Ife Journal of Agric. Vol. 2(2).

Genetic and environmental aspect of preweaning weight gain of pigs in South Western Nigeria.

A. O. LEIGH,
Department of Animal Science,
Faculty of Agriculture,
University of Ife,
Ile-Ife, Nigeria.

Abstract

Data recorded at Fasola Stock Farm for 451 litters and involving 66 boars and 4 breeds of pigs were analysed to investigate the environmental and genetic factors causing variation in preweaning weight gains of pigs. Two specific traits – average pig weight gain from birth to weaning (PPWG), and litter weight gain from birth to weaning (LPWG) were studied. The two traits did not show significant effects of breed, parity of dam, season or interaction ($P > .05$). Only PPWG showed highly significant effects of year ($P < .05$). However, litter size at birth and at eight weeks, and average pig weight at birth had significant influence on both traits. Estimates of heritability based on paternal half-sib correlation were 0.19 to 0.15 and 0.49 to 0.20 for PPWG and LPWG respectively. Both the phenotypic and genetic correlations between the two traits were high and positive ($rP = .75$ and $rG = .98$). It is suggested that weight gain from birth to weaning at 8 weeks instead of weaning weight per se should be used as criterion for making initial selections of future breeders.

Introduction

The study reported in this paper is one in a series of analyses of the genetic and environmental effects on pig production at the Fasola Stock Farm, Oyo State. Specificially, it deals with some identifiable genetic and environmental factors which influence the preweaning weight gain of the individual piglet and litter groups in this tropical environment. There is some evidence from similar studies in the temperate regions that the heavier a piglet is at birth, the better its preweaning (Edwards and Omtvedt, 1971), and post-weaning performance (Hazel, Baker and Reinmiller, 1943). On the other hand, rate of gain is related to general health, efficiency of feed utilisation and carcass composition; and pre-weaning performance has been shown to be a reliable estimate of maternal ability (Baker, Hazel and Reinmiller, 1943; Nordskog, Comstock and Winters, 1944). The factors responsible for observed variations in pre-weaning weight gains have not been sufficiently documented in Nigeria. Some of these factors have been identified and their effects examined in the present study.

Materials and Methods

The location, management and breeding policy of the farm, as well as the performance characteristics of the resident pigs, have been described elsewhere (Leigh, 1977, 1980). Data collected on piglet birth and weaning weights during the period 1965-75, were used in the present study. The data were collected from a total of 451 litters including 66 boars, all of which came from 4 breeds. The breeds were Large White, Duroc, Hampshire and Crossbreds which were grouped as a fourth 'breed', irrespective of their specific breed combinations.

Piglet pre-weaning weight gains (PPWG) and litter pre-weaning weight gains (LPWG) were calculated, and the effect of genetic (breed, parity of dam, litter size at birth and weaning at 8 weeks) and environmental (season and year of birth) factors on these traits were determined by subjecting the data to a least squares analysis of variance with unequal subclasses (Harvey, 1960) using the following fixed model:

$$X_{ijklmno} = \mu + B_i + P_j + L_k + S_l + Y_m + Z_n + (BS)_{il} + cW_{ijklmno} + E_{ijklmno}$$

where $X_{ijklmno}$ is the average pig (or litter) pre-weaning weight gain, μ is the common mean of the average pig (or litter) pre-weaning weight gain, B_i is the additive effect of the i^{th} breed, P_j is the additive effect of jth parity of dam, L_k is the additive effect of the k^{th} litter size at birth, S_l is the effect of l^{th} season of birth, Y_m is the effect associated with the m^{th} year of birth, Z_n is the effect of n^{th} litter size at weaning, (BS_{il}) is the effect of the interaction between the i^{th} breed and l^{th} season of birth, c is the regression coefficient of the pig (or litter) pre-weaning weight gain on the average pig (or litter) birth weight and $E_{ijklmno}$ is the random error specific to the particular observation.

The main genetic analysis was based on a nested model which consisted of the effects of breeds, sires within breeds, dams within sires and among progeny within dams. All effects were assumed to be random. The analysis of covariance between PPWG and LPWG was based on the procedure outlined by Kempthorne (1957). Because of the relatively fewer sires, dams and litters in the Duroc and Hampshire sub-classes, the analyses of variance and covariance were carried out using the Large White, Crossbred and pooled data only. Components of variance and covariance for sires, dams within sires and among progeny within dams were derived from these analyses. Phenotypic correlations, heritabilities and genetic correlations were then computed from the appropriate components of variance and covariance (Becker, 1975). Heritability in the narrow sense is usually estimated from the genetic relationship among paternal half-sibs. Howerver, since the present data also included substantial number of full-sib groups, estimates of this parameter were computed from both the sire and the sire plus dam components. Approximate standard errors of heritablities were obtained by the formula suggested by Dickerson (1960).

Results

Breed least squares means with their standard deviations and coefficients of variation are presented in Table 1. The co-efficients of variation for PPWG were about twice the values for LPWG, indicating considerably more variability in the average pig pre-weaning gain than in the litter preweaning gain. Least-squares means and standard errors of the two traits for each significant classification are presented in Table 2. Analyses of variance for PPWG and LPWG are given in Table 3. The assumed least squares model account for 87.9% and 92.7% of the variation in PPWG and LPWG respectively.

Effects of breed, parity of dam, season of farrowing and breed x season interaction were not statistically significant for both traits. Year effects were highly significant ($P < .005$) for PPWG only. On the other hand, litter size at birth, litter size at 8 weeks and average pig weight at birth had very highly marked effects ($P < .005$)on the two measures of preweaning weight gain.

The nested analyses of variance showing the various variance components for PPWG and LPWG are presented in Table 4. These analyses were based on the Large White, Crossbred and pooled data. Although the sire component was positive and much larger than the dam component for the two traits in all data groups except one, the sire component itself accounted for only between 3.25% and 7.71% of the variation in PPWG and only between 10.61 and 14.33% of the observed variation in LPWG. The intra-breed and pooled estimates of heritability with their standard errors which were computed from these sire components and the sire plus dam components are shown in Table 5.

TABLE 1: LEAST SQUARES MEANS WITH STANDARD ERRORS AND COEFFICIENTS OF VARIATION BY BREED

Breed	*Trait*[a]	*Sample mean* (Kg)	*Standard Deviation* (+)	*C.V* (%)
Large White	PPWG	1402[c]	0.72[c]	5
	LPWG	144.85	3.56	2
Duroc	PPWG	11.10	1.09	10
	LPWG	136.83	5.38	4
Hampshire	PPWG	14.47	1.08	7
	LPWG	154.67	5.32	3
Crossbreds	PPWG	13.70	0.92	7
	LPWG	147.73	4.52	3
Pooled Data	PPWG	13.32	2.02	15
	LPWG	146.92	9.09	7

[a]PPWG = Average pig weight gain from birth to 8 weeks (weaning).

LPWG = Litter weight gain from birth to 8 weeks (weaning)

TABLE 2: LEAST SQUARES MEANS AND STANDARD ERRORS FOR PPWG AND LPWG ACROSS THE SIGNIFICANT ENVIRONMENTAL FACTORS

Classification		*PPWG*[a] *Mean*	*S.E.* (±)	*LPWG*[a] *Mean*	*S.E.* (±)
General Mean (451)[b]		13.32	2.02	146.02	9.99
Litter size at Birth:					
3	(33)	12.92	1.72	151.20	8.48
4	(33)	10.86	1.63	145.17	8.06
5	(27)	12.94	1.66	154.56	8.18
6	(62)	15.29	1.16	160.40	5.74
7	(44)	13.97	1.32	156.12	6.54
8	(57)	13.55	1.19	151.23	5.88
9	(57)	12.61	1.22	142.45	6.04
10	(58)	14.79	1.11	146.06	5.48
11	(30)	12.69	1.50	140.82	7.39
12	(18)	14.07	1.94	131.56	9.59
13	(15)	12.43	2.13	122.93	10.50
14	(17)	13.70	1.99	139.79	9.85
Year:					
1965	(4)	12.31	3.70	122.22	18.27
1966	(12)	17.93	2.22	181.30	10.98
1967	(14)	17.59	2.13	166.44	10.52
1968	(22)	14.84	1.78	156.89	8.77
1969	(38	14.04	1.47	155.56	7.24
1970	(51)	13.73	1.31	145.82	6.47
1971	(78)	13.82	1.11	172.07	5.50
1972	(83)	13.68	1.04	154.33	5.15
1973	(70)	13.94	1.12	149.26	5.54
1974	(72)	15.61	1.15	155.75	5.67
1975	(.7)	6.02	3.04	46.60	15.34
Litter size at 8 weeks					
2	(83)	0.45	1.48	129.85	7.32
3	(35)	13.50	1.89	135.30	9.33
4	(46)	15.27	1.60	137.72	7.89
5	(63)	16.50	1.47	140.44	7.27
6	(56)	14.18	1.46	142.95	7.19
7	(43)	15.25	1.62	141.29	7.97
8	(48)	14.52	1.51	148.61	7.47
9	(39)	14.74	1.67	150.63	8.26
10	(29)	12.70	1.77	151.83	8.75
11	(6)	14.40	3.30	155.28	16.27
12	(2)	16.49	5.31	159.10	26.23
13	(1)	11.82	5.93	131.88	28.09

[a] See Table 1

[b] Number of litters in the sub-class.

TABLE 3: LEAST SQUARES ANALYSIS OF VARIANCE FOR PREWEANING WEIGHT GAIN IN PIGS

		M.S.	
Source of Variation	*d.f.*	*PPWG*[a]	*LPWG*[a]
Breed	3	87.65 n.s.	38.66 n.s.
Parity of dam	11	93.19 n.s.	10.35 n.s.
Litter size at birth	11	148.81***	50.26***
Season	1	24.34 n.s.	2.27 n.s.
Year	10	292.96***	21.32 n.s.
Litter size at 8 wks.	11	798.79***	860.70***
Breed x Season	3	28.61 n.s.	16.15 n.s.
Regression[b]	1	667.72***	1178.49***
Residual	399	60.74	18.78

[a]See Table 1.

[b]Regression of preweaning gain on average pig weight at birth.

* = P < .05; ***P < .005; n.s. = not significant (P > .05)

The phenotypic correlations (Table 6, above the diagonal) were all positive, moderate to high and significantly different from zero (P < 0.01), indicating a very strong and positive association between the two measures of preweaning gain in pigs and between each measure and average pig weight at birth. The estimates of genetic correlations computed from the sire component of variance and covariance based on the nested model are given in Table 6 (below the diagonal). It can be seen that genetic correlation between the two measures of preweaning gain and that between litter preweaning gain (LPWG) and average pig weight at birth (APWB) were positive, high and significantly different from zero (P < 0.01).

Discussion

The present data showed no breed effects unlike the report of Miller, Cain and Chapman (1979) which indicated highly significant breed influence on preweaning gain. The evidence on the effects of year and season provided by this study and the data of Steinbach (1971) and Miller *et al.* (1979) are conflicting. While Miller *et al.* (1979) reported non-significant year effects and highly marked effects of season, and Steinback (1971) in an almost identical tropical environment as in this study found significant seasonal differences, the present data indicated very highly significant year effects ($P < 0.005$) on PPWG and no discernible influence of season on both PPWG and LPWG. In a similar study involving cattle, however, Rastogi, Hennecart and Fontinelle (1979) found a pronounced year effect on preweaning gain. As regards the effect of litter size at weaning on preweaning weight gain the results of this study are consistent with the findings of Miller *et al.* (1979). The present data suggest that preweaning weight gains of either the individual pig or litter groups is highly susceptible to environmental conditions. The main components of those conditions are not yet known, and need to be identified. It could be safely concluded from the present results that pig weight at birth, litter size at birth and litter size at weaning combine in some manner to influence the pattern of preweaning weight gain in pigs.

The genetic analysis of the two traits summarised in Tables 4, 5 and 6 show that the sire component of variance observed for pig weight gain is between 3.25 and 7.71% of the total variance. Based on the pooled data it amounted to only 4.61% for PPWG. This finding is fairly similar to that of Baker *et al.* (1943) and Hazel et al. (1943) who reported, respectively, that percent of the total variance in preweaning gain attributed to sire effects were 5.8 and 6%. For many quantitative characters in pigs such as birth weight, weaning weight and particularly growth rate, the dam component of variance has been found to be larger than the sire component (Baker *et al.,* (1943; Hazel *et al.,* 1943). It is therefore surprising to find the dam component actually smaller (in some cases with negative values) than the sire component in the present data on piglet and litter preweaning weight gain. This suggests, contrary to the conclusion of those workers, that non-additive gene effects and environmental effects common to litter-mates do not exist, or at least are relatively unimportant for swine preweaning weight gain in this environment. The present results are, however, similar to those of Willham, Cox and Karas (1963) on avoidance learning in pigs.

The variance between litter-mates which is represented by litters/sows and estimated by the error component of variance (Table 4) is larger than the sire component in all cases. It is also possible to estimate the magnitude of environmental effects peculiar to the individual pig by the difference between the error component and the sire component (Baker *et al.,* 1943). Apparently, the contribution of the environmental effects peculiar to the individual pig is far greater than the sire component for either trait. In other words, it is reasonable to conclude like Baker *et al.,* (1943) and Hazel *et al.,* (1943) that genetic variance (additive gene effects variance) constituted only a relatively small proportion of the observed variance in preweaning weight gain of pigs.

Estimate of heritability in the narrow sense computed from the pooled data and based on paternal half-sib correlation was 0.19 for PPWG and 0.49 for LPWG. Hazel *et al.,* (1943) reported a similar estimate of 0.15 for pig preweaning gain. They did not estimate the heritablity of litter preweaing weight gain. From the present analysis, the heritability of PPWG is likely to be in the order of 10 - 30%. The heritability of LPWG is less precise, but probably ranges from extremes of about 15 to 50% based on the point estimates calculated. Pending further studies, it may be concluded that slow to moderate rates of improvement would be expected in preweaning weight gain if direct selection pressure is applied.

Both the phenotypic and genetic correlations bewteen PPWG and LPWG found in this study are high and positive ($r_p = 0.75$ and $r_G = 0.98$) indicating that a fairly large proportion of genes commonly control the two traits.

It is therefore most likely that a direct selection for either trait will result in a corresponding correlated response in the other.

Hazel *et al.,* (1943) have shown that although gain from birth to 8 weeks is not as efficient a measure of hereditary growth rate over the entire growth curve of a pig (particularly the boar) as gain from 8 weeks to 16 weeks of age, the genetic correlation between growth rates in the two periods is considerably high ($r_G = 0.708$). In other words, preweaning rate of gain is highly correlated genetically with post-weaning growth rate. In practical terms, the following general conclusion and suggestion can be made based on the fore-going. Moderate improvement could be expected in pre-weaning weight gain if it is subjected to selection. More importantly since there is advantage in being able to carry out selection early to be followed, perhaps, by a second stage selection when more data are available, it is suggested that weight gain from birth to weaning at 8 weeks might be used as an initial selection criterion for growth rate of future breeders.

TABLE 4: MEAN SQUARES AND VARIANCE COMPONENTS FOR PREWEANING WEIGHT GAIN

	Large White				*Crosses*				*Pooled Data*			
	d.f.	*MS*	*Components of variance*	*(%)*	*d.f.*	*MS*	*Components of variance*	*(%)*	*d.f.*	*MS*	*Components of vraince*	*(%)*
						PPWG						
Breeds									3	200.01	0.30	0.28
Boars	21	138.84	6.64	7.71	28	125.95	3.45	3.25	65	133.67	5.01	4.6
Sows/Boars	129	79.73	0.57	0.66	84	108.10	14.11	13.28	254	101.52	-1.44	0.0
Litters/Sows	65	78.91	78.91	91.63	43	88.74	88.74	83.47	123	103.53	103.53	95.11
						LPWG						
Breeds									3	14411.94	- 17.85	0.0
Boars/Breeds	21	12060.36	696.11	10.161	28	11192.41	983.46	14.33	65	10420.55	766.31	11.64
Sows/Boars	129	4655.87	848.02	0.0	84	6167.73	771.15	11.23	254	5351.09	-335.30	0.0
Litters/Sows	65	5865.00	5865.00	89.39	43	5110.74	5110.74	74.44	128	5816.14	5816.14	88.36

References

Baker, M.L., L.N. Hazel and C.F. Reinmiller, 1943. The relative importance of heredity and environment in the growth of pigs at different ages. *J. Anim. Sci.* 2: 3 - 13.

Becker, W.A. 1975. Manual of Quantitative Genetics. Students Book Corp. N.E. 700 Thatune, Pullman WA 99163.

Dickerson, G.E. 1960. Techniques and Procedures in Animal Production Research. pp. 56-105. American Society of Animal Production.

Edwards, R.L. and I.T. Omtvedt, 1971. Genetic analysis of a swine control population. II. Estimates of population parameters. *J. Anim. Sci.* 32: 185-190.

Harvey, W.R. 1960. Least squares analysis of data with unequal sub-class numbers. United States Department of Agriculture. ARS-20-8 (Mimeograph).

Hazel, L.N., M.L. Baker and C.R. Reinmiller, 1943. Genetic and environmental correlations between the growth rates of pigs at different ages. *J. Anim. Sci.* 2: 118-128.

Kempthorne, O. 1957. Introduction to Genetic Statistics. John Wiley and Sons, New York.

Leigh, A.O., 1977. Litter performance characteristics of pigs in tropical Southwestern Nigeria. I. Breed differences and effects of some non-genetic sources of variation. *Anim. Prod.* 24: 323-331.

Leigh, A.O. 1980. Litter performance characteristics of pigs in tropical Southwestern Nigeria. II. Estimates of repeatability, covariation and heritability. Anim. Prod. (In Press).

Miller, H. W., M.F. Cain and H.D. Chapman, 1979. Performance of purebred and crossbred pigs. *J. Anim. Sci.* 49: 943-949.

Nordskog, A.W., R.E. Comstock and L.M. Winters, 1944. Heredity and environmental factors affecting growth rates in swine. *J. Anim. Sci.* 3: 257-272.

Rastogi, R., C. Hennecart and S. Fontinelle, 1979. Preweaning growth performance of Santa Gertrudis, Jamaica Red and Guernsey crossbred calves in St. Lucia, West Indies, *Trop. Agric.* 56: 321-325.

Steinback, J. 1971. Effects of season and breed on sow performance in the seasonal-equatorial climate of Southern Nigeria. *J. Agric. Sc., Camb.* 77: 331-336.

Willham, R.L., Cox, D.F. and Karas, G.G. 1963. Genetic variation in a measure of avoidance learning in swine. *Journal of Comparative and Physiological Psychology* 56: 294-297.