Sex-linked Dwarf Gene for Broiler Production in Hot-humid Climates

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ABSTRACT : This review has been done to examine sex-linked dwarf gene in broiler production in hot-humid climates. Introduction of sex-linked dwarf gene especially in hot harsh tropical environments brings a great advantage for broiler production. The heavy broiler parent suffers due to the stress of these adverse climates. Sex-linked dwarf genes reduce body weight, egg weight, but are superior for adaptability under harsh tropical environments, with a lower requirement for housing and feed, better survivability and reproductive fitness giving fewer defective eggs, more hatching eggs, better fertility, hatchability, feed conversion efficiency and resistance to disease. Overall the cost of chick production from dwarf hens is lower than from their normal siblings. Market weights of broilers from sex-linked dwarf dams is almost similar to those of broilers from normal dams with normal sires. But the net benefit of broiler production from sex-linked dwarf dams is found to be greater than that of broilers from normal dams. This will be the most important to the rural communities in Bangladesh and in other countries where the similar environment and socio-economic conditions exist. Therefore, sex-linked dwarf hens might be used in broiler breeding plan as well as broiler production in the tropics. ***(Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 11 : 1662-1668)***

Key Words : Sex-linked Dwarf Gene, Adaptation, Reproductive Fitness, Chick Cost, Broiler, Growth, Profitability

INTRODUCTION

Poultry as well as broiler production is the simplest and shortest possible way to provide meat or egg to the human being. On the other hand broiler meat has already been got favorable to almost all classes of people throughout the World. Broiler or hybrid production started from the heavier breeds of Cornish and Plymouth Rock at temperate climate in America by 1923 (Latif, 1994). Now a day, broilers are rearing in both tropical and temperate climate as per need of the peoples. The day-old heavy broiler parents are imported and reared in the tropical region to produce fast growing broiler chicks where they suffer due to hot-humid climate, lower feed quality, non availability of medicine, vaccine, and non sophisticated management system. That is why they are poorer in production compared to the breeder standard, and farmers do not get optimum benefit. Generally in Bangladesh, broilers are sold as live because of consumer’s preference (Islam, 2000).

Considering the above points poultry scientists are thinking to incorporate sex-linked dwarf gene in broiler parents at tropical climate. A series of work has already been done on sex-linked dwarf gene and suggested to use it as broiler parent in the tropics for the advantages of adaptability to tropical environment, better productive and reproductive fitness, well resistant to disease (Jaap, 1969; Ricard, 1974; Horst, 1983; Oyabu et al., 1985; Horst, 1988; Dunnington and Siegel, 1998). The scientists are also interested to exploit dw gene for its numerous pleotropic effects on physiology, nutrition, behavior, pathology etc. (Ricard, 1974; Guillaume, 1976). Small size hen however laid small eggs as a constant correlation between body weight and egg weight (Jaap, 1971; Bernier and Arscott, 1972; Ricard and Cochez, 1972). Small size chicks are however come out from the small size egg of dwarf dam which has a negligible effect on broiler growth because of dw gene is not completely recessive (Chambers et al., 1972; Ricard, 1974). Practically the effect of egg weight on broiler weight is not a great handicap as mentioned above egg weight depression, can be reduced by genetic selection (Merat, 1970).

It has demonstrated that the broiler chicks may be produced from dwarf hen which is better for production, reproductive fitness, saving house and feed (Middelkoop, 1973; Ricard, 1974; Silber and Merat, 1974b).

Several studies have recommended that broiler production from dwarf breeders will be more profitable than the broilers from the normal breeders in the tropics (Jaap, 1969; Chambers et al., 1972; Johnson et al., 1973; Ricard, 1974; Islam, 2004).Therefore, the aim of the review is to produce broiler from dw dam with normal sire suited to hot-humid climate.

Dwarf gene

Dwarf genes are major genes described by the variability of body size. Two types of dwarf genes as autosomal dwarf (adw) is accompanied either by semi-lethality (cp) or by a poor hatchability (adw) or by very poor viability and hatchability (Cole, 1966), and sex-linked dwarf genes (dw) are located on the sex-chromosome, position of the locus dw was determined by Hutt’s 1959 and 1960. There are however two more genes (or alleles) that cause dwarfism without any marked effect on other

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Table 1. Mean and standard errors for performance traits of normal (Dw-) and dwarfs (dw-) layers

Trait	Brown population (LM)					
	l×l		m×m		h×h	
	Dw-	dw-	Dw-	dw-	Dw-	dw-
Body weight at 20 weeks (g/bird)	1,473±19.9	1,007±20.0	1,459±19.3	1,031±21.7	1,655±23.9	1,171±22.8
Body weight at 40 weeks (g/bird)	1,854±23.1	1,304±23.2	1,869±24.8	1,338±27.8	2,102±30.1	1,511±31.6
Shank length at 20 weeks (cm)	10.18±0.04	8.02±0.04	10.20±0.05	8.05±0.06	10.60±0.06	8.4±0.06
Shank length at 40 weeks (cm)	10.07±0.05	7.88±0.05	10.00±0.05	7.9±0.06	10.50±0.07	8.3±0.07
Total egg (no./bird)	251±4.53	212±4.52	247±4.89	212±5.50	244±5.29	222±5.03
Egg weight (g/egg)	57.4±0.37	54.1±0.37	57.6±0.38	54.7±0.43	58.7±0.43	56.2±0.41
Total egg mass (g)	14,443.3±30.1	11,493.2±30.2	14,255.5±28.0	11,657.2±32.0	14,371.2±31.7	12,516.2±30.2
Egg breaking strength (kg)	2.56±0.05	2.57±0.05	2.50±0.07	2.29±0.08	2.49±0.07	2.68±0.07
Yolk (%)	31.14±0.23	31.25±0.23	30.68±0.53	30.02±0.59	30.44±0.54	30.45±0.51
Albumen (%)	59.42±0.24	59.14±0.23	58.59±0.96	57.94±1.07	58.36±0.94	59.00±0.89
White population (LL)						
Body weight at 20 weeks (g/bird)	1,144±18.08	780±16.02	1,240±16.80	829±17.48	1,358±23.50	889±18.58
Body weight at 40 weeks (g/bird)	1,439±19.84	996±17.58	1,584±18.94	1094±19.69	1,711±2.83	1,177±21.23
Shank length at 20 weeks (cm)	9.68±0.05	7.55±0.04	9.80±0.04	7.89±0.04	10.27±0.06	8.03±0.04
Shank length at 40 weeks (cm)	9.50±0.05	7.48±0.04	9.80±0.04	7.6±0.04	10.14±0.06	8.03±0.05
Total egg (no./bird)	239±5.97	166±5.29	234±6.1	187±6.3	232±6.2	186±4.9
Egg weight (g/egg)	57.0±0.37	52.0±0.33	57.4±0.39	53.1±0.4	58.4±0.46	53.8±0.37
Total egg mass (g)	13,669.3±3.13	8671.0±2.77	13,485.6±2.97	9,947.5±3.09	13,588.4±4.37	10,021.4±3.46
Egg breaking strength (kg)	2.48±0.07	2.29±0.06	2.53±0.07	2.33±0.07	2.56±0.08	2.50±0.06
Yolk (%)	29.64±0.68	28.58±0.61	29.45±0.57	29.32±0.58	30.57±0.5	29.36±0.43
Albumen (%)	59.69±1.29	57.27±1.15	59.05±1.04	59.29±1.06	60.00±1.00	59.06±0.79

Source: Hussain et al. (1982), l = light weight group, m = medium weight group, h = heavy weight group, Laying period = 56 weeks.
Temperature = 22-34°C, Humidity = 60-80% (during experimental period).

Table 2. Performance comparison between normal (Dw-) and dwarf type (dw-) laying hens under the influence of long- term heat stress

Parameter	Ambient temperature					
	Temperate (20°C)			High (32°C)		
	Dw- (×)	dw- (×)	Reduction through dw in %	Dw- (×)	dw- (×)	Reduction through dw in %
Body weight (g/bird) (40weeks)	1,832	1,280	-30.1	1,545	1,093	-29.3
Laying maturity (days)	167	183	(-)*9.5	159	179	(-)*12.6
Laying intensity (%)	69.9	54.9	-21.4	58.7	46.9	-20.1
Egg weight (g/egg)	60.5	56.3	-7.1	52.7	50.3	-4.6
Egg mass (g)	40.5	29.7	-26.7	30.4	23.0	--24.2
Feed intake (kg/bird)	104.0	74.4	-28.5	68.6	52.5	-23.5
Feed conversion	2.33	2.15	(+)*7.7	2.23	2.04	(+)*8.5
Egg breaking strength (kg)	3.41	3.28	-3.8	2.61	2.46	-5.7
Thickness of white (mm)	7.09	7.01	-1.1	6.82	6.90	+1.2
Yolk (%)	29.4	28.8	-2.2	28.0	28.3	+1.0

Source: Horst and Petersen (1981), Feed conversion = Feed/egg mass, Testing period = 20-56 weeks.
* Change from an economic point of view.

performances of the chicken: the bantam gene (Maw, 1935) and dw (Hutt, 1949). Both genes are sex-linked. Some authors found in bantam birds a gene dwB belonging to the same allelic series as dw and that is probably the same as Maw's 1935 z gene. Both dw and dwB are incompletely recessive compared to "normal size".

Effect of dw gene on growth and feed conversion

As sex-linked dwarf gene (dw) effect, reduction of body weight of dam was 30% in temperate zone, but 29% at high ambient temperature zone (Tables 1 and 2). The effects of dwarf gene on body weight have been widely verified by many authors; adult body weight is reduced by 30% in the hen and 40% in the male (Hutt, 1959; Bernier and Arscott, 1972; Merat et al., 1974). Hartmann (1978) found the lower body weight in the broiler dam by 34% comparing with the normal sister. The dwarf gene (dw) reduce body size with lower maintenance requirements and more adaptable to harsh tropical environment, is now well recognized in the poultry industry. However, the reduction of body weight was lower at harsh tropical environment compared to the temperate climate (Horst and Petersen, 1977). A recent report showed that the body weight and feed intake of sex-linked dwarf hen (i-757) at 19 weeks old were1,576 g and

Table 3. Effect of high temperature on performance of normal (Dw-) and dwarf (dw-) laying hens in the midth of the laying period

Trait	Yield		Reduction through dw gene in %
	Dw-	dw-	
Body weight (g) (40 weeks)	1,552	1,108	-28.6
Egg number	53.9	47.0	-12.8
Egg weight (g)	53.0	50.6	-4.5
Egg mass per day (g)	28.5	23.6	-17.2
Feed intake (g/day)	69.1	51.3	-25.8
Feed conversion (Feed/egg mass)	2.42	2.17	[-]10.3
Shell strength (kg)	2.64	2.46	-6.8
Egg white height (mm)	68.3	69.4	+1.6
Yolk (%)	28.0	28.4	+1.5

Fullsister comparison: n = 475; Testing period: 44 to 52 weeks; warm condition: permanent 32°C, 45% H; * Change from an economic point of view.
Source: Horst and Petersen (1977.)

6.6 kg respectively (Anonym, 2003).

Several studies noted that nutrients as well as feed requirements of dwarf pullets were far lower than the normal siblings (Bernier and Arscott, 1960, 1966; Khoo and Syed-Hossein, 1982; Mathur and Horst, 1992). Dwarf bird consumed 37.2 g lower feed, and showed 8.4% higher feed efficiency than the normal birds (Katongole et al., 1990). Feed to gain ratio was found to be better in dwarf birds compared to their normal siblings (Bernier and Arscoot, 1960; Horst and Petersen, 1981; Khoo and Syed-Hossein, 1982). Dwarf layers had better feed conversion confirmed by several researchers (Rapp, 1970; Selvarajah, 1970; Quisenberry, 1972; Horst and Petersen, 1977).

Adaptation of dwarf chicken in the tropical climate

Due to the effect of dw gene, birds gained reduction body weight is an important factor in the acclimatization of temperate chicken to harsh tropical environment through body heat loss by radiation, convection, and endogenous heat production (Horst, 1989). It has also been found that the mortality of dw pullets (11.5%) was lower than the normal broiler dam (23.2%) (Table 4). It has been found on the report of Anonym, (2003) that the mortality was 1.29% at 19 weeks of i-757 strain.

Effect of dwarf gene (dw) on the reproductive fitness of chicken

Sexual maturity : Age of pullets at sexual maturity is usually considered as the age at laying of the first egg. Though the several reports noted the delaying sexual maturity of dwarf hens by 7-20 days compared to normal sister, the dwarf birds attained earlier sexual maturity at hot environment (30°C) than the temperate (20°C) environment (Tables 2 and 5). Khan and Verma (1983) found the sexual maturity of dwarf and normal broiler dam at 152 and 145 days respectively. Delaying sexual maturity reduces total egg production and egg mass. Dwarf roosters delayed in spermatozoa production similar to the delay observed in the female though the activity of testis per g tissue was unchanged, and the motility of spermatozoa was very good (Guillaume, 1976). But Anonym, (2003) found the earlier sexual maturity by 14 days in i-757 compared to the normal hens.

Egg production, egg weight and defective eggs

Dwarf birds laid more eggs than the normal full sibs-sister (Tables 4 and 5). But, Hutt (1959) found 7.9-13.3 lesser eggs in dwarf hen than their full-sized sisters from the same dam, and the proportion of egg and body weight of dwarf hen was higher than their normal sisters from the same sire.

But the reduction of egg production, rate of lay and egg weight are associated with the effect of dwarf gene, which were lower while the dwarf birds reared in hot-environment (Tables 1, 2 and 3 and Hartmann, 1977). Other reports showed that the reduction of laying rate was about 10% or

Table 4. Mean body weight, egg production (28-34 weeks) and mortality of experimental genotypes

Genotypes	No. of hens	Body weight at 30 weeks	Egg production (egg/100 hen day)	Coefficient of variation (%)	Mortality (%)
Dwarf broiler (DB)	69	1.45	55.3±0.87	16.6	13.3
Dwarf (pooled)	184	1.27	55.8±0.86	15.9	11.5
Normal broiler (NB)	33	2.39	44.2±1.70	26.9	23.2

Source: Khan et al. (1987), Data from May 2nd to June 20th (50 days), Data with the similar superscripts do not differ significantly, Results are based upon those birds that survived for the duration of the experiment. Temp = 21.1-45°C, Humidity=20-23% in morning and 20-77% in evening.

Table 5. Hatching egg production of i-757 (sex-linked dwarf gene), Arbor Acres and MPK broiler Parent stock

Strain	Sexual maturity (wks)	Production period (wks)	Total egg production (egg/bird)	Hatching egg production (egg/bird)	Egg weight (g/egg)
i-757	23	23-66 (304 days)	298.50	276.42	64.86
Arbor Acres	25	25-66 (290 days)	172.00	160.00	62.00
MPK	24	24-65 (290 days)	169.26	159.28	65.00

* Sexual maturity was counted at 5% of egg production in the flock.
Source: Anonym (2003).

Table 6. Percent of different types of defective eggs in normal broiler and dwarf broilrer

Egg type	Normal broiler			Dwarf broiler		
	I phase	II phase	Overall	I phase	II phase	Overall
Double yolked eggs	3.06	0.38	2.05	0.34	0.04	0.22
Membranous eggs	1.27	0.58	1.01	0.22	0.28	0.25
Soft-shelled eggs	0.81	1.35	1.01	0.07	0.70	0.32
Two eggs in a day	0.11	0.10	0.11	0.05	0.04	0.04
Total eggs	5.25	2.40	4.18	0.68	1.07	0.84

I phase = 20-30 weeks of age, II phase = 31-40 weeks of age, Overall = 20-40 weeks (280 days) of age.
Source: Khan and Verma (1983).

even more in very light breeds while the laying rate was unchanged or improved in heavy type birds. However, the higher vitelogenesis and an increased rate of abnormal ovulations in normal birds resulting lower hatching eggs were obtained in normal sized birds (Bernier and Arscott, 1960; Merat, 1969; Prod'homme and Merat, 1969; Ricard and Cochez, 1972; Summers, 1972; Yamada et al., 1972; Middelkoop, 1973; Polkinghorne and Lowe, 1973; Doran and Quisenberry, 1974). On the other hand, the dw gene reduced vitellogenesis. That is why dw bird produced with a greater reduction of defective eggs like, double yolked, hard shelled, shell less, soft shelled egg or other defective eggs and allowed normal a more normal lay (Jaap, 1969; Yamada et al., 1972; Middelkoop, 1973; Khan et al., 1975; Guillaume, 1976; Reddy and Siegel, 1977; Khan and Verma, 1983). Anonym (2003) observed a substantial higher normal as well as hatching eggs egg production in dwarf birds than the normal sister (Tables 5 and 6).

Egg shell thickness, albumen and yolk quality

The egg shell colour of dwarf hen is lighter, and the height of the albumen is greater with no differences of egg shell thickness between dwarf and normal medium size hen egg (Merat, 1970). Merat et al. (1974) observed fewer broken or cracked eggs shell, laid by dwarf hens. Albumen and yolk percent and thickness of white were almost similar between dwarf and normal hen eggs (Tables 1, 2 and 3).

Fertility and hatchability

High environmental temperature was associated with lower fertility, and poorer egg shell quality (Clerk and Sarakoon, 1967; Millar and Sunde, 1975). Reduction of egg shell quality has also been related to depressing hatchability, and weakening of the embryos (Peebles and Brake, 1985). The hatchability of egg was depressed by 15-20% whenever the mean weekly ambient temperature was exceeded 27°C where relatively smaller body size is associated with better production, survival adaptability and also for better reproductive fitness (Merat et al., 1974; Singh et al., 1980; Horst and Petersen, 1981). As effect of dw gene, hatchability was improved by 5-10% and the mortality was reduced at best during laying period (Yamada et al., 1972). Islam, 2004 found the highest fertility and hatchability in sex-linked dwarf hen eggs. The similar results were found by Ricard and Cochez (1972), Chambers et al. (1974) cited by Guillaume (1976). Hutt (1959) found the good viability, fertility and hatchability in dwarf hen as in larger birds.

Dwarf dams are superior to normal broiler type dams for better reproductive fitness producing greater number of normal as well as hatching eggs, while the lower mortality, and the higher fertility and hatchability were found in dwarf hen than that of their non-dwarf sisters at harsh tropical environment (Khan et al., 1975; Khan and Verma, 1983; Islam, 2004).

Effect of dwarf gene on Shank length

The dw gene reduced shank length by about 25% in high weight line, which was about 6% lower in low weight line than the high weight line (Reddy and Siegel, 1977). Hussain et al. (1982) found the shank length of dwarf hen by 7-8 cm, while normal bird had the shank length by 9.5-10.5 cm. That is why dwarf birds can easily acclimatize to harsh tropical climate through body heat loss by radiation and convection (Horst and Petersen, 1977).

Effect of dw gene on the cost of chick production as well as fattening performances of broiler

This seems to hold true in situations where feed costs for parents are high or the broilers are slaughtered at a small size, and the cost of hatching egg is relatively more important to the overall costs (Daghir, 1995). The dwarf gene may be used with some success in female parent of the commercial broiler having substantial saving in feed and housing for the small size broiler mother. Since dw gene incompletely recessive, phenotypically broiler progeny will be normal. The slightly loss was found in growth of heterozygous male broiler (Dwdw) close to 2.8% deviation representing 40-60 g of the genotype, and in the female broiler slaughter weight depression was 0.7% or 10-15 g may be offset producing cheaper broiler hatching eggs as well as cheaper broiler chick (Crawford, 1995).

Chambers et al. (1974) estimated that the reduction in feed cost per dozen eggs produced from dwarf broiler-type dams was 36.3%. Other reports showed that the number of chicks per hen appears higher in any dwarf cross or strain where laying rate is not decreased by the dw gene (Ricard, 1974). Broiler sire should be maintained as non-dwarf for the rapidity of broiler growth (Jaap, 1969). Because, when

Table 7. Fertility and hatchability of eggs from i-757 (sex-linked dwarf gene), Arbor Acres and MPK broiler strain

Parameters	Hatching period	Strain		
		i-757	Arbor Acres	MPK
Fertility (%)	January-March/2003	94.72	85.75	86.66
Hatchability on egg set (%)	January-March/2003	89.50	78.50	77.50
Hatchability on fertile egg (%)	January-March/2003	95.00	85.00	86.50

Source: Islam (2004).

Table 8. Growth performances, and profitability of i-757 (sex-linked dwarf gene), Arbor Acres and MPK broilers

Parameters	Strain		
	i-757	Arbor Acres	MPK
Rearing periods (days)	44	37	36
Live weight (g/bird)	1,400.00	1,382.44	1,254.08
Feed intake (g/bird)	3,500.56	3,318.39	3,134.55
FCR (Feed/live weight)	2.56	2.46	2.58
Mortality (%)	5.91	4.44	7.25
Production cost (Taka/kg broiler)	50.36	52.06	53.78
Profitability (Taka/kg broiler)	1.79	0.27	-0.57

Source: Islam (2004).

the smaller hens (dw-) mated with large size broiler type males produce rapidly growing normal sized broilers (Jaap, 1968). Pullets of large bodied type not only lay fewer eggs but also produce more defective eggs than their smaller egg producing birds (dw-) (Jaap and Muir, 1968; Anonym, 2003). The rearing cost of dwarf hens during their reproduction is considerably lower than that for the large bodied pullets (Jaap, 1969).

Several investigators have reported that broiler production from dwarf breeder is more economic than from the normal breeders (Jaap, 1969; Chambers et al., 1972, Ricard, 1974; Islam, 2004). Horst (1989) suggested that an appropriate breeding programme in the tropics should be made involving dwarf gene (dw-) in heavy broiler female breeder for more hatching eggs, and medium heavy layer male breeder lines to produce dwarf pullets for eggs and normal cockerels for male purpose. Broiler production cost from dwarf hens was lower than that of normal hens observed by Khoo and Syed-Hussein (1982) and Islam (2004).

Table 8 showed that the growth and profitability of broiler from dwarf hen is better than the broiler from normal dam. Other report showed that broiler progeny from dwarf hens had slightly lower body weight, but it had the better feed conversion and attained later market weight (1.8 kg) compared to the broiler progeny from normal hens (Khoo and Syed-Hussein, 1982). In addition, practically it has been found like in Bangladesh, the consumer demand for small size broiler (around 1 kg) is more than the large one. The heterozygous naked neck broilers gained about 3% more weight than their normally feathered siblings under commercial conditions at a constant high temperature of about 32°C (Cahaner et al., 1992; cited by Singh et al., 2001).

Immune responses of dwarf broiler breeder chickens

An assessment of cellular and humoral immunity indicated that sex-linked dwarfs may have more competent T-cell subpopulations and weaker B-cell reactivity compared to normal strain birds. Dwarf layers have the better resistance to heat and Marek's diseases showing the substantially lower mortality when the birds were injected with Marek's disease (Ahmed et al., 1971; Meurier, 1971; Meurier and Merat, 1972; Bernier and Arscott, 1972; Merat et al., 1974; Hartmann, 1978; Dunnington and Siegel, 1998)(Table 8). Coccidiosis challenge studies by Haas (1974) indicated that the dwarf broiler strain and the normal broiler strain were equally resistant to three species of Eimeria. Dwraf and cross-strain birds consistently had higher or equivalent cell-mediated immunity responses compared to normal strain birds (Klingensmith et al., 1983).

CONCLUSION

This review reveals that the utilization of sex-linked dwarf gene in broiler production under hot-humid climate is far better than that of broiler production from normal heavy type chicken. Considering the environment, adaptability, size, saving of feed and house, survivability, rearing facilities, chick production cost, profitability and consumer demand, should include sex-linked dwarf gene for broiler production in the tropics. Sex-linked dwarf gene should be exploited to make breeding plan for better economic gain in the tropics suggested by several scientists. Dwarf meat type strains have already been got success due to their better adaptability, reproductive fitness and lower cost of chick production. Therefore, inclusion of sex-linked dwarf hen in broiler production at hot-humid climate, both of poultry industry as well as consumers will be benefited.

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