenous type scattered throughout the country (Hoque and Sultana, 2003). Ducks are very efficient to convert waste resources like insects, weeds, aquatic plants, snails, nuts, bulbs, roots, succulent leaves, grasses and fallen seeds into meat and eggs. Duck meat is popular irrespective of religion, caste and community in Bangladesh. However, the country's growing demand has been fulfilled partially with the available indigenous and exotic egg type ducks due to absence of suitable meat type duck breed. Farmers also prefer indigenous ducks under traditional husbandry practices owing to higher adaptability to scavenging conditions, better foraging ability and appear to be more resistant to diseases (Pervin et al. 2013; Morduzzaman et al. 2015). Notably, agroecological zones have potential influence on duck demography and concentration. Large-scale flock ranging from around one hundred to thousand is found particularly in the north-eastern wetlands and coastal regions of Bangladesh (Khanum et al., 2005). Apart from this, duck rearing system throughout the country is mostly semi-scavenging with a small number of individuals.

Nageswari (N) is an egg type indigenous duck breed of Bangladesh having black or penciled black plumage color except white in breast region. Under intensive management condition, the average annual egg production was 204.23±14.19 and the 9th week live weight was only 1076.11±16.34 g

† To whom correspondence should be addressed : msabhuiyan@gmail.com

(Bhuiyan et al., 2017). However, this breed is well adapted to agro-climatic condition and existing management system of Bangladesh (Morduzzaman et al. 2015). On the other hand, Pekin (P) is an exotic meat type duck breed that has been introduced recently in Bangladesh and are being reared commercially by some farmers under intensive management condition. In confinement with adequate nutrients, it grows rapidly up to 2.5-3.0 kg at market age of 8 to 10 weeks and lays an average of 200 eggs per year (Microlivestock, 1991). However, they are not good scavengers and production is largely affected in semi-scavenging condition with poor quality and fluctuating feed supply. Therefore, their adaptability under semi-scavenging condition of Bangladesh is a big challenge for a profitable duck farming. Under the circumstances stated above, reciprocal crossing between Pekin and Nageswari will create opportunity to utilize hybrid vigor in the descendants for increasing meat production potentials without compromising egg production. The better performed crossbreds would be expected more adaptable under semi-scavenging production system of Bangladesh as of their 50% native inheritance.

Crossbreeding is a potential tool for improving growth and production potentials through exploitation of heterosis. Previous studies on intra and inter-generic crossbreeding have been reported to improve productivity, meat quality and reproductive traits (Padhi, 2010; Brun et al., 2012; Matitaputty et al., 2015). Reciprocal crossing is generally used to perform to identify suitable combination for commercial exploitation of production traits. Pekin and Muscovy ducks had significant additive effects on growth performance, meat quality and plumage color parameters (Matitaputty et al., 2015). However, crossbreeding effects on productivity using indigenous Nageswari duck is lacking in the literature. Therefore, the objectives were to investigate the morphological features, growth performance and meat production potentials of reciprocally produced Pekin-Nageswari F_1 crossbred ducks under intensive management condition.

MATERIALS AND METHODS

1. Ducks and Management Practices

This study was conducted as per guidelines of the Animal Care and Use Committee of Bangladesh Agricultural University (IACUC) and approval was taken from the University Ethical Committee (No.: BAURES/2020 ESRC/AH/03). Pekin and Nageswari breeding flocks were grouped into four different pens in order to get pure Pekin and Nageswari day old ducklings as well as their reciprocal crossbreds. In total, 400 fertile eggs were collected after 2 weeks of group formation and was incubated at Regional Duck Breeding Farm, Mymensingh. The male and female ratio was 1:6 in each breeding flock. A total of 301-day old ducklings were hatched out (hatchability 75.25% based on total eggs). The flocks were maintained up to 20th week of age on perch in a shed at Bangladesh Agricultural University Artificial Insemination Center. Commercial compound starter feed (Quality Feed Ltd., Bangladesh) was provided two times a day during the first four weeks of age while hand mixed compound feed was provided twice daily as per requirement of the dual type duck throughout the growing and pre-laying period. The nutrient contents of the supplied rations are given in Table 1. The shed was cleaned regularly and birds had unrestricted access to drinking water. Ducks were vaccinated against duck plague, avian influenza and duck cholera and vaccination schedule is presented in Table 2. Strict bio-security measures and hygienic control were maintained to ensure healthy environment of duck during the experimental period. Rigorous selection was performed twice at the age of 10th and 16th week based on their growth performance and phenotypic features.

2. Traits Under Study

1) Morphology and Morphometry

Pekin and Nageswari possess their typical breed characteristics regarding plumage color, morphological features and morphometric measurements. Hence, our aim was to investigate the inheritance of plumage color and pattern, morphological features and morphometric measurements in crossbreds. Six different morphometric traits were investigated in this study such as shank length, neck length, body length, wing length, bill length and shank circumference.

2) Growth Performance

Weekly live weight was recorded from day old to 12th

Table 1. Nutrient composition of ration supplied to experimental flocks

Nutrients*	Starter (0~4 week)	Grower (5~17 week)	Pre-laying (18~20 week)
ME (kcal/kg)	2,850	2,750	2,800
CP%	22.0	16.5	17.0
Lysine	0.80	0.70	0.78
Methionine	0.40	0.29	0.32
Methionine and cysteine	0.58	0.42	0.62
Calcium	1.10	1.00	2.75
Available phosphorus	0.50	0.50	0.48
Common salt	0.25	0.25	0.25

* Vitamin-mineral premix was added at a rate of 0.5 kg per 100 kg feed.

Table 2. Vaccination schedule practiced in the experimental flock

Disease name	Dose	Age of vaccination		Methods of administration
		Primary dose	Booster dose	
Duck plague	1.0 mL	25th day	40th day	Sub-cutaneous and intramuscular
Avian influenza	0.5 mL	31th day	46th day	Sub-cutaneous and intramuscular
Duck cholera	0.5 mL	60th day	75th day	Intramuscular

week of age and then fortnightly live weights were recorded up to 20th week of age. To make homogeneity of data, live weight was always taken in the morning before supplying feed and water. Based on the recorded information, several production efficiency indicators like growth rate (g/bird), feed conversion efficiency were estimated.

3) Meat Yield Characteristics

A total of 16 ducks (8 males and 8 females) were selected randomly and were slaughtered at 12th week of age (marketing age) having 4 individuals (2 males and 2 females) from each genotype. The slaughtered birds were allowed to bleed thoroughly and were subsequently dressed, eviscerated and dissected as per description of Ferdaus et al. (2015). The investigated traits were average live weight (g), neck weight with skin (g), carcass weight without giblet (g), dressing (%), heart weight (g), liver weight (g), gizzard weight (g), back half weight (g), drumstick with thigh weight (g), drumstick weight (g), thigh weight (g), wings weight (g), back weight (g), breast meat weight (g) and keel bone length (cm).

3. Statistical Analysis

Data on growth, meat production, morphology and morphometric traits were screened and compiled in excel spread sheet. All sorts of descriptive statistics such as mean, standard error, frequency, percentage and ANOVA were performed using SAS software for windows (SAS ver. 9.1.3). Sex of the birds were fitted as fixed effect in the analysis. Mean separation procedures were computed using Duncan's Multiple Range Test (DMRT).

RESULTS

1. Morphological Features

The morphological features and their distributions are

presented in Table 3. Pekin and Nageswari ducks possessed their typical breed characteristics. Here, our main focus on the inheritance of plumage color and pattern, and morphological features in P♂ × N♀ and N♂ × P♀ crossbreds. Typically, the black color was predominant over white color for all considered traits. However, there are considerable differences have been observed regarding plumage color and pattern between these two crossbreds. In particular, the head color was equally distributed as white spotted black (50%) and only black (50%) in P♂ × N♀ genotype while it was almost black (91.17%) in N♂ × P♀ crossbred. Breast color of P♂ × N♀ genotype was mostly white in color (93.33%) that extended up to belly but N♂ × P♀ possessed black with white spotted breast (91.17%). Wing color of two crossbreds was distinct, the P♂ × N♀ genotype had white primary and secondary feathers (80%) while complete black wing except few white primary feathers was observed (94.12%) in N♂ × P♀ crossbreds. The bill, shank and web color of P♂ × N♀ genotype was found dominantly yellowish or yellowish black. On the contrary, N♂ × P♀ crossbred genotype had mostly black and black with yellowish tint for the aforementioned traits.

2. Morphometric Measurements

Table 4 represents morphometric features of Pekin, Nageswari and their reciprocal crossbred ducks. The morphometric traits like neck length, shank circumference and body length had highly significant differences among the 4 genotypes ($P<0.01$). There were insignificant differences ($P>0.05$) obser-

Table 3. Morphological features of Pekin, Nageswari and their reciprocal crossbreds (F_1) at 20th week of age

Phenotype	Characteristic features*							
	Pekin (P)	Freq.	Nageswari (N)	Freq.	P♂ × N♀	Freq.	N♂ × P♀	Freq.
Head color	White (12)	100.00	Black (10)	90.91	Black (15)	50.00	Black (31)	91.17
			White spotted black (1)	9.09	White spotted black (15)	50.00	White spotted black (3)	8.82
Neck color	White (12)	100.00	Black (12)	100.00	White (5)	16.67	White (3)	8.82
					Black with white spotted (20)	66.67	Black with white spotted (23)	76.47
					Black (5)	16.67	Black (8)	23.53
Breast color	White (12)	100.00	Black with white spot (11)	100.00	Black with white spotted (2)	6.67	Black with white spotted (31)	91.17
					White extended up to belly (28)	93.33	White extended up to belly (3)	8.82
Wing color	White (12)	100.00	Black (11)	100.00	Primary and secondary feather white (24)	80.00	Black (2)	5.88
					Black except few white primary feather (6)	20.00	Black except few white primary feather (30)	94.12
Bill color	Yellowish (12)	100.00	Black (11)	100.00	Black (8)	26.67	Black (27)	79.41
					Black with yellowish tint (15)	50.00	Black with yellowish tint (7)	20.59
					Yellowish (7)	23.33		
Shank color	Yellowish (12)	100.00	Black (11)	100.00	Yellowish (11)	36.67	Yellowish (6)	17.65
					Yellowish black (11)	36.67	Yellowish black (2)	5.88
					Black (8)	26.67	Black (26)	76.47
Web color	Yellowish (12)	100.00	Black (7)	63.63	Yellowish (25)	83.33	Yellowish (10)	29.41
			Black with yellowish tint (4)	36.36	Black (1)	3.33	Black (3)	8.82
					Black with yellowish tint (4)	13.33	Black with yellowish tint (21)	61.76

* values in the parentheses indicate the number of observations.

Table 4. Morphometric features of Pekin and Nageswari and their crossbreds (F_1) at 20th week of age

Trait[1]	Sex	Genotype				Level of sig.[2]
		Pekin (P)	Nageswari (N)	P♂ × N♀	N♂ × P♀	
Neck length (cm)	Male	25.43^{a}±0.102 (6)	20.43^{c}±0.76 (7)	22.68^{b}±0.45 (11)	22.38^{bc}±0.61 (12)	***
	Female	21.96^{a}±0.55 (17)	20.16^{b}±0.44 (15)	22.21^{a}±0.31 (33)	21.38^{a}±0.20 (37)	**
Body length (cm)	Male	47.93^{a}±1.40 (6)	37.14^{b}±1.26 (7)	45.09^{a}±1.62 (11)	43.42^{a}±1.56 (12)	**
	Female	40.76^{a}±1.16 (17)	37.19^{b}±0.90 (15)	40.58^{a}±0.77 (33)	40.57^{a}±0.61 (37)	*
Wing length (cm)	Male	24.42±2.08 (6)	22.29±1.13 (7)	25.82±1.25 (11)	26.29±0.70 (12)	NS
	Female	23.94±0.87 (17)	22.87±0.83 (15)	24.03±0.49 (33)	24.03±0.60 (37)	NS
Bill length (cm)	Male	7.08±0.28 (6)	6.30±0.21 (7)	7.21±0.19 (11)	6.73±0.24 (12)	NS
	Female	6.91^{a}±0.12 (17)	6.01^{b}±0.15 (15)	6.63^{a}±0.10 (33)	6.59^{a}±0.08 (37)	***
Shank circumference (cm)	Male	4.26^{a}±0.28 (6)	3.42^{b}±0.22 (7)	4.04^{a}±0.15 (11)	4.03^{a}±0.13 (12)	*
	Female	4.39^{a}±0.13 (17)	3.63^{c}±0.10 (15)	3.96^{b}±0.03 (33)	3.99^{b}±0.07 (37)	**
Shank length (cm)	Male	6.88±0.38 (6)	6.05±0.16 (7)	6.93±0.28 (11)	6.84±0.16 (12)	NS
	Female	6.77±0.20 (17)	6.31±0.18 (15)	6.51±0.19 (33)	6.46±0.11 (37)	NS

[1] values in the parentheses indicate the number of observations.
[2] different superscripts in the same row within a trait differ significantly at *= P<0.05, **= P<0.01 and ***= P<0.001; NS = Non-significant (P>0.05).

ved among the four genotypes for wing length and shank length trait. However, bill length was highly significant among the four genotypes (P<0.01) in female while it was non-significant in males. The highest body length was found in exotic Pekin ducks and the lowest was in Nageswari ducks while the two crossbreds placed in intermediate position with insignificant differences.

3. Growth Performances

Growth performances of Pure Nageswari, Pekin and their reciprocal crossbreds under intensive management up to 12th week of age are presented in Table 5. Growth performances were highly significant among the genotypes (P<0.001). As expected, pekin ducks had the highest growth performance throughout the experimental period while Nageswari attained the lowest live weight among the 4 genotypes during the stipulated time. The average live weights of Pekin, Nageswari and two other crossbreds (P♂ × N♀ and N♂ × P♀) at day old and 12th week of age were 46.06±0.64 and 2038.35±29.74; 37.93±0.60 and 1542.44±33.61; 46.52±0.85 and 1851.85±28.59 and 42.18±0.48 and 1691.08±27.80 g, respectively. It is notable to mention that the P♂ × N♀ crossbred occupied 2nd position next to Pekin for growth performance. At marketing age (12th week), Pekin and P♂ × N♀ F_1 crossbred gained about 500 g and 250 g more live weights, respectively, than pure Indigenous Nageswari duck of Bangladesh. In addition, the mortality rate was found only 3.98% up to 12th week of age (data not shown).

4. Meat Yield Characteristics

In total, 15 different meat yield parameters were investigated in this study and are presented in the Table 6. All of the considered traits varied significantly among the 4 genotypes except the traits' liver and gizzard weight. The average eviscerated hot carcass weight of Pekin (1082.75±43.20 g) and two other crossbreds (1033.75±60.68 and 1031.25±48.85 g, respectively) had highly significant differences with Nageswari ducks (774.50±38.98 g). Accordingly, the dressing % was non-significant among the three genotypes (Pekin, P♂ × N♀ and N♂ × P♀) but differed significantly with Nageswari duck.

Table 5. Growth performance of Pekin and Nageswari and their crossbreds (F_1) under intensive management condition up to 12th week of age

Age	Live weight (Mean ± SE)[1]				Level of significance[3]
	Pekin (P)	Nageswari (N)	P♂ × N♀	N♂ × P♀	
DOD[2]	46.06^{a}±0.64 (50)	37.93^{c}±0.60 (42)	46.52^{a}±0.85 (108)	42.18^{b}±0.48 (101)	***
2nd week	318.66^{a}±7.03 (50)	219.90^{c}±7.9 (42)	305.16^{a}±5.87 (108)	287.11^{b}±5.30 (101)	***
4th week	769.98^{a}±15.75 (49)	492.29^{c}±21.89 (42)	606.88^{b}±15.74 (108)	577.93^{b}±15.74 (101)	***
6th week	1,085.24^{a}±19.36 (49)	674.39^{d}±24.05 (41)	950.72^{b}±13.63 (106)	888.31^{c}±14.62 (99)	***
8th week	1,538.37^{a}±23.18 (49)	1,005.60^{d}±27.62 (40)	1,357.90^{b}±20.15 (106)	1,244.34^{c}±20.19 (99)	***
10th week	1,839.84^{a}±34.54 (49)	1,359.05^{d}±25.12 (40)	1,718.65^{b}±24.46 (101)	1,588.61^{c}±25.80 (99)	***
12th week	2,038.35^{a}±29.74 (40)	1,542.44^{d}±33.61 (36)	1,851.85^{b}±28.59 (86)	1,691.08^{c}±27.80 (76)	***

[1] Live weight in gram, number in the parentheses represents the number of observations.
[2] DOD= day old duckling.
[3] Different superscripts in the same row differ significantly for different weeks of age at ***= P<0.001 level of significance.

Table 6. Meat yield characteristics of Pekin and Nageswari and their crossbreds at 12th week of age

Trait[1]	Pekin (P) [n=4]	Nageswari (N) [n=4]	P ♂ × N ♀ [n=4]	N ♂ × P ♀ [n=4]	Level of significance[2]
Average live weight (g)	1,792.50^{a}±61.32	1,303.00^{b}±59.27	1,655.00^{a}±103.15	1,640.50^{a}±65.30	***
Neck weight with skin (g)	152.75^{a}±6.97	112.75^{b}±5.51	131.25^{ab}±9.17	143.25^{a}±5.63	**
Carcass weight without giblet (g)	1,082.75^{a}±43.20	774.50^{b}±35.98	1,033.75^{a}±60.68	1,031.25^{a}±48.85	**
Dressing (%)	60.37^{ab}±0.60	59.47^{b}±1.14	62.52^{a}±0.68	62.82^{a}±0.87	*
Heart weight (g)	10.50^{ab}±0.65	8.00^{b}±0.41	11.00^{a}±0.91	13.00^{a}±1.22	**
Liver weight (g)	28.00±2.48	24.75±1.93	28.00±2.27	26.50±0.29	**NS**
Gizzard weight (g)	45.75±2.2	40.50±2.02	41.25±4.11	42.75±2.17	**NS**
Back half weight (g)	392.25^{a}±12.86	310.50^{b}±16.35	396.25^{a}±25.52	406.25^{a}±16.23	**
Drumstick with thigh weight (g)	252.75^{a}±13.37	195.75^{b}±10.18	252.75^{a}±21.39	272.00^{a}±10.86	*
Drumstick weight (g)	134.75^{a}±8.68	105.25^{b}±9.18	141.75^{a}±4.55	133.00^{a}±7.91	*
Thigh weight (g)	117.25^{ab}±5.07	90.00^{b}±4.49	113.00^{ab}±17.14	136.00^{a}±4.43	*
Wing weight (g)	179.75^{a}±8.19	130.75^{b}±6.24	168.75^{a}±7.36	163.75^{a}±7.30	**
Back weight (g)	139.25^{a}±4.00	113.75^{b}±6.94	141.00^{a}±11.40	134.50^{ab}±7.17	*
Breast meat weight (g)	299.25^{a}±24.19	183.50^{b}±7.19	263.75^{a}±19.06	267.00^{a}±20.03	**
Keel bone length (cm)	12.75^{a}±0.43	11.13^{c}±0.24	12.40^{ab}±0.33	11.52^{bc}±0.21	**

[1] Values in the parentheses indicate the number of observations
[2] Different superscripts in the same row within a trait differ significantly at *= P<0.05, **= P<0.01 and ***= P<0.001; NS = Non-significant P>0.05).

In addition, the significantly contributed meat yield traits like back half weight, drumstick with thigh weight, drumstick weight, thigh weight, wing weight and breast meat weight had insignificant differences among the Pekin, P♂ × N♀ and N♂ × P♀ genotypes. The drumstick with thigh weight was found 272.00±10.86, 252.75±13.37, 252.75±21.39 and 195.75±10.18 g in N♂ × P♀, Pekin, P♂ × N♀ and Nageswari ducks, respectively. However, breast meat yield, wing weight and hot carcass weight without giblet was found higher in Pekin duck.

DISCUSSION

Crossbreeding experiment have been performed across the world utilizing different duck populations for harnessing the heterosis effect in crossbreds. But those type of experiments are scare particularly in Bangladesh that limits to compare our results with previous literature. To our knowledge, this study is the first report involving P, N and their reciprocal crossbreds under intensive management condition of Bangladesh. The appearance of P × N F_1 crossbreds was almost similar with N ducks with some variations in the web, shank, wing and breast regions. This is might be due to influence of dominant E locus as black color dominant over white color in mammals and birds. Our result is similar with the findings of Lin et al. (2014) who reported Putian black colored duck exhibited full expression of extended black (E gene) over white and multi-colored egg type Chinese duck breeds. E locus is controlled by at least 11 different multiple alleles those involve in the plumage colors and patterns of domestic fowl (Crawford, 1990) that corroborates the present findings. In addition, the c.52 G>A and c.376 G>A substitutions of *MC1R* gene associated with extended black variants (E allele) in domestic duck (Yu et al., 2012) and the reconstructed haplotype (AAGC) of this gene showed association with the plumage color of Nageswari duck that possessed an extended black phenotype (Sultana et al., 2017). All of the previous studies reported that the black phenotype in domestic ducks is caused by a gain of function mutation in the extended black (E) locus which harbored by the *MC1R* gene.

All of the morphometric traits of this study varied significantly among the genotypes except shank and wing length in both males and females. Similar to our findings, Henrik et al. (2018) reported that reciprocal crosses increased the morphometric measurements in Indonesian local duck populations. They found that body weight, chest circumference, body length and neck length were highly significant (P<0.01) among Indonesian Tegal, Megalang and their crossbred ducks. Kokoszyński et al. (2019) found significant differences in all body measurement traits like neck length, trunk length, chest circumference, keel length, thickness of breast muscles, drumstick length and shank length among three lines of Pekin ducks at 49th day of age and is consistent to the present findings. According to Yakubu et al. (2011), the morphometric traits like body weight, neck length, foot length and thigh circumference differed significantly between two Muscovy populations and supports this study. Padhi and Sahoo (2012) found significant differences (P<0.05) for shank and keel length among Indigenous, Khaki Campbell, White Pekin and their crossbreds. They observed positive heterosis (%) estimates for these two parameters. Altogether, earlier studies showed that diallel and reciprocal crossing had positive effects on morphometric traits in different duck breeds.

Similar to the findings of this study, Heo et al. (2015) reported that weekly live weight of two commercial Korean native ducks and their reciprocal crossbreds differed significantly (P<0.05) except 2nd week of age. However, their average live weights were significantly higher as compared to this study at 2, 4, 6, and 8 weeks of age to be 625, 1,617, 2,466, and 2,836 g, respectively. These differences might be attributed with breed or genotype, quantity and quality of supplied feed. The weekly live weight of three Pekin lines differed significantly in both sexes up to 7th week of age except the 2nd week of age. Apart from this, greater paternal influences have been observed in most crossbred ducks during 6th to 8th week of age for growth rate and meat yield characteristics (Górska et al., 2014) and is similar to this study where Pekin male mediated P♂ × N♀ crossbred had better yield than the N♂ × P♀ genotypes. Prasetyo and Susanti (2000) reported that crossbreeds between Alabio and Mojosari duck breeds of Indonesia had potential in improving growth performance and production traits and supports our findings.

Pekin is mainly raised for meat production and the main

goal for crossing ducks with this breed is to improve meatiness (Kokoszynski and Bernacki, 2011; Xie et al., 2014). In a crossbreeding study with Pekin, Deshi and Jinding ducks, the breast meat yield was found significantly higher (P<0.05) in (Pekin × Pekin) than that of (Pekin × Deshi) and (Pekin × Jinding) crossbreds (Ansary et al., 2008) and is consistent with the present study. Similar to the present findings, Kokoszyński et al. (2019) found significant effects on preslaughter body weight, carcass weight, breast muscle yield, neck weight, liver weight and gizzard percentage among the three lines of Pekin ducks. Pekin derived crossbred ducks had better growth rate and meat yield characteristics like breast muscle yield, leg muscle yield and muscle yield in carcass at 8 weeks age (Padhi and Sahoo, 2012; Górska et al., 2014) and support the present results. In conclusion, considering growth, morphology and meat yield characteristics, our results suggested the P♂ × N♀ F_1 crossbreds could be an alternative genotype for better meat producing duck in Bangladesh. This crossbred genotype possesses 50% native inheritance and therefore, adaptability would be expected higher under hot and humid conditions of Bangladesh compared to exotic Pekin duck.

ACKNOWLEDGEMENTS

The authors acknowledge the financial support of Bangladesh Bureau of Educational Information and Statistics (BANBEIS), Ministry of Education (ID. No. LS2018707) for conducting this research.

ORCID

Md. Tanvir Ahmad https://orcid.org/0000-0002-1951-3899
Dristi Nandita https://orcid.org/0000-0002-7683-4875
Tanvir Mohammad Maruf https://orcid.org/0000-0002-8143-3398
Mohammad Hasanuzzaman Pabitra https://orcid.org/0000-0003-1103-5973
Sabrina Islam Mony https://orcid.org/0000-0002-5363-8687
Md. Shawkat Ali https://orcid.org/0000-0001-9300-4294
Md. Sarwar Ahmed https://orcid.org/0000-0002-2719-973X
Mohammad Shamsul Alam Bhuiyan https://orcid.org/0000-0003-1525-2182

REFERENCES

Ansary E, Mahiuddin M, Howlider MAR, Hai MA 2008 Meat production potential of different cross-bred ducklings. Bang J Anim Sci 37(2):82-88.

Bhuiyan MSA, Mostary DS, Ali MS, Hussain MM, Ferdaus AJM 2017 Performances of Nageswari duck of Bangladesh under intensive management condition. Bang J Anim Sci 46(3):198-205.

Brun JM, Mialon MM, Sellier N, Brillard JP, Rouvier R 2012 Inheritance of duration of fertility in female common ducks (*Anas platyrhynchos*) inseminated in pure breeding or in inter-generic crossbreeding with Muscovy drakes (*Cairina moschata*). Animal 6(11):1731-1737.

Crawford RD 1990 Poultry Breeding and Genetics. 1st ed. Elsevier, New York.

DLS 2019 Department of Livestock Services. Ministry of Fisheries and Livestock. Government of the People's Republic of Bangladesh, Dhaka.

FAOSTAT 2019 Food and Agriculture Organization Corporate Statistical Database. Statistics Division, Food and Agriculture Organization of the United Nations, 00153 Rome, Italy.

Ferdaus AJM, Bhuiyan MSA, Bhuiyan AKFH, Ali MS, Hassin BM, Howlider MAR 2015 Reproductive potentials, meat yield and egg quality characteristics of indigenous dwarf chicken of Bangladesh. Asian J Med Biol Res 1(3):416-423.

Górska A, Górski J, Mróz E 2014 Effect of inter-strain crossbreeding in diallele design (4 × 4) on growth, weight of carcass and weight of basic groups of muscles in Pekin duck crossbreds. Europ Poult Sci 78:1-13.

Heo KN, Hong EC, Kim CD, Kim HK, Lee MJ, Choo HJ, Choi HC, Mushtaq MMH, Parvin R, Kim JH 2015 Growth performance, carcass yield, and quality and chemical traits of meat from commercial Korean Native ducks with 2-way crossbreeding. Asian- Australas J Anim Sci 28(3):382-390.

Henrik, Purwantini D, Ismoyowati 2018 Morphometrics and

genetic diversity of Tegal, Magelang and their crossbred ducks based on *Cytochrome b* gene. J Indonesian Trop Anim Agric 43(1):9-18.

Huque QME, Sultana N 2003 Organic duck farming in Bangladesh and entrepreneurship development. Pages 279-287 In: Proceedings of 3rd International Poultry Show and Seminar, World's Poultry Science Association, Bangladesh Branch.

Khanum J, Chwalibog A, Huque KS 2005 Study on rural duck production systems in selected areas of Bangladesh. Livestock Res Rur Dev 17:113.

Kokoszyński D, Wasilewski R, Saleh M, Piwczyński D, Arpášová H, Hrnčar C, Fik M 2019 Growth performance, body measurements, carcass and some internal organs characteristics of Pekin ducks. Animals 9(11):963.

Kokoszyński D, Bernacki Z 2011 Comparison of meat performance of Pekin ducks from two conservative flocks. J Cent Eur Agric 12(1):215-225.

Lin RL, Chen HP, Rouvier R, Poivey JP 2014 Selection and crossbreeding in relation to plumage color inheritance in three Chinese egg type duck breeds (*Anas platyrhynchos*). Asian Australas J Anim Sci 27(8):1069-1074.

Matitaputty PR, Wijaya CH, Bansi H, Laudadio V, Tufarelli V 2015 Influence of duck species and cross-breeding on sensory and quality characteristics of Alabio and Cihateup duck meat. J Food 13(4):522-526.

Microlivestock 1991 Little Known Small Animals with a Promising Economic Future. The National Academies Press, Washington DC, USA.

Morduzzaman M, Bhuiyan AKFH, Rana M, Islam MR, Bhuiyan MSA 2015 Phenotypic characterization and production potentials of Nageswari duck in Bangladesh. Bang J Anim Sci 44 (2): 92-99.

Padhi MK 2010 Production benefits of the crossbreeding of indigenous and non-indigenous ducks growing and laying period body weight and production performance. Trop Anim Health Prod 42:1395-403.

Padhi MK, Sahoo SK 2012 Performance evaluation and crossbreeding effects for body weight and conformation traits in different breeds of ducks. Indian J Anim Sci 82(11):1372-1376.

Pervin W, Chowdhury SD, Hasnath MR, Khan MJ, Ali MA, Raha SK 2013 Duck production strategy and profile of duck farmers in the coastal areas of Bangladesh. Livestock Res Rur Dev 25(7).

Prasetyo LH, Susanti T 2000 Reciprocal crosses between Alabio and Mojosari ducks: early egg production. Jurnal Ilmu Ternak dan Veteriner 5(4):210-214.

SAS 2009 Statistical Analysis System User's Guide, version 9.1.3, SAS Institute Inc, Cary, NC, USA.

Sultana H, Seo DW, Park HB, Choi NR, Hoque MR, Bhuiyan MSA, Heo KN, Lee SH, Lee JH 2017 Identification of MC1R SNPs and their association with plumage colors in Asian duck. J Poult Sci 54(2):111-120.

Xie M, Jiang Y, Tang J, Wen ZG, Huang W, Hou SS 2014 Effects of stocking density on growth performance, carcass traits, and foot pad lesions of white Pekin ducks. Poult Sci 93(7):1644-1648.

Yakubu A, Kaankuka FG, Ugbo SB 2011 Morphometric traits of Muscovy ducks from two agro-ecological zones of Nigeria. Tropicultura 29(2):121-124.

Yu W, Wang C, Xin Q, Li S, Feng Y, Peng X, Gong Y 2012 Non-synonymous SNPs in MC1R gene are associated with the extended black variant in domestic ducks (Anas platyrhynchos). Anim Genet 44(2):214-216.

Received Mar. 31, 2021, Revised May 1, 2021, Accepted Jun. 14, 2021