CORRELATED RESPONSES IN WEIGHTS OF IMPROVED INDIGENOUS PIGS - NIGERHYB - IN NIGERIA

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ABSTRACT

Data collected on the weight of 1681 offsprings of improved indigenous pigs from 1984 to 1990 were used to obtain heritability estimates; genetic, environmental and phenotypic correlations among weights and gains from birth to mature and yearling weights. The estimates were used to predict expected change from correlated responses from single trait selection. Heritability estimates obtained from paternal half-sib analysis were birth weight 0.90 ± 0.08 ; gain from birth to weaning 0.14 ± 0.11 ; 150 days weight 0.49 ± 0.28 ; gain from weaning to 150 days 0.49 ± 0.15 ; weight gain from 150 days to yearling weight 0.41 ± 0.26 and yearling weight $0.66 \pm$. Genetic correlations among all weights and gains were fairly high, ranging from 0.25 to 0.81. Selection for individual pig weight at 56 days appear to be a single good criterion for selection for growth at other ages with coheritabilities of 0.669 for 56 and 150 days weight and 0.856 for 56 days versus yearling weight.

Keywords; Correlated responses, improved indigenous pigs, Nigerryb.

INTRODUCTION

In recent years much emphasis in applied livestock breeding programmes has been placed on growth rate as measured by mean of gain or weight for age (Purser, 1980; Quijandria, Muscari and Robinson 1983; Lundeheim *et al* 1994; deVries and Kanis, 1994). Estimates of genetic, environmental and phenotypic parameters for traits of economic importance are similarly needed to formulate effective breeding plans and establish selection procedures in different herds and for different species.

Studies reporting genetic correlations tend

to indicate that genetic correlation among weights and gains during various periods of the animal's life are fairly high (Shelby *et al*, 1963; Strang and Smith, 1979; Adebambo, 1985; Adebambo *et al*, 1993). Estimates of potential magnitude of response within population selection for growth rate at different ages have also been of interest to livestock breeders. With current breeding programmes all over the world showing many similarities, shaped by findings that crossbred animals have clear advantage above pure breeds and that performance testing is more efficient than progeny testing (Brascamp, 1994). The improved indigenous pigs of Nigeria (NIGERHYB) were developed to test the effectiveness of breeding procedures at producing large sized pigs of Nigerian origin based on crosses between the Nigerian indigenous pigs and two exotic lines, the Large White and Hampshire as sires. Their improvement and selection were based on growth rate, reproductive efficiency and carcass quality. Data on breed formation (Adebambo *et al* 1993), carcass quality (Adebambo, 1992), and growth selection responses (Adebambo, 1994) had been published for these set of pigs.

A study of selection response in animal weights (Wheat *et al*, 1981; Adebambo 1993; deVries and Kanis 1994 and Lundeheim *et al*, 1994) similarly showed that very efficient selection for highly heritable single traits cause more correlated responses than selection for complex selection indexes. Hence it is the objective of this study to obtain the heritability estimates, the environmental and phenotypic correlations for weights and gains from birth through maturity of these developed improved Nigeria's indigenous pig lines so as to derive information on expected direct and correlated responses from single trait selection.

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MATERIALS AND METHODS

The data used in this study were collected on improved Nigerian Indigenous pig Hampshire (HP) and Large White (LW) lines (NIGERHYB) raised at the Institute of Agricultural Research and Training, Ibadan, Nigeria between 1984 and 1990. The lines description and breed formation were presented on a previous work by Adebambo *et al* (1993). Performance of these lines and the selection criteria had been reported in a previous work by Adebambo (1994).

Birth weight and litter sizes were recorded within the first 12 hours after birth. The animals were introduced to 21% protein creep feeding from 2 weeks of age and weaning was at 56 days of age. They were placed on 16% protein diet till 150 days of age and supplemented with 30% brewers waste which when analysed resulted in about 14% crude protein and 11% crude fibre diet from 150 days to yearling weight on an *ad libitum* feeding. Data recorded were individual pigs birth weight (BW), weaning weight (WW), gains from 56 to 150 days (WG), weights at 150 days of age (IPW), gains from 150 days to yearling weight (IYW) and yearling weights (YW). Mass Selection was practised directly for rapid gain in the HP line and indirectly in the LW line, the emphasis on this line having been placed on reproduction. Within full-sib family selection for rapid gain was practiced in both lines.

The two lines were selected as random 20 gilts each were mated per generation. Selection criteria were based on the reproductive performance of the gilts in an over-all sow reproductive index and rate of growth of the selected individuals within the litter. During this period, 1681 offsprings with complete records were analysed. Analysis was by least-square methods of Harvey (1986) with model that included lines, years, dams within years, sires within lines, sub-group effects which were considered as random effects and the age of dam and age of offspring which were considered as fixed effects. Heritability estimates were calculated by the paternal

halfsib method (Becker, 1975) and genetic, environmental and phenotypic correlations were computed by the variance - covariance component method as described by Singh and Chaudhary (1977). The sexes were treated separately for measurement of selection differentials and response to selection. The expected selection differentials were calculated as the mean gain of the group selected to be parents of the next generation minus the generation mean for the line.

The realized selection differential for each sex was obtained by weighting the deviation of each selected individual from the line-sex mean by the number of progeny at weaning. Male and female responses to selection and the unweighed average for the two sexes were obtained by regression of the generation means for all progeny with complete records on generation number. Realized heritabilities were estimated by regression of generation means on the realized cumulative selection differentials. Response to selection was corrected for environmental effects. The analysis was done on generation means for males and females and the average of the two sexes for each line.

The model used to describe a generation mean for the sexes was:

$$Y_{ijk} = Q_k + X_{ij} + B_{ij}Z_{ijk} + E_{ijk}$$

Where Y_{ijk} = observed mean for the K^{th} generation ($K = 1, 6$) of the j^{th} line ($j = 1, 2$) of the i^{th} base population ($i = 1$)

Q_k = environmental effects common to all observations in the K^{th} generation

X_{ij} = intercept of the ij^{th} line.

B_{ij} = regression coefficient of response on realized cumulative selection differential (Z_{ijk}) for the ij^{th} line

E_{ijk} = random error assumed to be independent with mean zero and variance σ^2_{ijk} .

Direct response was calculated as:

$$\Delta G_s = h^2_{sp} p_g \text{ and correlated response as}$$

$$\Delta G_u = h_{ur} G_s G_{uopv}$$

The ratio of correlated response to direct response is presented as $\frac{\Delta G_u}{\Delta G_s}$

While the superiority of the line above the population mean was calculated using Hermas *et al* (1987) procedure as reported by Mukasa

TABLE 1 LEAST SQUARE MEANS AND STANDARD DEVIATION OF WEIGHTS AT DIFFERENT AGES

Line A	Sex	N	BW	BWG	WW	WG	IPW	IYW	YW
(LWX)	M	#52	1.45	6.35	7.80	18.81	26.61*	52.05*	78.66*
	F	423	1.26	5.68	6.94	16.05	22.99	45.49	70.48
	X		1.36	6.02	7.37	17.43	24.80	49.77	74.57
	SD		0.22	1.27	1.56	3.41	4.89	4.58	7.47
Line B (HIP X)	M	428	1.58	7.38	8.96	12.19	13.15*	51.94*	82.09*
	F	378	1.39	6.53	7.92	16.69	24.81	44.04	70.65
	X		1.49	6.96	8.44	18.94	27.38	47.99	76.37
	SD		0.18	1.16	1.36	3.25	5.01	5.24	9.55

*P < 0.05

LWX = Large white x indigenous cross
 HPX = Hampshire x indigenous cross.
 BW = Birth weight
 BWG = Birth to weaning gain
 WW = Weaning weight
 WG = gains from weaning to 150 days
 IPW = 150 day weight
 IYW = gains from 150 to yearling weight
 YW = yearling weight.

TABLE 2 AVERAGE SELECTION DIFFERENTIALS (KG PER GENERATION) FOR POST WEANING GAINS.

Line A	Generation	Expected Selection		Realized Selection				R:I	
		Differential (I)		Differential (R)					
		F	M	Ave	F	M	Ave		
(LWX)	1.	1.01	2.89	1.95	1.14	2.11	1.63	0.84	
	2	1.61	2.79	2.20	1.23	2.13	1.68	0.76	
	3	1.28	2.89	2.09	1.21	2.16	1.91	0.91	
	4	1.51	2.88	2.20	1.21	2.11	1.66	0.75	
	5	1.26	2.61	1.94	1.21	2.08	1.65	0.85	
	6	1.66	2.05	1.86	1.35	2.19	1.77	0.95	
Means ± S.D.		1.39 ± 0.25	2.69 ± 0.33	2.04 ± 0.144	1.23 ± 0.69	2.21 ± 0.20	1.72 ± 11	0.84	
Line B	1	1.59	3.02	2.30	1.57	2.96	2.27	0.99	
	2	1.43	2.54	2.01	1.29	2.14	1.72	0.86	
	3	1.31	2.16	1.74	1.24	2.14	1.67	0.96	
	(HIPX)	4	1.58	2.82	2.20	1.37	2.61	1.99	0.90
		5	1.27	3.10	2.10	1.29	1.66	2.01	1.65
		6	1.31	2.86	2.13	1.28	2.01	1.65	0.77
Mean ± S. D.		1.42 ± 0.14	2.76 ± 0.34	2.08 ± 0.19	1.34 ± 0.12	2.25 ± 0.46	1.89 ± 0.25	0.91	

- Mugerwa (1994) as

$$CR_{su} = i_s s_u (h_s^2)^5 (h_u^2)^5 r_{sgsu}$$

Where CR_{su} = correlated response in trait s when selection is for trait u

i_s = selection intensity for s

s_u = phenotypic standard deviation for u

$h_s^2 h_u^2$ = heritabilities for traits s and u

r_{sgsu} = genetic correlations between traits s and u .

RESULTS

The means and standard deviations for growth traits in the two lines are given in Table 1. The means are adjusted for age of dam and age of individual animal. The standard deviations are phenotypic. The mean and variance of body weight increase with age, showing a differential age response with relatively small response in preweaning weights (birth to 56 days), larger response to

maturity 150 days and even greater response among adults (yearling).

Selection differentials

Average realised selection differentials per generation varied from 1.63 to 1.77 for LW line and 1.67 to 2.01 for the HP line (Table 2), although expected selection differentials were 1.86 to 2.20 for LW and 1.714 to 2.20 for HP lines, respectively. The intended and realized selection differentials on the HP line were significantly higher than those of LW line. The realized differentials were 1.23 ± 0.07 and 2.21 ± 0.20 for the LW and 1.34 ± 0.12 and 2.25 ± 0.46 for the HP lines in the two sexes. The higher value for generation I particularly in the HP line was due to larger phenotypic variance. Although the difference between expected and realized differentials was not large, the ratio declined from 0.99 in the first

TABLE 3: HERITABILITY ESTIMATES (h^2), GENETIC (r_g), ENVIRONMENTAL (r_e) AND PHENOTYPIC (r_p) CORRELATIONS AMONG PATERNAL HALF SIBS

Trait	BWG	WW	WG	IPW	IYW	YW	h^2
BWG r_g^G	0.12	0.25	0.45	0.38	0.33	0.44	0.09 ± 0.08
r_e^E	6.48	0.58	0.49	0.36	0.42	0.31	
p	0.25	0.41	0.35	0.46	0.27	0.45	
BWG r_g^G	-	0.38	0.33	0.47	0.49	0.41	0.14 ± 0.11
r_e^E	-	0.54	0.46	0.71	0.42	0.54	
p	-	0.58	0.39	0.79	0.24	0.64	
WW r_g^G	-	-	0.25	0.81	0.54	0.78	0.25 ± 0.16
r_e^E	-	-	0.48	0.86	-0.58	0.64	
p	-	-	0.45	0.92	0.29	0.66	
Trait	BWG	WW	WG	IPW	IYW	YW	h^2
WG r_g^G	-	-	-	0.65	-0.21	0.41	0.49 ± 0.28
r_e^E	-	-	-	0.68	-0.31	0.38	
p	-	-	-	0.64	-0.19	0.46	
IPW r_g^G	-	-	-	-	0.18	0.76	0.49 ± 0.28
r_e^E	-	-	-	-	-0.11	0.58	
p	-	-	-	-	-0.10	0.68	
IYW r_g^G	-	-	-	-	-	0.36	0.41 ± 0.26
r_e^E	-	-	-	-	-	0.40	
p	-	-	-	-	-	0.34	

TABLE 4: COMPONENTS OF COVARIANCES

Traits	PBW Vs PWW	PBW vs IPW	PBW vs PYW	PWW vs IPW	PWW vs PYW	IPW vs PYW
covariances						
σ_{gu}^k s	0.066	0.080	0.681	0.33	0.764	0.468
σ_{eu}^e s	-0.013	0.153	0.270	0.166	0.372	1.137
σ_{pu}^p s	0.19	0.233	0.951	0.493	-0.892	-0.669
Coheritability	0.316	0.343	0.716*	0.669	0.856*	0.699*

* $P < 0.05$

generation of the HP line, but was not consistent in the LW line.

Heritability estimates

The combined sex and line for all generations were used to calculate heritability estimates. The genetic, environmental and phenotypic correlations and the heritability estimates are given in Table 3. The heritability of birth weight was 0.09 ± 0.08 . It increased from 0.25 ± 0.16 at weaning to 0.66 ± 0.28 for yearling weights. Heritabilities for weights at each age demonstrate evidence of change in the proportion of genetic variance with age. In particular, the preweaning weight has a low heritability of 0.09 to 0.14, while adult weights

were consistently high, 0.25 to 0.66. Genetic and phenotypic correlations between weights at various ages were estimated for each pair of weights. The phenotypic correlations showed a high value between successive weights while the genetic correlations were lower and more variable. The birth weight was apparently genetically independent of body weight at any subsequent stage of development. Similarly body weight up to weaning had a low genetic correlation with adult weights. The negative correlation between gains from weaning to 150 days and 150 to yearling weight was not unexpected. The coheritability estimates which is the ratio of genotypic covariances to

TABLE 5 AVERAGE CORRELATED RESPONSE EXPECTED FROM SINGLE TRAIT SELECTION AND THE RATIO OF CORRELATED TO DIRECT RESPONSES.

Selected Trait		BW	BWG	WW	WG	IPW	IYW	YW
BW	a	0.63	1.47	2.11	2.45	3.65	6.79	7.74
$\sigma_p = 0.19$	b	1.00	0.45	0.39	0.16	0.57	0.45	0.56
BWG	a	0.98	1.60	2.05	-2.11	4.51	5.29	6.18
$\sigma_p = 1.20$	b	0.47	1.00	0.26	-0.22	0.52	0.65	0.46
WW	a	0.89	1.69	2.58	2.65	1.95	6.25	6.19
$\sigma_p = 1.42$	b	0.65	1.03	1.00	0.63	0.79	0.76	0.92
WG	a	0.22	1.49	1.95	3.85	4.78	8.19	10.25
$\sigma_p = 3.31$	b	0.08	0.24	0.28	1.00	0.36	0.61	0.76
IPW	a	1.71	2.79	0.95	6.95	9.25	7.81	9.38
$\sigma_p = 4.91$	b	0.38	0.68	0.79	1.00	0.77	0.94	0.94
IYW	a	1.21	2.65	1.21	5.11	6.05	4.11	8.56
$\sigma_p = 5.01$	b	0.41	0.46	0.42	0.45	0.58	1.00	0.81
YW	a	2.03	2.85	2.92	6.21	7.18	6.58	8.21
$\sigma_p = 8.27$	b	0.69	0.66	0.92	0.76	0.94	0.68	1.00

a = Correlated Response $\Delta G_u = h s u r G_s G_u \sigma_p u$
 b = Response shown as ratio $\Delta G_u / \Delta G_s$
 ΔG_s = Direct Response = $h_2 s \sigma_p s$

TABLE 6: LINE SUPERIORITY FOR CORRELATED RESPONSES FOR WEANING WEIGHT VERSUS 150 DAYS (IPW) AND YEARLING WEIGHT (YW)

		IPW (kg)	YW (kg)
LWX	Male	17.075 $\pm$ 2.351	25.118 $\pm$ 2.194
	Female	8.823 $\pm$ 1.620	12.979 $\pm$ 2.010
	Mean	12.949 $\pm$ 2.118	19.085 $\pm$ 2.631
HPX	Male	20.589 $\pm$ 1.785	38.663 $\pm$ 2.774
	Female	10.593 $\pm$ 1.108	19.892 $\pm$ 2.164
	Mean	15.516 $\pm$ 1.632	29.138 $\pm$ 3.011

phenotypic covariance for correlated characters are given in Table 4. This is reportedly low and insignificant between birth and other weights except for yearling weight. The weight at other ages were high and significant ranging from 0.471 for 56 to 150 days weight, 0.949 for 56 to yearling weight and 0.670 for 150 days versus yearling weight. This resulted in correlated responses expected from the single trait selection among the pooled data of 0.63 to 7.74 between birth and other weights, 1.71 to 9.38 between 150 days weight and other weights and 2.03 to 8.21 between yearling weights and weights at other ages (Table 5).

Expected Responses

The direct and correlated responses expected from single trait selection is presented in Table 5. Expected response from

direct selection was greater than expected correlated response in all cases. Selection for weaning weight appears to be a good criterion for selection for growth. The expected correlated response in weaning weight was 79% as effective as direct selection while correlated response for 150 days and yearling weights would be equally as effective as direct selection with 94% and 92% represented, respectively. From the correlated response, it follows that for every kilogram increase in weaning weight above the population mean, there could be expected a 12.95kg and 19.09kg weight increase at 150 days and 1 year of age, respectively in the LW line and 15.52 and 29.14kg increase in the HP line (Table 6). While the overall weight increase in the males were 17.08 and 25.12kg at 150 and yearling weights in the LW line and 20.59 and 38.67 in

the HP line, it was much lower in the females of LW line and for the HP line at 150 days and yearling weights, respectively. The two lines are not only sexually dimorphic with the males superior to the female, the HP line is superior to the LW line.

DISCUSSION

The reported pattern of weight change with age is in line with those reported by Dillard *et al* (1972), Olivier (1985) and Atkins (1986) although the reported genetic correlation between body weight at different ages were not very high. A faster rate of growth post weaning would have adequately expressed the potential of the animal unlike post maturity when gains at this stage reflect more of fat deposition as reported by Fetuga *et al* (1979) for the pure indigenous pigs of Nigeria. Contrary to expectation the improved indigenous pigs were found to have a higher lean deposition beyond the 60kg weight (Adebambo, 1992). Conversely, selection for increased weight at maturity would result in little change in size at birth and growth rate till weaning as reflected by the degree of correlation but with moderately correlated changes in post weaning weight.

From comparison of phenotypic and genetic correlation, it was clear that estimates of environmental correlation were widely distributed, indicating that environmental effects on body weight at any stage of development were highly correlated with such effects at other stages of growth. The heritabilities for birth weight, weaning gain and weaning weight found in this study are lower than the average of offspring-sire and offspring-dam regression for weaning gain or weaning weight summarized by Ollivier (1985). It was, however, within the range of paternal halfsib correlation reported by Quijandria *et al* (1983); Jovic *et al* (1984); Adebambo 1985 and Benevides Filho *et al* (1986). What can be summarized from the genetic correlations are that weights at weaning and yearling are essentially linear.

Response resulting from direct selection for any weight or gain would therefore amount to

as much or more than correlated selection for that trait for all weights and gain except from birth to weaning. If one therefore selects for weights at weaning, corresponding weights at 150 days and at one year old can be predicted in these lines of pigs. This was expected since a part-whole relationship existed between each pair of traits although this does not necessarily imply that a significant relationship exists between growth at different stages. Atkins (1986) showed that the genetic correlation between body weights at different ages were not very high in sheep. Similarly, in line with reports of Purser (1980) Lundheim *et al* (1994), deVries and Kanis (1994), birth weight was reported to be apparently genetically independent of body weight at other ages in laboratory and other domestic animals. Hence, selection based on preweaning body weights often resulted in slow rates of response since heritability of direct and natural effects were often less than 0.1 as reported by Olivier (1985). It could therefore be suggested that for direct genetic effects, it would be more efficient to base selection on post weaning weight gains because of the high heritability, coheritabilities and high genetic correlations observed with weight at weaning in these sets of pigs.

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