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In-Breeding Effect on Performance of Rhode Island Chickens Selected for Part-Period Egg Production

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Abstract: Data from 4336 pullets progeny of 144 sires and 779 dams for strain A and 4843 pullets, progeny of 158 sires and 1108 dams for strain B belonging to 5 generations under selection for part-period egg production to 280 days of age were used for this study. The number of pullets housed at about 18weeks per population ranged from 326 and 1000 per generation for each of the population. The effective number of parents in each generation averaged 174 and 187 for male and female populations, respectively. The traits measured were egg number to 280 days (EGG280 D), age at sexual maturity (ASM), egg weight average (EWTAV) and body weight at 40 weeks of age (BWT40). The co-efficient of inbreeding per generation due to finite population size was 0.005 for both the male and the female lines respectively. For the control population the values obtained were 0.008 vs 0.007 for both the male and female lines respectively. The average performance of the birds over the study period for the male and female lines respectively ranged from 38.38 vs 50.94 and 37.03 vs 51.25 for EGG280 D, 194 vs 212 and 197 vs 214 for ASM, 48.29 vs 55.93 and 48.29 vs 55.11 for EWTAV, 1600 vs 1754 and 1440 vs 1908 for BWT40.The effective number of parent in each generation averaging about 175 probably caused an average inbreeding of about 0.5% per generation. Although the level of inbreeding in this population is not critical there is evidence of an increasing trend, which could lead to homozygosity in the flock. There is need to widen the genetic base to prevent selection depression too early in the flock.

Key words: Chicken, inbreeding, performance, egg production

Introduction

Genetic improvement of livestock and poultry is based on two alternative approaches: crossbreeding and selection (Szwaczkowski *et al.,* 2003). Crossbreeding leads to the creation of more heterozygotes and in consequence to greater genetic variation in the population. In contrast, selection determines both genetic gain and inbreeding rate. Inbreeding effects include increased homozygosity, higher risk for the incidence of lethal or deleterious recessive alleles and decrease in the performance and fitness traits (Milgior *et al.,* 1995). On the other hand, mating of relatives has been used over the last centuries to produce breeds, varieties and lines.

In recent years, a number of studies on inbreeding effects in livestock and poultry populations have been carried out (Klemetsdal, 1998, Thompson *et al.,* 2000a,b). Inbreeding depression in reproductive and productive traits has been reported by Flock *et al.* (1993) and Smith *et al.* (1998). Therefore, from current perspective, the inbreeding rate is perceived as negative, especially for small, closed populations. Hence mating designs with constrains of inbreeding levels are developed (Oyama and Mukai, 1998; Nomura, 1998). Contrary to livestock, laying hens are characterized by some traits (e.g. short generation interval) which lead to an increase in the inbreeding rate. Jeyaruban *et al.* (1995) reported that the use of best linear unbiased prediction (BLUP) induced larger inbreeding rate compared to selection response, especially for traits of low heritability.

Information on the effect of inbreeding on productive and reproductive trait on livestock and poultry populations in Nigeria is scanty. The objective of this study was to evaluate inbreeding trends and its effect on some reproductive traits in Rhode Island chickens selected for part-period egg production.

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. Adeyinka (1998), had earlier reported details of hatching procedure, and management of the birds.

Data from 4336 pullets, progeny of 144 sires and 779 dams for strain A and 4843 pullets progeny of 158 sires and 1108 dams for strain B belonging to 5 generations (1991-1995) under selection for part period egg production to 280 days of age were used. The expected numbers of individuals to monitor to 280 days are 1000 and 250 hens for the selected and control populations respectively. The actual number of hens monitored

Table 1: Effective number of sires, dams and parents and computed in breeding co-efficient (selected population)

Line	Gen	No. of Female Tested	Sires N_m	Dams N_f	Effective Parents		Inbreeding ΔF
					Ne Wright	Ne gowe	
Male	1	696	34	148	110.6	185.0	0.0045
	2	979	27	180	92.9	192.0	0.0053
	3	917	28	188	97.5	194.9	0.0051
	4	803	27	142	90.7	161.6	0.0055
	5	941	28	121	91.0	137.6	0.0055
	6	326	27	192	97.7	-	0.0051
Average					96.7	174.2	0.0052
CumulativeΔF							0.0259
Female	1	845	35	234	121.8	243.0	0.0041
	2	1000	31	235	109.5	256.9	0.0046
	3	1000	31	224	108.9	202.9	0.0046
	4	998	28	206	98.6	82.3	0.0051
	5	1000	33	209	114.0	150.2	0.0044
	6	341	28	198	98.1	-	0.0051
Average					110.6	187.9	0.0046
CumulativeΔF							0.0228

however varied from this ideal number from year to year depending on factors such as hatchability and infra structural facilities.

Data collection and analysis: The following traits were measured

1) Age at sexual maturity (days) (ASM): This was obtained by recording the age to first eggs for each pullet.
2) Egg number (EGG280 D): Eggs laid from first egg were recorded and collected on daily basis up to 280 days of age.
3) Egg weight (gm) (EWTAV): This was obtained by taking the average weight of eggs at 35,36,37 and 38 weeks of age.
4) Body weight at maturity (gm) (BWT40): This was obtained by weighing the surviving hen at 40 weeks of age.

Hens with all the parameters measured were used in the data analysis. Likewise hens that produced less than ten eggs to 280 days 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. Estimates were obtained using SAS (2002) after correcting for hatch and generation/year effect.

Effective population size: The effective population size (N_e) in each parental generation for the selected group was computed as described by Wright (1931).

In breeding co-efficient: The inbreeding co-efficient per generation due to finite population size was calculated as described by Wright (1931) from available pedigree data across five generations. The inbreeding coefficients were expressed as percent. The following unitrait animal model was employed:

$$y_{ijk} = \mu + s_i + p_j + bx_{ijk} + \alpha_{ijk} + e_{ijk}$$

Where:
y_{ijk} = an observation of ijk $^{-th}$ individual
μ = overall mean
s_i = fixed effect of I-th generation (1, 2,……….5)
p_j = fixed effect of j^{-th} hatch (1, 2,…………..8)
b = coefficient of partial linear regression
x_{ijk} = inbreeding coefficient of ijk $^{-th}$ individual
α_{ijk} = random genetic additive effect of ijk $^{-th}$ individual
e_{ijk} = random error associated with ijk $^{-th}$ observation
All effects are random, normal and independent with expectations equal to zero.
Computations were performed using the DFREML package programmes of Meyer (2001)

Results and Discussion

The number of pullets housed at about 18 weeks per population ranged from 326 and 1000 per generation for each of the population (Table 1). The effective number of parents in each generation averaged 174 vs 187 for male and female population respectively. The co-efficient of inbreeding per generation due to finite population size was calculated as averaging 0.005 for both the male and female line (Table 1). For the control population (Table 2) the values obtained were 0.008 vs 0.007 for the male and female line respectively. The average performance of birds by generation, population and traits for both the male and female lines are presented (Tables 3 and 4). The values over the study period for both the male and female lines respectively ranged from 38.38 vs 50.94 and 37.03 vs 51.25 for EGG280D, 194 vs 212 and 197 vs 214 for ASM, 48.29 vs 55.93 and 48.29 vs 55.11 for EWTAV, 1600 vs 1754 and 1440 vs 1908 for BWT40. These estimates, which were

Table 2: Effective number of sires, dams, parents and calculated in breeding co-efficients (control population)

Line	Gen	Population Size	Sires N_m	Dams N_f	Effective Parents	Inbreeding ΔF
Male	1	170	13	130	160.0	0.0079
	2	110	11	115	136.7	0.0088
	3	289	14	94	154.8	0.0070
	4	207	14	95	155.3	0.0070
	5	105	12	61	120.7	0.0055
	6	167	12	80	132.4	0.0083
Average					143.3	0.0079
CumulativeΔF						0.0472
Female	1	141	17	146	201.6	0.0057
	2	256	13	80	139.8	0.0076
	3	256	15	96	163.4	0.0067
	4	259	14	130	169.3	0.0074
	5	71	13	37	101.3	0.0080
	6	198	12	85	134.9	0.0082
Average					151.7	0.0073
CumulativeΔF						0.0436

Table 3: Average performance by generation, population and traits of male line

Trait	Group	1991 Mean±SE	1992 Mean±SE	1993 Mean±SE	1994 Mean±SE	1995 Mean±SE
Egg280D[a]	Whole[1]	35.34±15.43	35.25±16.72	27.99±12.65	39.15±14.11	34.67±14.74
	Selected[2]	48.06±10.87	50.74±11.5	38.38±10.16	50.94±8.53	41.47±11.78
	Control[3]	34.18±14.36	35.56±16.63	25.38±13.37	39.49±15.83	35.63±13.5
ASM[b]	Whole[1]	203.13±18.55	207.73±22.09	222.34±18.57	214.08±17.29	212.33±22.58
	Selected[2]	194.42±12.97	195.44±16.62	212.33±15.55	207.72±10.92	207.21±14.12
	Control[3]	200.55±15.6	205.77±20.06	221.31±20.6	212.54±14.39	210.61±13.74
Egg wt[c]	Whole[1]	55.99±4.24	54.88±3.65	55.97±4.08	55.92±4.62	48.29±3.69
	Selected[2]	55.61±4.09	54.39±3.25	55.93±3.92	55.66±4.2	48.16±3.64
	Control[3]	55.61±4.43	54.65±3.82	54.45±4.76	56.25±.94	50.6±3.13
BWT40[d]	Whole[1]	1559.6±183.01	1726±213.3	1659.2±229.64	1708.4±223.29	1466±200.00
	Selected[2]	1601.5±188.32	1754.8±216.65	1687.5±229.87	1723.8±221.99	1600±228.00
	Control[3]	1685.7±223.86	1687.6±189.55	1704.9±177.14	1659.8±252.56	1430±192.63

[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(days).
[c]Matured egg weight(g). [d]Body weight at 40 weeks of age(g)

for the selected group, were improved when compared to other groups both within and across the years. There was an average gain of 12.87 and 14.36 eggs for the male and female lines respectively when compared to the control population. This result agrees with John *et al.* (2000) who reported, 9.87 and 12.3 eggs over ten generations. The decline in ASM (6.54 vs 12.12 for the male and female lines) is expected as selection for more eggs favours early maturity, because of the negative genetic association of the two traits. This agrees with the work of John *et al.* (2000). However there is no definite trend established for the EWTAV and BWT40. This is at variance with the works of Ayyagari *et al.* (1980) Mohapatra *et al.* (1983), Thiagasundaram (1984) and John *et al.* (2000) who reported a decline in egg weight and a gradual increase in 20-week body weight after a few generations of selection for egg number.

The small number of parents in each generation averaging about 175 probably caused an average inbreeding of about 0.5% per generation. This level of inbreeding is not critical and hence no appreciable effect on performance. These findings agree with the results of other authors. Nordskorg and Cheng (1998), Gowe *et al.* (1993); Sewalem *et al.* (1999) reported inbreeding co-efficient of 0.13 on the average over 7 generation of selection, which is higher than the value reported in this study. Szwaczkowski *et al.* (2003), in his studies using White leghorn (H77) and New Hampshire (N88) observed no definite trend but reported that annual mean inbreeding level appeared lower in strain H77 (2.5%) than in N88 (3.5%). Also Schmidt and Figueiredo (2005) in their study with white egg layer strains reported inbreeding rate increasing at 0.4% per generation but observed no inbreeding depression. They explained that the selection model used compensated for any negative effects of inbreeding.

Their effective number (160) however, was considerably lower than those obtained in the population being considered in this study. Although, it is generally recommended, that the rate of in breeding in chickens be kept at a level lower than 1% (Morris and Pollot, 1997). Nomura *et al.* (2001 and 2002) obtained values greater than this critical level without blunting genetic

Table 4: Average performance by generation, population and traits of female line

Trait	Group	1991 Mean±SE	1992 Mean±SE	1993 Mean±SE	1994 Mean±SE	1995 Mean±SE
Egg280D[a]	Whole[1]	30.79±14.96	30.74±16.31	25.34±13.12	40.74±14.73	31.7±13.51
	Selected[2]	44.31±9.77	47.41±10.19	37.03±9.68	51.25±10.37	37.37±10.2
	Control[3]	38.31±13.33	28.37±17.02	19.94±11.13	34.39±14.87	25.52±11.2
ASM[b]	Whole[1]	208.49±28.64	218.26±21.01	224.14±16.8	212.23±10.78	217.41±19.93
	Selected[2]	197.56±12.91	203.58±12.78	214.52±17.24	206.98±8.862	207.22±9.12
	Control[3]	201.48±1474	202.84±19.25	237.35±20.23	215.4±13.15	220.74±10.64
Egg wt[c]	Whole[1]	43.35±17.27	55.73±3.71	55.64±4.26	54.85±4.36	48.86±3.46
	Selected[2]	54.17±9.77	55.11±3.57	54.87±3.84	54.63±4.8	48.91±3.19
	Control[3]	48.72±13.77	54.83±5.66	54.8±5.92	55.03±3.73	49.24±3.42
BWT40[d]	Whole[1]	1603.5±192.66	1777.2±218.81	1834.3±300.39	1703.2±288.48	1414.73±248.63
	Selected[2]	1607.7±182.72	1808.6±209.87	1908.8±282.08	1722.8±266.14	1440±228.00
	Control[3]	1615.5±198.91	1667.9±209.63	1687±194.56	1614.7±256.37	1446±180.00

[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 (days). [c]Matured egg weight (g).
[d]Body weight at 40 weeks of age (g)

gains over 15 generations. Burrow (1993) stated that in the absence of inbreeding, selection is an effective tool in the improvement of most economic traits of importance to the livestock breeder. It is however, possible that in closed population inbreeding depression may overwhelm the positive responses from selection resulting in zero gain in performance. This is due largely to limited population size and reduction in genetic variability (increased homozygosity). The higher the effective population size, the lower the expected inbreeding depression. Rates of in breeding are largely inflated in selected populations because of the reduced, effective population size. Inbreeding reduces genetic variability, vigor and reproductive performance and increases the probability of fixation of unfavorable genes. In recent years, various methods have been proposed to reduce the rate of in breeding in selection programmes while keeping genetic gains at the same level (Nomura *et al.*, 2002). In studies conducted in beef cattle (McNeil *et al.*, 1992) dairy cattle (Ahmad *et al.*, 1974) and sheep (Erasmus *et al.*, 1991) it was concluded that inbreeding had no appreciable influence on selection response. Burrow (1993) however categorically maintained that under mild level of inbreeding selection is an effective tool in improving performance in heritable traits.

In general, the inbreeding effects in the populations studied were not significant. Jeyaruban *et al.* (1995) pointed out that intense selection in his study population based on BLUP led to a high inbreeding rate (15%) whereas the genetic gain reached only 5%. Hence the inbreeding effect obtained can be affected by selection intensity applied to the populations studied. From a statistical point of view, a relatively low inbreeding level of both populations is not suitable for evaluating the inbreeding effects.

The result as presented here led to the following conclusions.

The inbreeding level seems to be relatively low in these populations undergoing selection.

Even though the observed inbreeding levels were low, it is however pertinent to note that there is an increasing trend in the inbreeding co-efficient per generation in the populations. There is the need to widen the genetic base by introducing additional lines to prevent inbreeding depression too early in the flock under the selection programme.

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