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Genetic and phenotypic response in Vanaraja male line chicken under short term selection experiment

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ABSTRACT

The genetic and phenotypic response for 6 weeks shank length (SL6) and correlated response for body weights at 2, 4 and 6 weeks of age were evaluated in short term selection experiment in Vanaraja male line (PD-1) utilizing the data collected for the last 6 generations in a pedigreed mating. The direct response in SL, the primary trait was 2.01±0.85 mm on genetic scale and 2.35±0.36 mm on phenotypic scale. The SL was 68.07±0.004 mm in first generation of study (S4) which gradually improved to 81.01±0.002 mm over the last 6 generations. The correlated genetic response in body weight at 2, 4 and 6 weeks of age was in positive direction though not significant. The body weights improved as correlated response to the primary trait. The phenotypic response in body weights was in positive direction and significant at 6 weeks of age; however at 2 and 4 weeks, it was not significant. The effective population size (N_e) ranged from 150 to 167, the selection intensity (i) between 0.24 to 1.09 and rate of inbreeding from 0.0029 to 0.0033 in the last 6 generations. The realized and estimated heritability estimates were 0.17 and 0.12 for 6 week shank length, respectively. The study concluded that, the genetic and phenotypic responses were positive over the generation with a gradual improvement in the primary trait as well as the juvenile body weights in PD-1 line. The improvement trend was also reflected in Vanaraja, a terminal cross produced for rural/backyard poultry using PD-1 as male line.

Key words: Body weight, Correlated response, Genetic response, Shank length, Vanaraja

Selection experiments continue to be powerful tool to generate information on quantitative traits in terms of their underlying genetic variability, the relationships between traits and their effects on performance (Tercic 2013). Genetic progress in the population is determined by the response to selection for primary as well as other traits of economic importance. The phenotypic response indicates the continuous source of additive and non-additive genetic variation in the selected population. Response to any selection is influenced by the initial population size, gene frequency, mutation, allelic fixation, random drift and physiological limits (Falconer and Mackay 1997). Estimation of direct response to selection is very important in a selection experiment. The magnitude and direction of correlated responses are also significant in developing effective breeding strategies for improved productivity, more so in case of positively correlated traits due to linkage and pleotropy. Summary of selection experiments over a period of time for body mass or growth rate in poultry resulted in decreased fitness and/or increased body weight in most of the experiments (Sholtz *et al*. 1990).

The aim of selection for higher shank length (SL) in male line was to improve the SL in terminal cross, Vanaraja. Longer and stronger shanks play an important role in movement of birds under free range conditions and help escape from predators as predation is the major cause of mortality. In addition, selection for SL also improves the body weight as correlated response. Shank length has been an effective means of selection criterion especially in male lines intended to produce dual purpose chicken varieties. Selection experiments with shank length as selection criteria are limited in literature. Therefore, the present study on the short term selection response for primary trait as well as associated traits was evaluated in Vanaraja male line (PD-1) chicken.

MATERIALS AND METHODS

The experiment was conducted at poultry experimental farm of ICAR-Directorate of Poultry Research, Hyderabad, Telangana. The state experiences usually hot and humid tropical climate with temperature ranging from 20°C in winter to 45°C in summer. The experiment was approved by the Institute Animal Ethics Committee.

Experimental population: Vanaraja male line (PD-1), control broiler (CB) and Vanaraja chicks of 6 generations reared at ICAR-Directorate of Poultry Research were utilized for the present study. PD-1 line was derived from a low performing Red Cornish population which has been

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under selection for higher 6 week shank length since last 8 generations. PD-1 is utilized as male line for production of Vanaraja chicken. CB, a synthetic random-bred control line was utilized as control population to estimate the genetic response. The CB population is maintained as pedigreed random mating population. Vanaraja terminal cross, a dual purpose variety developed for backyard/free-range farming is used to assess the performance over the generations in terminal cross.

Rearing and management: Chicks from all 3 genetic groups (PD-1, CB and Vanaraja) were hatched simultaneously in every generation; CB and Vanaraja hatches were taken along with second hatch of PD-1 line. The chicks were wing banded and kept on the floor for brooding. Standard brooding, feeding and management practices were followed in each generation uniformly. The chicks from all the three genetic groups were fed *ad-libitum* with broiler starter ration (2900:ME, 22:CP) up to 6 weeks of age. The chicks were vaccinated against Marek's disease, Newcastle disease, infectious bursal disease and fowl pox on 1st, 5th, 14th and 21st day, respectively.

Traits measured: The data collected on shank length and body weight over last 6 generations were utilized in the present study. The SL was measured by digital Vernier calipers with an accuracy of 0.01 mm at 6 weeks of age. The body weight was measured using digital electronic balance (accuracy of 0.01g) at bi weekly (2, 4 and 6 weeks) intervals. Data on birds surviving up to 6 weeks of age were included in the study.

Statistical analysis: Data were analyzed using least squares technique (Harvey 1990) with a computer package and the hatch corrected data were utilized for estimating the genetic and phenotypic responses. Genetic and phenotypic responses were determined by regression of control deviated means and population means over the generations, respectively. The hatch corrected data were utilized for estimating the heritability estimates in last generation by variance component analysis (King and Henderson 1954). The effective population size, selection intensity, rate of inbreeding, realized heritability were estimated by standard procedures (Falconer and Mackay 1997).

RESULTS AND DISCUSSION

The shank length and body weight improved over the generations (Table 1) due to positive effects of selection for SL, the primary trait and associated correlated effect on the body weight as the SL and body weights are highly correlated (Rajkumar *et al*. 2010, Padhi *et al*. 2012). Gradual improvement was observed in 6 week SL over the generations indicating presence of genetic variation and the effectiveness of selection. The body weights also showed gradual increasing trend with some fluctuations during the early age, which might be due to the minor variations in the management and environment in different generations. Increased genetic and phenotypic responses for body weights were also reported in Nigerian indigenous chicken (Ogbu 2012), colour broiler male and female lines (Reddy *et al*. 2013), Rhode Island Red chickens (Nwagu *et al*. 2007).

The body weight data in Vanaraja, the terminal cross of PD-1 and PD-2 line did not reveal any specific trend during the 6 generations of study (Table 1). The primary trait showed an increasing trend over the generations which improved from 71.65±0.40 to 73.87 mm in Vanaraja chicken. The sudden reduction during S-7 generation is due to high mortality recorded in Vanaraja birds.

The direct response in SL was 2.01±0.85 mm on genetic scale and 2.35±0.36 mm (P<0.05) on phenotypic scale (Table 2; Fig. 1). The correlated genetic response in body

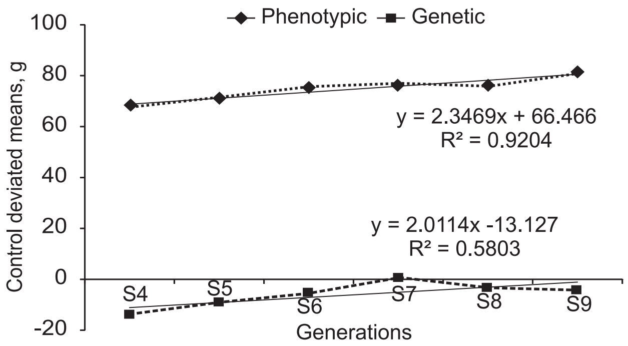

Fig. 1. Direct genetic and phenotypic response for primary trait shank length in PD-1 line.

Table 1. Body weight and shank length (Mean ± SE) in PD–1 line and terminal cross Vanaraja in last six generations

Generation	PD-1 (Vanaraja male line)					Vanaraja (terminal cross)		
	Body weight, g			Shank length, mm		Body weight, g		Shank length, mm
	BW2	BW4	BW6	SL6	BW2	BW4	BW6	SL6
S4 (1375)	115.41±0.02	299±0.04	607.00±0.09	68.07±0.004				
S5 (3001)	133.31±0.006	316.72±0.02	568.67±0.03	70.85±0.001	137.38±1.39	354.15±3.71	514.40±7.16	71.65±0.40
S6 (3087)	127.98±0.01	336.73±0.18	640.21±0.33	75.39±0.001	136.24±1.54	290.34±4.62	526.00±7.00	72.33±0.44
S7 (3106)	135.61±0.006	346.61±0.019	668.00±0.04	76.45±0.002	93.10±1.02	232.25±3.93	466.00±9.00	65.52±0.49
S8 (2488)	121.72±0.08	307.90±0.22	665.00±0.41	76.31±0.002	100.41±1.61	266.00±4.81	622.00±10.00	73.16±0.48
S9 (2678)	161.13±0.08	435.20±0.22	778.00±0.42	81.01±0.002	116.94±1.45	349.00±4.82	617.00±8.02	73.87±0.48

The number in the parenthesis is the sample size utilized for the study in each generation. PD-1 line, Project Directorate-1 line (Vanaraja male line); BW2, Body weight at 2weeks of age; BW4, Body weight at 4 weeks of age; BW6, Body weight at 6 weeks of age; SL6, Shank length at 6 weeks of age. S4–S9 indicate the generations of selection.

weight at 2, 4 and 6 weeks of age was positive though not significant (Table 2; Figs 2–4). The phenotypic response in body weights was positive and significant (P<0.05) at 6 weeks of age; however, at 2 and 4 weeks, it was not significant (Table 2). The short-term genetic and phenotypic responses in PD-1 line were in positive direction for the primary trait of selection (SL6) indicating the improvement of the trait on genetic as well as phenotypic scales. In a short- or long-term selection experiment, the underlying genetic theory is that response for a quantitative trait would continue only if additive genetic variation remains in the population or if spontaneous mutations occurs that influence the performance of the trait under selection (Dickerson 1955, Falconer and Mackay 1997) and also due to epistasis and gene interaction that influence the phenotypic expression (Dunnigton *et al*. 2013). In short term selection experiment over a few generations, the response to selection is primarily a function of the alleles segregating in the base population (Fuller *et al*. 2005). A summary of selection experiments for growth rate in poultry revealed that 90% of the studies yielded positive response similar to the present study, while unfavourable results were obtained in some cases (Eisen 2007). The positive response observed for SL in the present study might be due to the ideal breeding program preventing inbreeding depression, large effective population size and the pleiotropic effects of the loci for growth. Continuous positive response over the generations suggests the presence of genetic variance and network of interacting loci for the primary trait at the beginning of the breeding plan (Dunnington *et al.* 2013, Pettersson *et al.* 2011). Positive genetic response for growth traits in chicken was observed by many authors (Sholtz *et al*. 1990, Reddy *et al*. 2013, Dunnington *et al*. 2013). Contrary to these results, some authors reported unfavourable response for growth especially with feed efficiency as selection criterion (Dunnington *et al*. 2013) which might be attributable to inbreeding depression, deviation from an optimum body size associated with fitness and negative pleiotropic effects at the loci affecting the growth and fitness and undesirable side effects (Roberts 1979).

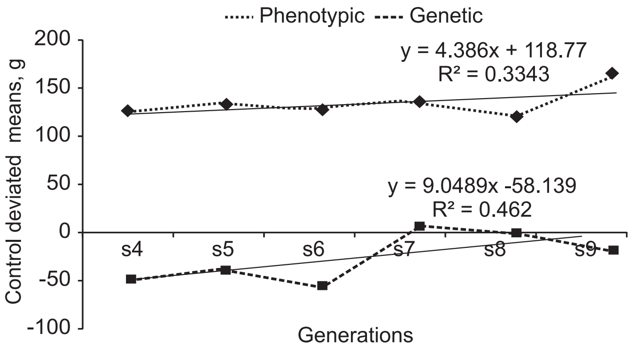

Fig. 2. Correlated responses (genetic and phenotypic) for second week body weight in PD-1 line.

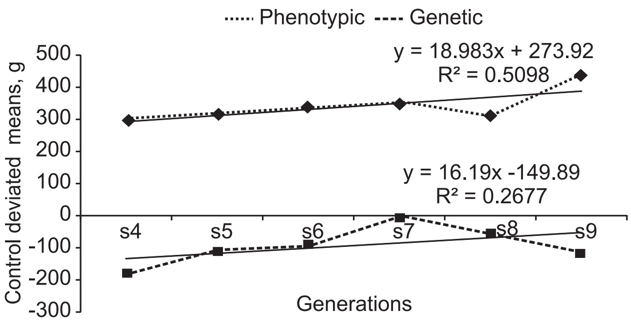

Fig. 3. Correlated responses (genetic and phenotypic) for 4-week-body weight in PD-1 line.

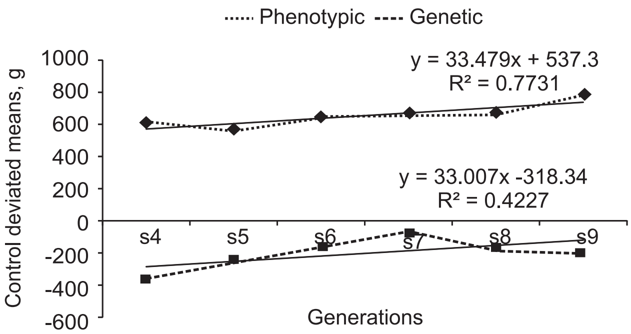

Fig. 4. Correlated responses (genetic and phenotypic) for 6-week-body weight in PD-1 line.

Table 2. Direct and correlated response for shank length (mm) and body weight (g) in PD-line

Parameter	Genetic response	Phenotypic response	Realized heritability	Estimated heritability
Direct response				
SL6, mm (primary trait)	2.01±0.85	2.35±0.36*	0.17	0.12±0.04
Correlated response				
BW2, g	9.05±4.88	4.38±3.01	0.15	0.26±0.05
BW4, g	16.19±9.38	18.98±9.31	0.17	0.23±0.05
BW6, g	33.01±13.28	33.48±9.07*	0.13	0.21±0.4

*Significant at P<0.05. PD-1, Project Directorate-1 line; BW2, body weight at 2 weeks of age; BW4, body weight at 4 weeks of age; BW6, body weight at 6 weeks of age; SL6, shank length at 6 weeks of age. S4-S9 indicate the generations of selection.

The effective population size (N_e) ranged from 150 in S4 and S5 generations to 167 from S6 generations as the number of dams increased to 250. The selection intensity (i) and rate of inbreeding ranged from 0.24 to 1.09 and 0.0029 to 0.0033, respectively, in the last 6 generations (Table 3). Realized and estimated heritability estimates were 0.17 and 0.12, respectively, for the primary trait, 6 week shank length. Realized heritability estimates were lower than the estimated ones for body weight at 2, 4 and 6 weeks of age (Table 2). The selection records estimated from the number of sires and dams utilized for pedigreed mating indicated that the population was under ideal condition. Selection response is the function of effective population size (N_e). The effective population size obtained was large enough to avoid any inbreeding to set in the population as

Table 3. Effective population size, selection intensity and rate of inbreeding in PD-1 line in last six generations

Generation	Sires	Dams	Effective population size (N_e)	Selection intensity (i)	Rate of in breeding (ΔF)
S4	50	150	150.00	0.47	0.0033
S5	50	150	150.00	0.30	0.0033
S6	50	250	166.67	0.50	0.0029
S7	50	250	166.67	0.56	0.0029
S8	50	250	166.67	1.09	0.0029
S9	50	250	166.67	0.24	0.0029

S4-S9 indicate the generations of selection.

evidenced by the low levels of rate inbreeding estimates. The larger effective population size aids in improving the genetic response by reducing the inbreeding depression as well as preventing the loss of desirable alleles as a consequence of genetic drift in the population (Dunnigton *et al*. 2013). The selection intensity appears to be reasonable over the generations as it yielded a positive response with an increase of 2.35 mm in 6 week shank length. The higher estimate of realized heritability for primary trait in the present study is in accordance with the reports of Reddy *et al*. (2013) in broiler chickens. Higher realized heritability estimates in short term selection experiments were common due to the presence of high degree of variation in the base population which tends to reduce the variation over the period of time resulting in lower magnitudes of realized heritability in long term selection experiments. However, the realized heritability estimates for body weights were lower in the present study which might be attributable to reduced variation for the trait. Discrepancies between realized and estimated heritability estimates might be due to accumulation of inbreeding, changes in gene frequency and/or mutations (James 1990). Moreover the realized heritability is a function of linear regression of response over the generations which could only be an approximation as the response was never linear (Pinard *et al*. 1992).

Vanaraja, a dual purpose rural/backyard chicken variety was developed by utilizing PD-1 as a male line. Therefore, the improvement pattern was assessed in terminal cross which gives a fair idea whether the desirable characters of parents are transferred to the offspring. The data clearly revealed that the SL in Vanaraja also improved gradually over the generations. The results indicated and substantiated the hypothesis that selection for desirable traits in parents improves the performance in terminal crosses.

The study concluded that, the genetic and phenotypic responses were positive over the generations with a gradual improvement in the primary trait, six week SL as well as the juvenile body weight in PD-1 line. The positive trend was also reflected in Vanaraja, a terminal cross produced for rural/backyard poultry using PD-1 as male line indicating the selection for desirable traits in parents improves the performance in terminal crosses.

REFERENCES

Dickerson G E. 1955. Genetic slippage in response to selection for multiple objectives. *Cold Spring Harbor Symposia on Quantitative Biology* **20**: 213–24.

Dunnington E A, Honaker C F, Mc Gilliard M L and Seegel PB. 2013. Phenotypic response of chickens to long term bidirectional selection for juvenile body weight-Historical perspective. *Poultry Science* **92**: 1724–34.

Eisen E J. 2007. Animal Breeding: What does the future hold? *Asian Australian Journal of Animal Sciences* **20:** 453–60.

Falconer D S and Mackay T F C. 1997. *Introduction to Quantitative Genetics.* Longman Group, Essexx, England.

Fuller R C, Baer C F and Travis J. 2005. How and when selection experiments might actually be useful. *Integrated Comparative Biology* **45**: 391–404.

Harvey W R. 1990. User's gude for PC-2 version of LSM LMW mixed model least-squares and maximum likelihood computer program. W. R. Harvey, Columbus, OH.

James J W. 1990. Selection theory versus selection results-A comparison. *Proceedings of 4th World Congress on Genetics Applied to Livestock Production*. Vol. XIII, 195. (Eds) Hill W G, Thompson R and Woolliams J A. Edinburgh, Scotland.

King S C and Henderson C R. 1954. Variance component analysis in heritability studies. *Poultry Science* **33**: 147–54.

Nwagu B I, Olorunju S A S, Oni O O, Eduvi L O, Adeyinka A, Sekoni A A and Abeki F O. 2007. Response of egg number to selection in Rhode Island Red chickens selected for part period egg production. *International Journal of Poultry Science* **6**: 18–22.

Ogbu C C. 2012. Phenotypic response to mass selection in the Nigerian indigenous chickens. *Asian Journal of Poultry Science* **6:** 89–96.

Padhi M K, Rajkumar U, Niranjan M, Haunshi S and Bhanja S K. 2012. Genetic studies of juvenile traits in Vanaraja male line a dual purpose backyard chicken. *Indian Journal of Poultry Science* 47: 234–36.

Pettersson M, Esnier F B, Siegel P B and Carlborg O. 2011. Replication and explorations of high-order epistasis using a large advanced intercross line pedigree. *PLoS Genetics* 7 e1002180. http://dx.doi.org/10.1371/journal.pgen.1002180.

Pinard M H, van Arendonk J A M, Nieuland M G B and van der Zijpp A J. 1992. Divergent selection for immune responsiveness in chickens: Estimation of realized heritability an animal model. *Journal of Animal Science* **70**: 2986–93.

Rajkumar U, Rajaravindra K S, Niranjan M, Reddy B L N, Bhattacharya T K, Chatterjee R N and Sharma R P. 2010. Evaluation of naked neck broiler genotypes under tropical environment. *Indian Journal of Animal Sciences* **80:** 463–67.

Reddy B L N, Chatterjee R N, Rajkuamr U, Niranjan M, Rajaravindra K S and Bhattacharya T K. 2013. Genetic evaluation of short term selection in synthetic coloured broiler male and female lines-Direct and correlated responses. *Indian Journal of Animal Sciences* **83**: 285–89.

Roberts R C. 1979. Side effects of selection for growth in laboratory mice. *Livestock Production Science* **6**: 93–104.

Scholtz M M, Roux C Z and Schoeman S J. 1990. An investigation into the consequences of selection for growth, size and efficiency. *South African Journal of Animal Science* **20**: 170–73.

Tercic D. 2013. Divergent selection experiments in poultry. *Slovakian Veterinary Research* **50**: 139–44.