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Response of Egg Number to Selection in Rhode Island Chickens Selected for Part Period Egg Production

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Abstract: Records obtained from 4336 pullets progeny for strain A and 4843 pullets, progeny for strain B under selection for part-period egg production to 280 days of age were used for this study. The response variables measured were Age at sexual maturity (ASM), Egg number to 280 days (EGG280 D), Egg weight average (EWTAV) and Body weight at 40 weeks of age (BWT40). The genotypic response was only 0.42 eggs per generation in the male line. The female line population showed a much higher positive response to selection, the phenotypic value being 1.67 eggs per generation while the genotypic response was 3.1 eggs per generation. The genetic correlation estimates between the different economic traits ranged from -0.70± 0.38 to 0.82 ± 0.42 vs -0.71 ± 0.47 to 0.76 ± 0.29 for the male and female lines respectively. The correlation between egg number and egg weight was small non significant. ASM was highly and negatively correlated with egg production to 280 days in both lines being higher than- 0.60 in most cases. The genetic correlation between egg number and BWT40 showed no definite trend. In the female line, correlated response in age ASM and BWT40 had negative values. In the male line however except for BWT40 which showed a positive correlated response of 3.4g/year, all other traits showed negative correlated responses. Generally it was evident that selection was more effective in improving the egg number in the female line than in the male line showing an increase of 1.67 vs 0.19 eggs per year in the female and male lines, respectively. The low egg number reported was as a result of the delay in sexual maturity especially during the later years of the selection experiment. Another factor that may have contributed to the variable response achieved from generation to generation may also be due to varying season of hatching across generation. However the positive response in the female line population may be attributed to reduced age at sexual maturity.

Key words: Response, egg number, egg production

Introduction

Poultry breeders must consider so many traits that are economically important that it becomes difficult to apply sufficient selection pressure on key traits in egg laying stock (Egg production rate, sexual maturity, egg size, feed efficiency, fertility and hatchability). Other traits such as egg quality and bodyweight are generally of less importance unless when a strain exhibits specific problems (Schmidt and Figueiredo, 2005). Thus, with such a large number of traits, it is important to avoid placing more selection pressure on a trait than is required, so that selection intensity on the primary traits can be maintained. The primary factors affecting response to genetic selection are accuracy to selection, selection intensity, and effective population size. Current breeding theory indicates that optimum response to selection can be achieved by maximizing these factors (Gowe *et al.*, 1993). Unfortunately, with limited resources, not all factors can be maximized simultaneously. For example, increasing selection intensity decreases effective population size and results in a decreased response selection (Muir, 2000). Similarly, increasing accuracy of selection by use of family indices or BLUP breeding values also reduces the effective population and results in more rapid increase in the rate of inbreeding (Quinton *et al.*, 1992; Quinton and Smith, 1995). A second factor to consider is the time scale. Breeders are not only concerned with selection limits, but they must also stay in business long enough to achieve those limits. Thus optimization of short- term response to selection is also economically crucial.

Bohren *et al*. (1966) and Bohren (1970) have indeed shown that theoretically, genetic correlation between partial and full egg record could change from positive to negative in the course of selection. However, there is no evidence that such change has taken place in practice. Nestor *et al*. (1996) and John *et al*. (2000) reported an average of 0.45 as genetic correlation between partial and residual egg number from Light Sussex and Brown Leghorn populations. Nestor *et al*. (1999) reported 0.55 from a commercial White Leghorn population. Sharma and Krishna (1998) reported positive genetic correlation between part and residual period percentages of production. Morris (1964) and Bohren (1970) reported genetic correlation of 0.92 and 0.58 respectively while Bohren *et al*. (1966) reported 0.38 between number of eggs in the two periods. From available literary citation, reports on response to selection in egg layer stock is few in Nigeria. The objective of this study is to obtain

Table 1: Average performance of Rhode Island chicken by generation, population and traits of male line selected for part-period egg production

Trait	Group	1991 Mean	1992 Mean	1993 Mean	1994 Mean	1995 Mean	b_p	b_g
Egg280D[a]	Whole[1]	35.3±15.43	35.3±16.72	28.0±12.65	39.2±14.11	34.7±14.74	0.19	0.42
	Selected[2]	48.1±10.87	50.7±11.50	38.4±10.16	50.9±8.53	41.5±11.78		
	Control[3]	34.2±14.36	35.6±16.63	25.4±13.37	39.5±15.83	35.6±13.50	-10.80	
ASM[b]	Whole[1]	203.1±18.55	207.7±22.09	222.3±18.57	214.1±17.29	212.3±22.58	2.95	-0.21
	Selected[2]	194.4±12.97	195.4±16.62	212.3±15.55	207.7±10.92	207.2±14.12		
	Control[3]	200.6±15.60	205.8±20.06	221.3±20.60	212.5±14.39	210.6±13.74	7.65	
Egg wt[c]	Whole[1]	56.0±4.24	54.9±3.65	56.0±4.08	55.9±4.62	48.3±3.69	-1.13	-0.43
	Selected[2]	55.6±4.09	54.4±3.25	55.9±3.92	55.7±4.20	48.2±3.64		
	Control[3]	55.6±4.43	54.7±3.82	54.5±4.76	56.3±0.94	50.6±3.13	0.55	
BWT40[d]	Whole[1]	1559.6±183.01	1726.0±13.30	1659.2±229.64	1708.4±223.29	1466.0±0.00	-12.18	34.45
	Selected[2]	1601.5±188.32	1754.8±216.65	1687.5±229.87	1723.8±221.99	1600.0±28.00		
	Control[3]	1685.7±223.86	1687.6±189.55	1704.9±177.14	1659.8±252.56	1430.0±92.63	-54.00	

[1]Whole = population before outstanding producers were selected. [2]Selected = Population of the selected group.
[3]Control = Population of the control group. [a]Egg number to 280days. [b]Age at sexual maturity. [c]Matured egg weight. [d]Body weight at 40 weeks of age. b_p = phenotypic change per generation. b_g = genetic change per generation

information on the response of egg number to selection in Rhode Island chickens selected for part period egg production using multi trait index selection and independent culling level.

Materials and Methods

The study was carried out at the National Animal Production Research Institute (NAPRI), Ahmadu Bello University, Shika-Zaria, Kaduna State, Nigeria. The chickens for the study were obtained from a random-bred population of two strains (A and B) of Rhode Island breeder hens, which form part of the poultry breeding flocks maintained at the institute.

Records obtained from 4336 pullets progeny for strain A and 4843 pullets, progeny for strain B belonging to 5 generations (1991-1995) under selection for part-period egg production to 280 days of age were used for this study. The response variables monitored were Age at sexual maturity (days) (ASM), Egg number (EGG280 D), Egg weight (gm) (EWTAV) and Body weight at maturity (gm) (BWT40)

Data analysis: Records from hens with all the parameters measured were used in the data analysis. Hens that produced less than ten eggs to 280days were excluded. For genetic and performance analysis, the data was edited to exclude records of dams with two offspring per sire and sires with less than nine offspring. This is to minimize the prediction error variance associated with the estimates. Data was analyzed using SAS (1996) after correcting for hatch and generation/year effect.

Selection procedure: Selection was based on an index, which combines information on individual production, the sire and family averages. The selection indexes were based on the method developed by Hazel (1943), Osborne (1957a,b) and Henderson (1963). The female's breeding value was predicted from her own phenotype (performance) and the average (means) of full and half-sisters. However, since virtually all of the traits studied are manifested in the females only, the male's breeding value was predicted from the means of his half and full sisters. Heritability estimate obtained was used to obtain weights b_1, b_2 b_3 and b_4 in the selection index. This procedure gave an unbiased prediction of selection response, as the index values were unbiased estimates of the animal additive genetic values.

Estimation of expected genetic change: Expected genetic change in one generation of selection was estimated by: $G = h^2 \times SD$

Where h^2 is the heritability estimate calculated using variance component analysis.

SD is the selection differential, which refers to the superiority, or inferiority of those selected as parents, P_s as compared to the average of the population, P from which the breeding animals were selected.

$$SD = (\bar{P}_s - \bar{P})$$

Where $\bar{P}_s$ is the average of the selected individuals
$\bar{P}$ is the average of the population before selection

Estimation of expected and realized response to selection for primary trait under selection: Expected response to selection for egg production to 280 days was calculated as per Falconer and Mackey (1998).

The genetic response per generation was estimated by regression of annual response to selection on generation number.

Regression coefficient was tested for statistical significance using t-test.

Results and Discussion

Tables 1 and 2 show the average performance by generation, population and traits in the male and female

Table 2: Average performance of Rhode Island chicken by generation, population and traits of female line selected for part –period egg production

Trait	Group	1991 Mean	1992 Mean	1993 Mean	1994 Mean	1995 Mean	b_p	b_g
Egg280D[a]	Whole[1]	30.8±14.96	30.7±16.31	25.3±13.12	40.7±14.73	31.7±13.51	1.67	
	Selected[2]	44.3±9.77	47.4±10.19	37.0±9.68	51.3±10.37	37.4±10.20		3.14
	Control[3]	38.3±13.33	28.4±17.02	19.9±11.13	34.4±14.87	25.5±11.20	0.68	
ASM[b]	Whole[1]	208.5±28.64	218.3±21.01	224.1±16.8	212.2±10.78	217.4±19.93	1.01	
	Selected[2]	197.6±12.91	203.6±12.78	214.5±17.24	207.0±8.862	207.2±9.12		-3.92
	Control[3]	201.5±1474	202.8±19.25	237.4±20.23	215.4±13.15	220.7±10.64	7.71	
Egg wt[c]	Whole[1]	43.4±17.27	55.7±3.71	55.6±4.26	54.9±4.36	48.9±3.46	-1.21	
	Selected[2]	54.2±9.77	55.1±3.57	54.9±3.84	54.6±4.80	48.9±3.19		-0.89
	Control[3]	48.7±13.77	54.8±5.66	54.8±5.92	55.0±3.73	49.2±3.42	0.03	
BWT40[d]	Whole[1]	1603.5±192.66	1777.2±218.81	1834.3±300.39	1703.2±288.48	1414.7±248.63	-28.6	6.12
	Selected[2]	1607.7±182.72	1808.6±209.87	1908.8±282.08	1722.8±266.14	1440.0±228.00		
	Control[3]	1615.5±198.91	1667.9±209.63	1687.0±194.56	1614.7±256.37	1446.0±180.00	-0.52	

[1]Whole = population before outstanding producers were selected. [2]Selected = Population of the selected group.
[3]Control = Population of the control group. a Egg number to 280days. b Age at sexual maturity. c Matured egg weight.
[d]Body weight at 40 weeks of age. b_p = phenotypic change per generation. b_g = genetic change per generation

Table 3: Estimated genetic and phenotypic change per generation in Rhode Island chicken selected for part-period egg production

Trait	Male line		Female line	
	b_g ± S.E	b_p ± S.E	b_g ± S.E	b_p ± S.E
Egg no.	0.42±0.02	0.19±0.09	3.14±0.02	1.67±0.12
ASM	-0.21±0.08	2.95±0.06	-3.92±0.08	1.01±0.03
BWT40	34.45±0.60	-12.18±0.03	6.12±0.07	-28.60±0.60
EWTAV	-0.43±0.03	-1.13±0.02	-0.89±0.03	-1.21±0.04

4b_g = genetic change per generation.
b_p = phenotypic change per generation

lines. Table 3 shows genetic and phenotypic change per generation while Table 4 shows realized response and predicted gain for egg production to 280 days of age.

The genotypic response observed in the male line was 0.42 eggs per generation (Table 1 and 3). The phenotypic response was 1.67 eggs per generation while the genotypic response was 3.1 eggs per generation (Table 3).

From the values obtained it was obvious that selection was effective in improving the egg number in the female line but not in the male line. There was an increase of 1.67 vs 0.19 eggs per year in both female and male line, respectively. This values were similar to 1.26 eggs per generation reported by Gowe *et al*. (1993) and similar also to those reported by Johari *et al*. (1989), Gowe and Fairful (1986), Poggenpoel (1986) and Lie (1988). However, when the mean of the selected line was adjusted by subtracting the mean of the appropriate control within a generation, the resulting genetic response was high and significant (P<0.05) in the female line but not in the male line. The low actual egg number obtained could be as a result of the delay in sexual maturity especially during the later years of the selection experiment. Another factor that may have contributed to the variable response achieved from generation to generation may also be due to varying season of hatching across generations (hatching could be during the hot dry, rainy or cool dry harmattan period). The selection response in egg number to a fixed age of 40 weeks is a function of rate of lay and age at first egg. However, since the age at first egg in this study was mostly delayed due to occasional inadequate feeding, the negative genetic gain in egg number could be attributed to the negative correlation between inadequate feeding and age at first egg. The actual genetic gain in the female line was higher than predictions especially from the 3rd generation. It could be seen that the realized genetic gain in both lines was different from predictions. These were in consonance with the report of Poggenpoel and Erasmus (1978), Ayyagari *et al*. (1980) and Barua (1983). Srivastava (1985) reported that the only possible reason for variable responses among strains could either be genotype x environment interaction or due to correlated responses. Dickerson (1963) and Dhaliwal *et al.* (2003) discussed the issues of variable response and concluded that this could be caused among other factors by genetic 'slippage' due to fluctuating yearly environmental trend, negative genetic correlations between components of performance, random loss of useful genes by inbreeding, time trend and natural selection.

Genetic ‘slippage’ according to Dickerson (1963) was as a result of selection being mainly directed towards non-additive genetic effects or over dominance, which dissipates in the next generation. However slippage was not a problem in this work as selection was directed towards a single trait of egg number to 280 days. Inbreeding effect in reducing the actual genetic gains as expected was offset by increase in selection efficiency from the multi trait Osborne's index selection and independent culling level employed in this study. The lack of response observed in the male line population selected over the generations is not unusual. Nordskorg *et al.* (1974) reported a non-statistically detectable response in egg production in two breeds of chicken selected for increase in rate of egg production.

Table 4: Realized Response and Predicted Gain for egg production up to 280 days in Rhode Island chicken selected for part- period egg production

	Gen	Genetic response	Predicted gain	Realized/ predicted ratio
Male	1	1.16	3.05	0.38
Line	2	0.31	3.71	0.08
	3	2.61	1.45	1.79
	4	0.34	2.36	0.14
	5	0.96	2.45	0.39
Female	1	7.52	5.14	1.46
Line	2	2.37	6.17	0.38
	3	5.3	3.77	1.4
	4	6.35	2.00	3.18
	5	6.18	0.85	7.27

They found no appreciable response in their White Leghorn selected for part year rate of lay until the 8th generation.

In both male and female line populations, there was positive response of egg number over six generations. These values represented the phenotypic response of egg number to five generations of selection. After correction for environmental effect by using random bred control population, the response became negative for the male line while the magnitude of the response was increased in the female line. This observation agrees with the report by Johari *et al.* (1989) and Lie (1988) for white leghorn population. Liljedahl *et al*. (1979) however reported higher response of 4.4-6.2 eggs per generation in a selection experiment covering a similar period.

The positive response in the female line population could be attributed to reduced age at sexual maturity. This is supported by the findings of Lijedahl and Weyde (1980) who reported that contribution of age at sexual maturity to response to selection lies between 50 and 80% over 4 generations of selection.

In conclusion there was a better response in the female line than in the male line for egg production to 280 days of age. It is therefore recommended that in the production of commercial day old chicks in Kaduna State, Nigeria using Rhode Island Chickens, the strain of choice for the production of fertile eggs is the female line while the cocks of the male line are kept to mate with them to take advantage of heterosis.

References

Ayyagari, V., S.C. Mohapatra, A. Venkatramaiah, T. Thiagasundaram, D. Chaudary, D.C. Johari and P. Ranganathan, 1980. Selection for egg production on part records 1. Evaluation of short term response to selection. Theor. and Applied. Genetics, 57: 2177-283.

Barua, N., 1983. Genetic evaluation on economic traits as a consequence of intra population index selection for part time egg production in egg type chicken, Ph.D. thesis, Rohikhand, University, Bareily.

Bohren, B.B., W.G. Hill and A. Robertson, 1966. Some observation on asymmetrical correlated response to selection Genet. Res. (Camb) 7: 44-57.

Bhoren, B.B., 1970. Genetic gain in annual egg production from selection on early part records. World Poult. Sci., 26: 647-657.

Dhaliwal, S.K., M.L. Chaudhary and G.S. Brah, 2003. Genetic analysis of egg quality in selected and control lines of Japanese quails. Ind. J. Poult. Sci., 38: 89-95.

Dickerson, G.E., 1963. Experimental evaluation of selection theory in poultry, Proc. 11th Intern. Congr. Genet., 3: 747-759.

Falconer, D.S. and T.F.C. Mackey, 1998. Introduction to Quantitative Genetics. 4th Edition, Thompson Press Ltd. India.

Gowe, R.S. and R.W. Fairful, 1986. In III Long term selection for egg production in chicken in III World congress on genetics applied to livestock production.

Gowe, R.S., R.W. Fairful, I. McMillan and G.S. Schmidt 1993. A strategy for maintaining high fertility and hatchability in a multi-trait egg stock selection program. Poult. Sci., 72: 1433-1448.

Hazel, L., 1943. The genetic basis for constructing selection indexes. Genetics, 28: 476-490.

Henderson, C.R., 1963. Selection index and expected genetic advance. Statistical genetics and plant breeding. Nat. Academic, of Sci. Nat. Res. Council Pub., 982. Washington, D.C.

Johari, D.C., B.R. Dey, M.C. Kataria, V. Ayyhagari, S.C. Mohapatra and R.A.M. Gopal, 1989. Long term selection for part period egg production. Evaluation of direct response and correlated response in egg quality traits. Ind. J. Anim. Sci., 59: 1170-1172.

John, C.L., A. Jalaludeen and P. Anitha, 2000. Inpact of selection for part period egg production in two strains of White Leghorn. Ind. J. Poult. Sci., 35: 156-160.

Lie, Y., 1988. Analysis of effectiveness of selection in Beizing White Leghorn lines. Anim. Breedg. Abstr., 56: 2245.

Liljedahl, L.E., N. Kolstad, P. Sorensen and K. Maijala, 1979. Scandinavia selection and cross breeding experiment with laying hens. I. Background and general outline. Acta Agri. Scand., 28: 273-286.

Liljedahl, L.E. and C. Weyde, 1980. Scandinavian selection and corss breeding experiment with laying hens. II results from the Swedish part of the experiment. Acta Agri. Scand., 30:237-73-260.

Morris, J.A., 1964. The usefulness of early records as selection criteria. Proceedings of the Australian Poultry Sci. Convention, pp: 7-11.

Muir, W.N., 2000. Estimation of response to selection in non –replicated populations. In : Proc 41st National Breeders Round table, St Louis, MO., pp: 95-121.

Nestor, K.E., Noble, D.O. and Y. Moritsu, 1996. Direct and Correlated responses to long- term selection for increased body weight and egg production in turkeys. Poult. Sci., 75: 1074-1191.

Nestor, K.E., J.W. Anderson and R.A. Patterson, 1999. The effect of selection for increased body weight, egg production and shank width on development stability in turkeys. Special Circular, 171-00, 82: 212 - 226.

Nordskorg, A.W., H.S. Tolmaan, D.W. Casey and C.Y. Lin, 1974. Selection in small population of chickens. Poult. Sci., 53: 1188-1219.

Osborne, R., 1957a. The use of sire and dam family averages in increasing the efficiency of selective breeding under hierarchical mating system. Heredity 11: 93-116.

Osborne, R., 1957b. Family selection in poultry. The use of sire and dam averages in choosing male parents Proc. Soc. Roy (Edinburgh), 64: 456-461.

Poggenpoel, D.G., 1986. Correlated response in shell and albumen quality with selection for increased egg production. Poult. Sci., 19: 111-123.

Poggenpoel, D.G. and J.E. Erasmus, 1978. Long term selection for increased egg production. Br. Poult. Sci., 19: 111-123.

Quinton, M., C. Smith and M.E. Goddard, 1992. Comparison of selection methods at the same level of inbreeding. J. Anim. Sci., 70: 1060-1067.

Quinton, M. and C. Smith, 1995. Comparison of evaluation - selection systems for maximizing genetic response at the same level of inbreeding. Journal of Anim. Sci., 73: 2208-2212.

SAS Institute, 1996. SAS/STAT Soft ware. Changes and Enhancements through release 6.11, Cary, N.C. pp: 531-656.

Schmidt, G.S. and E.A.P. Figueiredo, 2005. Selection for reproductive traits in white egg stock using independent culling levels. Braz. J. Poult. Sci., 7: 231-235.

Sharma, A.K. and S.T. Krishna, 1998. Genotypic and phenotypic parameters of economic traits in 'V' strain of White Leghorns under selection. Ind. J. Poult. Sci., 33: 198-201.

Srivastava, P.N., 1985. Genetic analysis for some of the economic traits of four strains of White Leghorn breed. Ph.D thesis. Jawahal Neru Agricultural University Jabapur, India.