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Genetic architecture of growth and production parameters in a laying cycle of 72 weeks in naked neck chickens

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ABSTRACT

A comprehensive study was undertaken to investigate the reproductive, growth and production performance in a complete production cycle of 72 weeks of age in naked neck broiler breeders. The data collected on chicks (927) for juvenile growth and 196 hens for production parameters produced from 40 sires and 160 dams in a pedigreed mating was analyzed for evaluating the performance in naked neck chicken. The mean fertility and hatchability (FES: fertile egg set and TES: total egg set) % was 81.09, 82.14 (FES) and 75.46 (TES), respectively in naked neck hens. The mean body weight at 4 and 6 weeks of age was 510.35and 1058.86g, respectively with a shank length of 79.62mm (6 weeks) with moderate to high heritability estimates. The ASM in naked neck birds was 160.11 days with moderate heritability (0.24). The body weight of hens at 20, 40, 52, 64 and 72 weeks of age was 2455.60, 3046. 89, 3297.44, 3542.89 and 3805.13g, respectively. The egg weight varied from 53.20 at 28 weeks of age to 70.45g at 72 weeks of age with low to moderate heritability. The part period egg production to 40 weeks was 64.18 with an annual production of 164.37eggs which was fairly reasonable for a broiler breeder chicken. The correlation coefficients revealed strong positive and significant association between body weights at different ages, body weights and egg weights, while negative association between body weights and egg production. The overall performance of naked neck broiler breeders suggests that it offers a bright future for tropical broiler production under the predictions of global warming and temperature rise.

Key words: Correlation, Growth, Heritability, Naked neck, Production parameters

Naked neck, an important ecotype of native chicken distributed along the hot-humid coastal regions of India, is known for its heat tolerance. The *Na* gene is incompletely dominant with a tuft of feathers on the ventral side of the neck in heterozygotes (Scott and Crawford 1977), whereas no plumage on the neck in homozygotes with reduced feather tracts or no feather tracts (Somes 1988). The *Na* gene received attention in broiler production because of its association with heat tolerance (Merat 1986, Cahaner *et al*. 1993, Singh *et al*. 2001, Lin *et al*. 2006, Rajkumar *et al*. 2010a, b), an important inhibiting factor for poultry production in hot tropical climate (Horst 1987). The '*Na*' gene results in a relatively higher growth rate and meat yield in broilers than normal birds at normal temperature and the effect is more pronounced at high temperature (Cahaner *et al*. 1993, Rajkumar *et al*. 2010a). Islam and Nishibori (2009) documented the superior qualities in terms of growth rate, egg production, disease resistance and meat yield in hot-humid tropical climates. Naked neck gene reduces relative feather mass thus increasing the heat dissipation (Patra *et al*. 2002 and Rajkumar *et al*. 2010a), leading to better heat tolerance compared to their normal siblings (Merat 1986, Patra *et al*. 2002). Naked neck chicken was studied extensively with respect to heat tolerance, growth, carcass and immune parameters, however the information on production performance during complete production cycle of 72 weeks of age are limited. Therefore, the present study was carried out to evaluate the juvenile and production performance in a complete cycle of 72 weeks in naked neck chicken.

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MATERIALS AND METHODS

Experimental population: Naked neck gene was introduced into a synthetic broiler breeder line by crossing with a homozygous naked neck (NaNa) population for improving the broiler production under tropical environment during late nineties. The base population of naked neck line was developed after 4 successive generations of backcrossing and is maintained under mild selection pressure for 6 weeks body weight for the last 7 generations at Project Directorate on Poultry, Hyderabad, India.

Rearing and management: The chicks were fed *ad lib.* with broiler starter (2900, ME 22, CP) and finisher (3000, ME 20, CP) diets based on maize-soybean meal from 0–4 and 5–6 weeks of age, respectively. Hens (196) selected at 6 weeks of age were reared up to 72 weeks of age in individual cages with one and half square feet floor space with automated drinkers. The birds were kept on restriction feeding schedule from seventh weeks onwards to maintain the target body weight during the laying cycle for better egg production. The birds were maintained on a broiler grower ration (2600, ME and 18, CP) up to 20 weeks of age and broiler breeder ration (2700, ME; 17, CP and calcium: 3.5%) till the end of the production cycle. The birds were vaccinated against Marek's disease (day 1), Newcastle disease, Lasota (day 7 and 30), infectious bursal disease (day 14 and 26), fowl pox (week 6), ND R_2B (week 9) and IB and ND inactivated (week 18). The ambient temperature ranged from 34 to 42°C during the rearing period.

Traits studied and statistical analysis: The data collected on 927 naked neck chicks produced from 40 sires and 160 dams in 2 hatches during eighth generation were utilized for the present study. The reproductive parameters, fertility and hatchability; growth traits such as fourth and sixth weeks body weight; shank length at 6 weeks of age were measured. The production parameters like age at sexual maturity, body weight (20, 40, 52, 64 and 72 weeks), egg weight (28, 32,40,52,64 and 72 weeks) and egg production (40, 52, 64 and 72 weeks) were recorded from 196 birds reared up to 72 weeks of age.

The pedigreed data were analyzed using least squares technique (Harvey 1990) and the hatch corrected data were utilized for estimating the heritability estimates by variance component analysis (King and Henderson 1954). Genetic and phenotypic correlations were estimated from variance – covariance component analysis (Becker 1975).

RESULTS AND DISCUSSION

Reproductive traits: The mean fertility % was 81.09±2.16 in naked neck hens. The hatchability % on fertile egg set (FES) and total egg set (TES) was 82.14±3.01 and 75.46±2.51, respectively. Peter *et al*. (2008) observed fertility of 80.62±6.1 and hatchability of 82.63±5.7 which were in accordance with the results of our study in naked neck chicken from Nigeria. In general, the hatchability % in naked neck chicken was low due to the high incidence of late embryonic mortality (Crawford 1990 and Merat 1986) which was also true in the present study wherein sizeable embryos were dead in shell after transfer into hatcher. The fertility rate in this study were comparable to the findings of Hauque and salahuddin (2001) and Islam *et al*. (2001) whereas, hatchability % were lower. However, better fertility and hatchability estimates were recorded in naked neck chicken at high and humid temperatures (Ladjali *et al*. 1995).

Juvenile traits (body weight and shank length): The mean body weight at 4 and 6 weeks of age was 510.35±0.17 and 1058.86±0.39g, respectively, with a shank length of 79.62±0.02 mm (6weeks) in naked neck birds (Table 1). The juvenile body weights (4 and 6 weeks) observed in this study were lower compared to the results of Rajkumar *et al*. (2010b, 2011a) and Singh *et al*. (1998) in naked neck chicken which might be because of management variation in 2 periods of rearing. Reddy *et al*. (2008) observed lower juvenile body weight (467.30±0.67 and 877.60±0.10 g) at 4 and 6 weeks of age respectively in naked neck chicken than the present finding which might be due to the favorable effects of selection, feeding regime followed and other managemental variations, environmental temperature and season of hatching during the experimental. Magothe *et al*. (2010) also reported lower body weights in native local naked neck chicken from Kenya. Almeida and Zuber (2010) observed lower juvenile body weights for naked neck chicken under temperate climate than the present finding which might be due to the favorable expression of *Na* gene under hot-tropical climate (Merat 1986 and Rajkumar *et al*. 2011b). Higher shank length was observed by Rajkumar *et al*. (2010b) compared to the present findings which were reflected in the higher body weights.

The heritability estimates for juvenile body weights (4 and 6 weeks) were moderate to high (Table 1) in naked neck broilers indicating scope for further improvement through traditional selection and breeding techniques. Similar to the body weights, moderate to high heritability estimates were observed for shank length in naked neck birds (Table 1). The heritability estimates from sire component was lower and dam component was higher at 4 weeks of age indicating the importance of maternal effects in the early part of the life. The sire components h^2 for 6 weeks body weight was higher (0.39±0.18) indicating, high additive genetic variance providing the breeders an opportunity to impose selection to improve the birds for body weight justifying the selection of parent on 6 weeks body weight being followed in naked neck chicken. Higher heritability estimates for body weights similar to the present results were reported by Rajkumar *et al*. (2010b) and Reddy *et al*. (2008) in naked neck birds with variations in magnitude of the estimate.

Production traits: Production parameters, viz. age at sexual maturity, body weight, egg weight and egg production

Table 1. Juvenile performance in Naked neck chicken during 8th generation

Parameter	Mean	Heritability (h^2)		
		h^2 ($_S$)	h^2 ($_D$)	h^2 ($_{S+D}$)
Body weight (g)				
4 weeks	510.35±0.17	0.13±0.22	0.47±0.27	0.29±0.11
6 weeks	1058.86±0.39	0.39±0.18	0.38±0.13	0.39±0.18
Shank length (mm)				
6 weeks	79.62±0.02	0.24±0.16	0.51±0.20	0.37±0.13

upto 72 weeks of age in naked neck broilers are summarized in Table 2. The ASM in naked neck birds was 160.11±0.09 days. The body weight of hens at 20 weeks of age was 2455.60±1.66 g, reached to 3046. 89±3.29 at 40 weeks and finally attained 3805.13±5.48 g at 72 weeks of age (Table 2). The birds were on restriction feeding to maintain the target body weight during laying cycle to overcome the negative effect of higher body weight on egg production, therefore the variations observed in body weight may not be a true reflection of its genetic potential.

The body weights (20 and 40 weeks) observed was higher than that reported by Padhi *et al*. (2001) and Reddy *et al*. (2008) in naked neck chicken. The variation in body weights of naked neck chicken might be attributable to the genotype × environment interactions prevailing in the area of study. Padhi *et al*. (2001) observed, 189±3.01 days for ASM in naked neck chicken from Andaman & Nicobar Islands and Reddy *et al*. (2008) reported 175.8±0.09 days which was significantly higher compared to the present result in naked neck chicken. Rajkumar *et al*. (2011c) observed earlier age at sexual maturity (157.34±0.93 days) by 3 days from the ASM recorded in the present study. The marginal variation observed might be due to the feeding and lighting schedule followed during the grower (pullets) stage of the birds.

Egg weight plays an important role in consumer preference and marketing. Therefore, egg weight is always one of the important parameters in selection and better early egg weight allows the breeder to reproduce the birds at an early age especially in the breeders resulting in improved economics due to more number of saleable chicks. Naked neck birds had better egg weight from 28 weeks onwards

Table 2. Production performance up to 72 weeks of Naked neck chicken

Traits	Mean	Heritability		
		h^2_S	h^2_D	$h^2_{(S+D)}$
ASM (days)	160.11±0.09	0.19±0.18	0.27±0.19	0.24±0.15
Body weight (g)				
20 weeks	2455.60±1.66	0.44±0.41	0.21±0.32	0.34±0.23
40 weeks	3046.89±3.29	0.17±0.30	0.43±0.34	0.31±0.24
52 weeks	3297.44±3.28	0.19±0.33	0.11±0.19	0.14±0.23
64 weeks	3542.89±3.33	0.14±0.24	0.29±0.38	0.26±0.27
72 weeks	3805.13±5.48	0.09±0.31	0.17±0.35	0.15±0.28
Egg weight (g)				
28 weeks	53.20±0.03	0.64±0.22	—	0.17±0.23
32 weeks	55.84±0.04	—	0.18±0.21	0.10±0.26
40 weeks	60.61±0.04	0.16±0.32	0.55±0.32	0.35±0.28
52 weeks	65.12±0.04	0.13±0.31	0.28±0.39	0.21±0.38
64 weeks	67.32±0.05	0.27±0.40	0.44±0.41	0.31±0.42
72 weeks	70.45±0.05	—	0.22±0.32	0.12±0.27
Egg production (nos.)				
40 weeks	64.18±0.13	0.14±0.29	—	0.10±0.22
52 weeks	111.39±0.17	0.09±0.21	0.13±0.28	0.11±0.41
64 weeks	149.94±0.18	0.13±0.41	0.01±0.39	0.09±0.29
72 weeks	164.37±0.18	—	0.20±0.47	0.05±0.21

(53.20±0.03 g) to 72 weeks (70.45±0.05) of age (Table 2). Higher egg weight and brown colouration makes the eggs more preferred in the market. Garces *et al*. (2001), reported an average egg weight (31–52 weeks) of 58.6 g in layers of naked neck from South Africa which was lower to the present estimate, which may be because of higher production due to the presence of layer inheritance. Reddy *et al*. (2008) and Galal *et al*. (2007) also reported comparable estimates for egg weights in naked neck chicken. Lower egg weights recorded at 28, 32 and 40 weeks of age (Rajkumar *et al*. 2009, 2011c) and 36 - 56 weeks of age (El Safty *et al*. 2006) in earlier studies than the present might be due to the increased body weight, ASM and feeding schedule during the laying period.

Part-period egg production up to 40 weeks was 64.18±0.13 in naked neck hens. The egg production in a complete laying cycle of 72 weeks was 164.37±0.18, which was considered reasonable for a broiler bird. The part-period egg production at 40 weeks of age in naked neck birds was in agreement with the reports of Rajkumar *et al*. (2011c) and Reddy *et al*. (2008). Higher egg production of (138.9) upto 52 weeks of production cycle was reported by Grobbelaar *et al*. (2010) than the present egg production at 52 weeks of age (Table 2). However, still higher production (266 eggs) was recorded in naked neck layer variety (Garces *et al*. 2001) from South Africa. The lower production in the present study might be due to broiler inheritance and genotype × environment interactions between the birds and 2 geographical locations. The overall production of 164.37±0.18 eggs in a production cycle of 72 weeks was reasonably fair for broiler breeder line. El Safty *et al*. (2006) recorded 61.8±1.3 eggs in naked neck chicken from Egypt in a laying period of 20 weeks from 36 to 56 weeks of age.

Genetic parameters: Heritability provides the breeders an idea about the presence of additive genetic variance, which is the transmittable portion to the offsprings. The ASM was moderately heritable with 0.24±0.15 h^2 estimate in naked neck birds. The h^2 estimates of body weights at 20 and 40 weeks was moderate to high in naked neck chicken whereas, after 40 weeks of age the h2 estimates for body weight (52, 64 and 72 weeks) were low to moderate (Table 2). Reddy *et al*. (2008) and Rajkumar *et al*. (2011c) observed higher heritability estimates for 20 and 40 weeks body weights and ASM in Naked neck chicken. The variations in the heritability estimates might be attributed to breed, environmental effects and sampling errors. The non genetic factors like environment and poor management might increase the residual variance and decrease the h^2 estimates (Adeyinka *et al*. 2006). The h^2 from dam component was relatively high indicating the higher maternal effects for ASM in naked neck chicken.

The h^2 estimates of egg weights were low to moderate (Table 2) in naked neck chicken. The h^2 from dam components was relatively higher for egg weights indicating the presence of maternal effects as it is a sex limited trait.

Table 3. Genetic (above the diagonal) and phenotypic (below the diagonal) correlations for production traits in naked neck chicken

Parameter	ASM	BW40	BW52	BW64	BW72	EW40	EW52	EW64	EW72	EP40	EP52	EP64	EP72
ASM	*	0.39	0.43	0.14	0.21	0.86*	0.26	0.79*	0.67*	–0.37	–0.33	–0.18	–0.45
BW40	0.12	*	0.82*	0.69*	0.71*	0.92**	0.85**	0.46	0.49	–0.21	–0.36	–0.53	–0.42
BW52	0.14	0.59	*	0.60*	0.59*	0.14	0.91**	0.83*	0.64*	0.03	–0.77	–0.48	0.11
BW64	0.21	0.49	0.61	*	0.67*	0.11	0.21	0.54	0.61*	0.19	–0.14	–0.28	–0.31
BW72	0.10	0.41	0.64	0.42	*	0.20	0.14	0.31	0.68*	0.09	–0.19	0.23	–0.42
EW40	0.15	0.61	0.08	0.14	0.21	*	0.89**	0.82**	0.69*	–0.59*	–0.52	–0.21	–0.24
EW52	0.11	0.47	0.58	0.18	0.07	0.55	*	0.79*	0.48	0.24	–0.72**	–0.54*	–0.44
EW64	0.12	0.38	0.37	0.49	0.11	0.46	0.48	*	0.81*	0.11	–0.09	–0.77*	–0.55*
EW72	0.17	0.31	0.33	0.35	0.49	0.51	0.38	0.54	*	0.21	0.09	–0.22	–0.39
EP40	–0.66	–0.44	–0.13	0.05	0.09	–0.39	0.19	0.11	0.09	*	0.79*	0.71*	0.59*
EP52	–0.39	–0.18	–0.34	–0.07	0.10	–0.23	–0.32	–0.16	–0.13	0.69	*	0.82**	0.61*
EP64	–0.42	0.09	–0.31	–0.31	–0.13	–0.29	–0.36	–0.35	0.12	0.78	0.73	*	0.77*
EP72	–0.37	–0.22	0.14	–0.40	–0.42	–0.01	–0.19	–0.33	–0.32	0.54	0.61	0.70	*

*$P \leq 0.05$, **$P \leq 0.01$; ASM, age at sexual maturity; BW40, body weight at 40 weeks; BW52, body weight at 52 weeks; BW64, body weight at 64 weeks; BW72, body weight at 72 weeks; EW40, egg weight at 40 weeks; EW52, egg weight at 52 weeks; EW64, egg weight at 64 weeks; EW72, egg weight at 72 weeks; EP40, egg production at 40 weeks; EP52, egg production at 52 weeks; EP64, egg production at 64 weeks; EP72, egg production at 72 weeks.

Reddy *et al*. (2008) and Rajkumar *et al*. (2011c) observed comparable h^2estimates for egg weights at 28, 32 and 40 weeks of age in naked neck birds.

The 40 weeks egg production was a low heritable trait with h^2 estimate of 0.10±0.22 in naked neck birds. The h^2 estimates were low for egg production, ranging from as low as 0.05±0.21 for 72 weeks egg production to 0.11±0.41 for 52 weeks egg production. Varied h^2 estimates ranging from low to high were documented for egg production in the literature (Jilani *et al*. 2007, Reddy *et al*. 2008, Rajkumar *et al*. 2011c). Jilani *et al*. (2007) observed very high estimates (<0.7) for 40 weeks egg production. However the present estimates are fairly reasonable, keeping in view the low heritable nature of the trait.

Genetic and phenotypic correlations between various traits are presented in Table 3. The ASM and body weight at different ages (40–72 weeks of age) were positively associated indicating the delayed maturity (ASM) in heavier birds. The ASM and egg weights also had significant positive correlations; the birds matured late, laid heavier eggs at all ages. All the egg weights, at different ages are positively correlated. However, ASM was negatively associated with egg production with consistent negative correlation coefficient for egg production at all ages.

The correlation coefficients between body weights at different ages were significantly ($P<0.05$) and positively associated in naked neck chicken (Table 3). The correlation coefficient varied between 0.59 (BW52 and BW72) and 0.82 (BW40 and BW52) in naked neck broilers. Significant ($P \leq 0.05$) positive correlations were observed among BW40 and EW 40 and EW52; BW52 and EW52, EW64 and EW72; BW64 and EW72; BW72 and EW72. The heavier birds laid heavier eggs indicating the positive association between body weights and egg weights. The egg weights at different ages had significant ($P \leq 0.05$) positive correlation except between EW52 and EW72 which was not significant (Table 3). The positive association between the body weights and egg weight at different weeks was proved (Rajkumar *et al*. 2011c, Adeyinka *et al*. 2006; Reddy *et al*. 2008). Both genetic and phenotypic correlations showed almost similar trend with varying magnitude of coefficients.

The egg production at 40 weeks of age was negatively correlated with ASM, BW40 and EW40, whereas with all other traits it was positive with less magnitude (0.03 to 0.21). EP40, EP 52, 64 and 72 had negative association with ASM, body weights and egg weights at all ages with few exceptions (Table 3). The egg production at different ages was significant and positive with 0.59 r_g (EP40 and EP72) and 0.82 r_g (EP52 and EP64). The negative association of egg production with body weights and ASM is well established phenomenon (Rajkumar *et al*. 2011c; Reddy *et al*. 2008). The association between egg production with all other traits was in agreement with the earlier studies in various chicken populations (Jilani *et al*. 2007; Reddy *et al*. 2008).

The study on the growth and production performance of naked neck broiler breeders during the complete laying cycle of 72 weeks of age revealed that these birds have potential to perform on par with the other broiler breeders, thus offering a bright future for broiler production under the global predictions of rise in atmospheric temperatures.

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