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Body Conformation, Morphometry Indices and Inheritance Pattern of Indigenous Dwarf Chickens of Bangladesh

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ABSTRACT

The study was conducted to investigate the body dimension, morphometric features and inheritance pattern of indigenous dwarf chicken (IDC) of Bangladesh under intensive management condition. The experiment was conducted at Bangladesh Agricultural University (BAU) poultry farm for a period of 28 months from March 2013 to June 2015 including a total of 979 birds. Body weight, shank length and circumference, chest girth, length of trunk, wing, keel and body, and body conformation indices were recorded at 8, 24 and 52 weeks of age. The average shank length, shank circumference and live weight at 24th week in adult dwarf males and females were 7.38 and 4.37 cm, 6.20 and 3.63 cm, and 1650 and 1067 g, respectively. The reduction of live weight for dwarf male and female chickens relative to their normal shank counterpart (NSC) at same age was 14.06 and 16.05%, respectively. Length of body, trunk, wing, shank and keel of IDC were also significantly shorter than NSC at all ages. The indices of shape, massiveness and long leggedness of NSC were significantly greater than IDC almost all ages. Shank lengths of day old chicks were measured within 1.4-1.6 cm. The ratio of non-dwarf and dwarf in indigenous chicken populations was found 9:7 for 1st generation where significant deviation observed in subsequent generations. Among the dwarf progeny, the male and female ratio was close to 1:1. Current hypothesis is in favor of autosomal dwarfism control by at least 2 pairs of genes where duplicate recessive gene interaction also known as complementary gene effect has probably been exerted between two pairs of genes. In conclusion, the present estimates give some insight information on morphometry and body conformational aspects between normal shanked and dwarf chickens which relate with lowered motoric activity, reduced metabolic rate and their body surface-mass makes the dwarf birds suitable for hot-humid climate like Bangladesh.

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Introduction

Indigenous chicken contributes to rural livelihood, woman empowerment, food security, and still remains main genetic resource of Bangladesh. About 89 % of rural households keep indigenous chicken with an average flock size of 5.33 per holding under backyard scavenging system (Bhuiyan et al., 2013). The preferences of indigenous chicken are for pigmentation, taste, leanness, firmness, flavor and suitability for special dishes and even consumers have willingness to pay more money for the products from indigenous chicken (Islam and Nishibori, 2009). Although indigenous chickens have lower in productivity but they are well adapted to tropical hot-humid climatic condition and better scavenger (Islam et al., 1981). For effective conservation and utilization of available poultry genetic resources, phenotypic characterization should be prioritized (FAO, 2012). Maciejowski and Zeiba (1982) reported that morphometric traits such as shank length and diameter were indicators of leg development while body girth was an indicator of breast development. According to Olawunmi et al. (2008), characterization of indigenous chickens is a necessary pre-requisite for indigenous breed development and the development of rural poultry.

Cole (1973) first described autosomal dwarf (*adw*) chicken and its inheritance. Dwarfing inheritance among the chickens is of interest to the scientists for their numerous pleiotropic effects (Chen et al., 2009). Dwarfing suppress adult weight and feed consumption without affecting egg production and quality and increased heat tolerance (Horst et al., 1996). Pandey (1996) estimates that dwarf chickens have a commercial potential for poultry breeding. Indigenous dwarf chicken is found very few in number throughout the country. However, the potentiality of *adw* gene was not sufficiently explored for improving economic traits of indigenous chicken of Bangladesh. Therefore, it becomes imperative to search an observation for the presence of dwarfing genotypes and their inheritance pattern. Notably, in Bangladesh, the inheritance and influence of dwarfism were tested by Yeasmin and Howlider (1998) using only few individuals. So far, there was very limited information about body dimension and inheritance indices and pattern on dwarf chickens in Bangladesh. Therefore, the objective of this study is to investigate the body dimension, conformation indices and inheritance pattern of Bangladeshi indigenous dwarf chicken under intensive management condition.

Materials and Methods

The experiment was carried out at BAU Poultry farm for a period of 28 months from March 2013 to June 2015 including a total of 979 birds. Initially, 12 cocks and 48 hens of indigenous dwarf chicken were collected from different localities based on their phenotypes as foundation stock. The flock had been reared and multiplied up to 3rd generation to conduct this experiment. The number of birds investigated in G_1, G_2 and G_3 generations were 536, 52 and 93, respectively. The hatching eggs were incubated at BAU poultry farm. Day old chicks were wing banded and brooded separately with a stocking density of 100 cm^2/ chick. All birds were vaccinated and medicated regularly. Flocks were being maintained under same feeding and intensive management practices.

Measures of live weight and morphometric traits were taken using a weighing balance and a measuring tape for all experimental chickens. The following metric measures (FAO, 2012) were recorded (cm): body length (distance from the tip of the beak, through the body trunk to the tail), wing length (length of the wing from the shoulder joint to the last digit of the wing), shank length (length of the tarso-metatarsus from the hock joint to the metatarsal pad), shank circumference, drumstick length, thigh length (the length from the knee joint to the hock joint), the sternum or carina length, chest girth (the circumference of sternum), comb length (horizontal distance from the beginning to the end of the base of the comb), trunk length (from the base of the neck to the base of the tail). Therefore, measurements were taken only from birds of ages 8, 24 and 52 weeks. All measurements were taken by the same person to minimize human error.

Live weight and body measurement values at 8, 24 and 52 weeks old chickens were calculated the body conformation indices (Kokoszynski et al., 2012) of massiveness (percentage ratio of weight in kg to trunk length, in cm), compactness (percentage ratio of chest circumference to trunk length, in cm) and long-leggedness (percentage ratio of shank length to body length, in cm). Measurements on body weights and various body dimensions were individually collected from the chicken. The formulae used to calculate the body shape index and body mass index (BMI) are given below:

$$\text{Shape Index} = \frac{\text{Shank length (cm)}}{\sqrt[3]{\text{Body weight (kg)}}} \text{ (Guillaume, 1976)}$$

$$\text{BMI} = \frac{\text{Body weight (g)}}{(\text{Body length (cm)})^2} \text{ (Mendes et al., 2007)}$$

An assortative mating was followed during the experimental period. Reciprocal crosses between Indigenous dwarf chicken (IDC) and their normal shank counterparts (NSC) were performed among the progenies of foundation stock. Normal shank progenies of foundation stock were also intercrossed to know the dwarf inheritance. Thus, extra 297 chicks were used to confirm the pattern of dwarf inheritance. Dwarfism in chickens was identified at 8 weeks of age with morphological symptoms described by Cole (2000). The dwarfs can usually be recognized by a combination of three criteria. Those consist of low body weight, a somewhat shortened shank, and a compact conformation of the body. Least-squares means and standard errors (SE) of body weights, various body measurements and indices were calculated using the SAS 9.1.3 (Statistical Analysis System, 2002-03) software.

Results

Morphometric Measurements

Body dimensions and morphometry of indigenous dwarf male (IDM) and female (IDF) chickens and their normal shanked counterparts at the age of 8, 24, 52 weeks are presented in Table 1 and Table 2. The results showed that the average shank length of both IDM and IDF were generally lower ($P<0.001$) at all ages. Length of body, trunk, wing and sternum or carina of IDF were also shorter than those of normal shanked female (NSF) at all ages ($P<0.001$). Shank circumferences of both sexes of IDC were wider than that of NSC at 8, 24 ($P<0.001$) and 52 ($P<0.05$) weeks. Chest girth was higher ($P<0.001$) in NSC of both sexes at 8th week. Trunk and body length of IDM were smaller than those of normal shanked male (NSM) at 8, 24 ($P<0.001$) weeks of rearing but was non-significant at 52th week. Body lengths of NSM and NSF were higher ($P<0.05$) compared to IDC at the aforementioned ages. Wing length of IDM was shorter than NSM at 24 ($P<0.001$) and 52 ($P<0.05$) weeks of age where sternum length of NSM was higher ($P<0.05$) at 24 weeks of rearing.

Body Conformation Indices

Body conformation indices of IDM and IDF and their normal shanked counterparts at 8, 24, 52 weeks are given in Table 3 and Table 4. Though body mass index (BMI) of IDC and NSC was not statistically significant, it was reduced in dwarf chicken by 2.05-4.51%. Massiveness index of NSM was higher ($P<0.01$) than that of IDM at 8, 24 weeks of age and it was higher in NSF than those of IDF at 8th ($P<0.05$), 24th and 52nd ($P<0.001$) week. Compactness index was higher in IDM ($P<0.05$) and IDF ($P<0.01$) than their NSC at all ages. The indices of shape and long leggedness in NSM and NSF were greater than in the dwarf birds in almost all ages.

Table 1. Body conformation and morphometry of indigenous dwarf male chicken and their normal shanked contemporaries at different age

Trait	Age (week)	Mean ± SE IDM (n[1])	Mean ± SE NSM (n[2])	Reduction† (%)	Significance level
Shank length (cm)	8	5.06±0.04	6.21±0.05	18.52	***
	24	7.38±0.06	9.17±0.07	19.52	***
	52	7.5±0.07	9.5±0.05	21.05	***
Trunk length (cm)	8	11.2±0.08	12.59±0.09	11.04	***
	24	20.87±0.12	22.40±0.22	6.83	***
	52	21.45±0.53	22.88±0.46	6.25	NS
Chest girth (cm)	8	18.26±0.12	20.18±0.13	9.51	***
	24	34.04±0.44	35.27±0.69	3.49	NS
	52	35.26±0.67	36.55±0.41	3.53	NS
Comb length (cm)	8	-	-		
	24	10.88±0.18	11.03±0.21	1.36	NS
	52	12.61±0.31	13.41±0.23	5.97	NS
Body length (cm)	8	23.87±0.17	25.87±0.20	7.73	***
	24	44.50±0.32	46.72±0.26	4.75	***
	52	46.23±0.64	48.21±0.13	4.11	*
Wing length (cm)	8	-	-		
	24	17.18±0.19	18.55±0.16	7.39	***
	52	18.25±0.28	19.52±0.54	6.51	*
Sternum length (cm)	8	-	-		
	24	17.62±0.17	18.28±0.16	3.61	*
	52	18.76±0.19	19.20±0.12	2.29	NS
Shank circumference (cm)	8	2.96±0.01	2.68±0.02	-10.45	***
	24	4.37±0.05	4.10±0.03	-6.59	***
	52	4.69±0.07	4.49±0.05	-4.45	*

IDM-Indigenous Dwarf Male, NSM-Normal Shanked Male, SE-Standard Error, NS P>0.05, *P<0.05, ***P<0.001; n^1– 114, 25, 15 birds of IDM and n^2- 90, 15, 10 birds of NSM at 8, 24, 52 weeks of age; †-(Normal shanked-dwarf)/normal shanked x 100%

Table 2. Body conformation and morphometry of indigenous dwarf female chicken and their normal shanked contemporaries at different age

Trait	Age (week)	Mean ± SE IDF (n[1])	Mean ± SE NSF (n[2])	Reduction† (%)	Significance level
Shank length (cm)	8	4.65±0.04	5.85±0.05	20.51	***
	24	6.20±0.04	8.48±0.06	26.89	***
	52	6.28± 0.04	8.76± 0.03	28.31	***
Trunk length (cm)	8	9.58±0.02	10.37±0.06	7.62	***
	24	16.33±0.07	17.38±0.15	6.04	***
	52	17.48±0.06	18.75±0.17	6.77	***
Chest girth (cm)	8	16.34±0.06	17.33±0.10	5.71	***
	24	28.42±0.24	29.06±0.47	2.20	NS
	52	29.39±0.28	30.27±0.56	2.91	NS
Comb length (cm)	8	-	-		
	24	4.49±0.06	4.48±0.17	-0.22	NS
	52	5.12± 0.09	5.16±0.18	0.78	NS
Body length (cm)	8	22.51±0.15	24.13±0.13	6.71	***
	24	37.32±0.12	40.29±0.25	7.37	***
	52	38.26 ± 0.18	42.17±0.34	9.27	***
Wing length (cm)	8	-	-		
	24	14.61±0.07	16.60±0.15	11.99	***
	52	14.88 ± 0.10	17.76±0.18	16.22	***
Sternum length (cm)	8	-	-		
	24	15.05±0.08	15.82±0.19	4.87	***
	52	15.46 ± 0.11	16.69±0.12	7.37	***
Shank circumference (cm)	8	2.71±0.01	2.53±0.02	-7.11	***
	24	3.63±0.02	3.35±0.04	-8.36	***
	52	3.69± 0.03	3.60± 0.01	-2.50	*

IDF- Indigenous Dwarf Female, NSF-Normal Shanked Female, SE-Standard Error, NS P>0.05, *P<0.05, ***P<0.001; n^1– 134, 70, 60 birds of IDF, and n^2- 84, 24, 21 birds of NSF at 8, 24, 52 weeks of age; †-(Normal shanked-dwarf)/normal shanked x 100%

Table 3. Exposer of dwarfism by differentiation of body conformation indices between indigenous male dwarf chicken and their normal shanked contemporaries

Trait	Age (week)	Mean ± SE		Reduction† (%)	Significance level
		IDM (n^1)	NSM (n^2)		
Body mass index	8	0.798±0.02	0.823±0.01	3.04	NS
	24	0.831±0.01	0.869±0.02	4.37	NS
	52	0.945±0.03	0.970±0.02	2.58	NS
Massiveness index	8	4.05±0.08	4.36±0.05	7.11	**
	24	7.89±0.13	8.55±0.19	7.72	**
	52	9.40±0.19	9.90±0.34	5.05	NS
Compactness index	8	163.18±0.58	160.68±0.89	-1.56	*
	24	163.06±1.82	157.31±2.06	-3.66	*
	52	164.74±1.38	160.04±1.82	-2.94	*
Long leggedness index	8	21.25±0.16	24.05±0.16	11.64	***
	24	16.58±0.05	19.63±0.09	15.54	***
	52	16.27±0.27	19.71±0.20	17.45	***
Shape index	8	663.63±1.99	758.78±3.26	12.54	***
	24	625.36±3.17	739.53±4.07	15.44	***
	52	594.99±4.74	725.10±4.82	17.94	***

IDM-Indigenous Dwarf Male, NSM-Normal Shanked Male, SE-Standard Error, NS P>0.05, *P<0.05, **P<0.01; ***P<0.001; n^1– 114, 25, 15 birds of IDM and n^2- 90, 15, 10 birds of NSM at 8, 24, 52 weeks of age; †-(Normal shanked-dwarf)/normal shanked x 100%

Table 4. Exposer of dwarfism by differentiation of body conformation indices between indigenous female dwarf chicken and their normal shanked contemporaries

Trait	Age (week)	Mean ± SE		Reduction† (%)	Significance level
		IDF (n^1)	NSF (n^2)		
Body mass index	8	0.762±0.01	0.780±0.02	4.51	NS
	24	0.766±0.005	0.782±0.003	2.05	NS
	52	0.792±0.006	0.812±0.005	2.46	NS
Massiveness index	8	4.08±0.08	4.35±0.09	6.21	*
	24	6.53±0.04	7.31±0.09	10.67	***
	52	6.62±0.02	7.70±0.09	14.03	***
Compactness index	8	170.61±0.68	167.21±0.82	-2.03	**
	24	173.77±0.82	167.19±2.34	-3.94	**
	52	168.04±1.19	161.35±2.38	-4.15	**
Long leggedness index	8	20.65±0.10	24.23±0.11	14.78	***
	24	16.63±0.10	21.04±0.04	20.96	***
	52	16.41±0.04	20.78±0.13	21.03	***
Shape index	8	638.62±1.53	769.24±8.12	16.98	***
	24	607.39±3.41	782.98±2.16	22.43	***
	52	598.26±3.67	775.17±2.51	22.82	***

IDF- Indigenous Dwarf Female, NSF-Normal Shanked Female, SE-Standard Error, NS P>0.05, *P<0.05, **P<0.01; ***P<0.001; n^1– 134, 70, 60 birds of IDF, and n^2- 84, 24, 21 birds of NSF at 8, 24, 52 weeks of age; †-(Normal shanked-dwarf)/normal shanked x 100%

Determination of Dwarfism by Shank Length

The findings from Table 5 indicated that the chicks of IDC could be identified by their short shank length also known as achondroplasia. The observations were quite evident at 8 weeks of age. All day old chicks (DOCs) were exposed later as dwarf chickens when the shank lengths varied between 1.4-1.6 cm at day zero. Accordingly, 92.5, 72.22, 25.64 and 8.33% DOCs were exposed as dwarf chickens when their shank length at day zero were found to be 1.7, 1.8, 1.9, and 2.0 cm, respectively. The DOC exhibiting shank length of more than 2.1 cm did not exhibit dwarfism related traits at 8 weeks of age. Shank length of IDM and IDF were found to be 5.06 and 4.65 cm while 6.21 and 5.85 cm shank length was measured for NSM and NSF at 8th week.

Inheritance Pattern

Inheritance pattern of IDC is shown in Table 6. We found a modified Mendelian phenotypic ratio among the dwarf and non-dwarf purebred chicks. Complementary gene effect was found in Indigenous dwarf chicken of 1st generation that 9:7 ratio was maintained between normal shank and dwarf chickens. This trend was also found in case of IDC♂ × NSC♀ and NSC♂ × IDC♀ genotypes. On the contrary, our findings based on χ^2 test indicated deviation of complementary gene effects in IDC of 2nd (P<0.05) and 3rd (P<0.01) generations. Among the dwarf progenies, the male and female ratios were close to 1:1. Complementary gene effect on the morphology of IDC could not be fully explored as current investigation was undertaken on a selective population. Remarkably, the population was non-random and flock size was small.

Table 5. Exposure of dwarfism by shank length at 8th week of age

Shank length of DOC (cm)	No. of DOC*	Mean ± SE (range)		Exposed as dwarf chick	
		Male chicks	Female chicks	No. of chicks	% dwarf chicks
1.4-1.6	136	5.06 ± 0.04 (4.3-5.6)	4.65 ± 0.04 (4.1-5.2)	136	100
1.7	80			74	92.50
1.8	36			26	72.22
1.9	39			10	25.64
2.0	24			2	8.33
2.1-2.4	107	6.21 ± 0.03 (5.9-7.1)	5.85 ± 0.03 (5.5-6.4)	Nil	0

*DOC-day old chick

Table 6. Inheritance pattern of indigenous dwarf chicken of Bangladesh

Genotype	Total chicks (n)	Normal shanked chicks (n)	Dwarf chicks (n)	(%)	Female dwarf (%)	Male dwarf (%)	χ^2 value for complementary gene effect$^{\beta}$ (9:7)
IDC							
G_1	536	288	248	46.27	54.03	45.97	$(1.28)^{NS}$
G_2	53	23	30	56.60	53.33	46.67	(4.89)*
G_3	93	38	55	59.14	43.64	56.36	(8.95)**
IDC×NSC†	119	61	58	48.74	56.90	43.10	$(1.20)^{NS}$
NSC×IDC†	106	56	50	47.17	54.00	46.00	$(0.50)^{NS}$
NSC×NSC†	72	70	2	2.78	50.00	50.00	$(0.05)^{NS}$
Total	979	536	443				

$^{\beta}$ -Irrespective of sex, χ^2 test was done in between normal shanked chicken and dwarf counterparts, †-progenies of G_1 of indigenous dwarf chicken, G-Generation, IDC-Indigenous dwarf chicken, NSC-Normal shanked counterparts (heterozygous) of IDC, NS = not significant, * and **= level of significance at 0.05 and0.01 %, respectively.

Discussion

Morphometric Measurements

The reduction of body length of IDM and IDF were 4.11-7.75% and 6.71-9.27% than their normal shanked counterparts at different ages in the current study. Faruque et al. (2010) observed body length of indigenous male and female chickens were 43.64 and 37.03 cm which support the findings of present study. In this study, wing length of IDM and IDF were found to be 6.51-7.39% and 11.99-16.22% respectively. These lengths were lower than wing length of NSC. These observations are in consonance with the findings of Sarker et al. (2014) and Uddin et al. (2011) who reported that average wing length of indigenous chickens were 12.60 and 17.70 cm, respectively. The sternum or carina length of IDM and IDF were 2.29-3.61% and 4.87-7.37%, respectively. These measured values were reduced than sternum or carina length of NSC. Sarker et al. (2014) reported that sternum or carina length of indigenous chicken was 9.10 cm and was even lower than our study. Breed/type of chickens might be the major attributing factor for this variation. Trunk length of IDM and IDF was found to be 6.25-11.04% and 6.04-7.62%, respectively and these findings lower than NSC trunk length. Uddin et al. (2011) have found that the average trunk length of indigenous chicken was 22.25 cm like the current study. Chest girth of IDM and IDF were 3.53-9.51% and 2.20-5.71% reduced than their NSC counterparts in the present investigation. Sarker et al. (2014) have stated that the average chest girth of indigenous chicken was 29.98 cm at 30 weeks of age which was much closer to the current study.

Remarkable differences were found between shank lengths in IDC and NSC as well as between sexes of both genotypes at all ages in the current study. The shank lengths of the IDC were shorter by 18.52-28.31% when compared to their NSC at different ages in the present investigation. These findings partially supported with the reports of Kgwatalala et al. (2012) that they observed dwarf males and females had the shortest shanks. They found that sex had no significant influence on shank length between male and female of IDC but significant differences in shank lengths were observed at all ages between the normal and dwarf chicken (both sexes). The findings have also indicated that the differences in shank length were higher among the mature chickens which were in close agreement with the reports of Yeasmin and Howlider (2013). Hussain et al. (1982) observed the shank length in the dwarf and normal chickens to be 7.0 to 8.0 and 9.5 to 10.5 cm, respectively and are close to the present findings. Yeasmin and Howlider (1998) have reported that normal shanked adult hen always had higher shank length (7.7 cm) than that of dwarf hen (5.5 cm). Raut et al. (1996) observed that shank length in male and female dwarfs at 20 weeks were 6.0 and 5.1 cm, respectively. Petersen et al. (1977) found that shanks in dwarfs were shorter by 9.6 and 20.9%, respectively than in normal chicken at 5 and 20 weeks. Chen et al. (2009) observed that the reduction of shank length in dwarf chicken reached 19.4 and 21.7% of shank length of the normal chicken at 10 and 20 weeks of age, respectively.

Relatively wider shank circumference was observed in IDC (in both sexes) compared to NSC (in both sexes) at all ages. The findings also indicated that the shank circumferences of the dwarf chicken were wider (2.50-10.45%) when compared to their NSC across the different ages. However, Sarker et al. (2014) reported that shank circumference of indigenous chicken was 4.12 cm which coincides with the present study. Breed/Type of chicken might be the major attributing factor for this variation.

Body Conformation Indices

The results pertaining to the massiveness and long leggedness indices of dwarf chickens were 6.21-14.03% and 11.64-21.03% lower than their NSC at different ages in the current study. However, dwarf chickens were 1.56-4.15% more compact than their normal counterparts at different ages in the present investigation. Shape index was 12.54- 22.82% reduced in IDC than their NSC at different ages in the present study. Ricard (1970) reported that shape index had a similar value in dwarf and normal chickens when trunk was considered, while it is reduced by 12% when calculated on shanks. Shape index of female and male White Leghorn were 604 and 624 respectively at 8 weeks (Jaap, 1941) which was not significantly different from the current study.

Duplicate Recessive Epistasis (Complimentary Gene Effect)

When recessive alleles at either of the two loci can mask the expression of dominant alleles at the two loci, it is called duplicate recessive epistasis, also known as complementary epistasis. The typical 9:3:3:1 ratio for the inheritance of dihybrid cross is sometimes modified by different types of gene action like epistasis, linkage and crossing over. Complementary gene effect is one of the epistatic actions responsible for modifying the dihybrid ratio as 9:7 in plants and animals (Crew, 1925).

In our study, we found both dwarf and non-dwarf chicks in first generation that suggested the collected dwarf stock were heterozygous for dwarf alleles. Moreover, small sample size can result in random shift from the expected 9:7 ratio in the successive G_2 and G_3 generations. The deviations as observed in this study are in close accordance with those reported by Yeasmin and Howlider, (1998, 2013). In contrast, Cole (2000) reported a single autosomal recessive gene associated with dwarfism in Cornell K-strain of White Leghorns and is inconsistent to our results. We found both male and female dwarf chicks in our experiment which contradicts with sex-linked dwarfism in various chicken populations reported by Maw (1935); Godfrey (1953); Hutt (1953); Jaap (1971); Custodio and Jaap (1973); Hsu et al., (1975); Guillaume (1976), and Dunnington and Siegel (1984). In addition, the obtained non-dwarf and dwarf ratio among the experimental birds in three successive generations did not support the autosomal single gene dwarfism previously identified in different chicken populations (Cole, 1973 and 2000; Scanes et al., 1983, Leenstra and Pit, 1984; Erf et al., 1987). Such an appearance of normal and dwarf progenies indicates that the mode of expression of *adw* gene perhaps depends on the interaction with the background genomes. It implies that though *adw* gene is a recessive (major) and it's phenotypic expression seemed to be polyallelic in action. This mode of expression of *adw* gene as observed is in close accordance with the observation of Reddy and Siegel (1977); Wu et al. (1998); Decuypere et al. (1991). All of them reported variable effects of *adw/dw* gene on shank length and live weight in different breeds. Reddy and Siegel (1977) suggested variable effects of *dw* gene on growth and reproduction are largely dictated by specific interaction with the genotypic back ground and the presence of genetic modifiers. In another study Leenstra and Pit (1984) reported that the appearance of normal and dwarf progenies in equal ratio by crossing the normal and *adw* dwarf chickens. However, when they mated *adw* dwarf sires to normal hens reported ratios differed from the result of this study.

Our findings are supported by the inheritance of side-sprigs in single-comb White Leghorns investigated by Asmundson (1926), who found approximately a 9:7 ratio for this trait which is partially agreed with the current study. Previously, Yeasmin and Howlider (1998, 2013) reported the inheritance pattern of autosomal dwarfism in pure and crossbreeding experiments using indigenous dwarf chicken of Bangladesh. They reported 9:7 ratio in the offspring among the dwarf and non-dwarf chickens. Based on the above findings and those of the present study, it can be concluded that the autosomal dwarfism is controlled by at least 2 pairs of genes, these two pairs were duplicate recessive gene with interaction between the two genes observed in the studied traits. However, the hypothesis need to be further ascertained through further crossing experiments between the two genotypes.

Conclusion

The study revealed that dwarf chicken is characterized by shortened shank length, reduced body weight, as well as other body dimensions and conformation indices. But, wider shank circumferences and more compactness of the body are important criteria of dwarf chicken. The inheritance pattern between non-dwarf and dwarf was followed complementary gene action with a ratio of 9:7 which revealed that such type of autosomal dwarfism controlled by at least 2 pairs of genes with duplicate recessive gene interactions. It can be concluded that the considerable reduction of body mass and conformation and its general effect on lower motoric activity, reduced metabolic rate and their body surface-mass relation makes the dwarf birds suitable for hot-humid climate like Bangladesh.

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