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Effect of inbreeding on pre-weaning and sow performance traits in Large White Yorkshire pigs

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ABSTRACT

The present study was undertaken to study the effect of inbreeding on pre-weaning and sow performance traits of Large White Yorkshire pig population. Data on 7596 Large White Yorkshire pigs maintained at PGRIAS, Kattupakkam from the period of 1990 to 2015, were subjected to least square analysis to study the effect of inbreeding and other non-genetic factors *viz.*, period, season, sex, parity, litter size at birth on various traits using general linear model. Inbreeding was calculated as Wright's path co-efficient. The mean inbreeding co-efficient of LWY population studied was 2.45 %. Among 7596 animals in the pedigree, 2088 were inbred and the range of individual inbreeding co-efficient (F) was from 0 to 37.5 per cent. The average inbreeding in the inbred population was 8.92 %. The effect of inbreeding was found to be significant for weaning weight, pre-weaning average daily gain and litter weight at weaning, where the traits were found to increase with inbreeding (enhancement). The absence of depressive effect on fitness traits observed in the present study could be due to lower levels of inbreeding, which was possible due to periodic introduction of breeding animals and planned mating.

Key words: Inbreeding, Large White Yorkshire, Pig, Performance traits.

INTRODUCTION

Inbreeding tend to increase with generation in livestock farming especially when animals are maintained as a closed herd. Every population has some degree of inbreeding depression, more often in the case of fitness traits (Falconer, 1981). Any small closed population is exposed to inbreeding at a rate which increases continuously from generation to generation and depends on the mating strategy and selection applied. Depression due to inbreeding can cause severe economic loss caused by depression in important economic traits and reduced fitness. Large White Yorkshire (LWY) is one of the important exotic pig breeds used extensively for pure and crossbreeding in India. A herd of pure LWY Pigs maintained at Post Graduate Research Institute in Animal Sciences (PGRIAS), Kattupakkam, was studied for effect of inbreeding on important individual pre-weaning and sow performance traits. Such a study was important to assess the level of inbreeding in the herd and formulate suitable breeding plan. So, the study was under taken to evaluate inbreeding and analyse its effect on different economic traits.

MATERIALS AND METHODS

Data pertaining to 7596 Large White Yorkshire pigs maintained at Post Graduate Research Institute in Animal Sciences (PGRIAS), Kattupakkam accumulated over 25 years from 1991 to 2015 were utilized for the study. Sex ratio of males to females for breeding was 1:3 and the method used was pen mating. The inbreeding was calculated from pedigree information as Path co-efficient (Wright, 1921) using Pedigree viewer Version 5.5 software package. Individual pre-weaning traits such as birth weight (BW), weaning weight (WW), pre-weaning average daily gain (ADG) and pre-weaning mortality (PWM) and sow performance traits such as age at first fertile service (AFFS), litter size at birth (LSAB), number born alive (NBA), litter weight at birth (LWAB), litter size at weaning (LSAW), litter weight at weaning (LWAW) and farrowing interval (FI) were studied. Inbreeding coefficient as covariate and other fixed classes of period, season, sex, parity, litter size at birth and weaning age were included as fixed effects in a general linear model using SPSS version 25. A separate analysis to study the effect of level of Inbreeding was done with five classes of inbreeding *viz.* 0, 0-3.125 %, 3.125-6.125%, 6.126-12.5% and 12.6 % and above. The 25 years study period was divided into 5 periods of 5 years each. Months of the year was classified in to four seasons as summer (march-may), south-west monsoon (june-august), north-east monsoon (september-november) and winter (december, january and february), based on meteorological data.

RESULTS AND DISCUSSION

The pedigree of the study population included records from 7596 animals and 932 litters which were from 130 sires and 362 dams were studied. The least square means for BW, WW, ADG, PWM, AFFS, LSAB, NBA, LWAB, LSAW, LWAW and FI were 1.18 kg, 8.69 kg, 153.10 g, 4.80 per cent, 411.04 days, 9.41, 8.09, 9.74 kg, 7.92, 68.67 kg

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Table 1: Partial regression co-efficient (b) of individual and sow performance traits on inbreeding (F).

Traits	b
Individual traits	
Birth weight (kg)	0.00 ± 0.00^{NS}
Weaning weight (kg)	0.02 ± 0.00**
Pre-weaning ADG (g)	0.46 ± 0.05**
Pre-weaning mortality (%)	0.001 ± 0.00^{NS}
Sow performance traits	
Age at first fertile service (days)	0.83 ± 1.36^{NS}
Litter size at birth	-0.01 ± 0.02^{NS}
Number born alive	-0.01 ± 0.01^{NS}
Litter weight at birth (kg)	0.01 ± 0.01^{NS}
Litter size at weaning	-0.01 ± 0.01^{NS}
Litter weight at weaning (kg)	0.22 ± 0.09*
Farrowing interval (days)	0.74 ± 0.58^{NS}

**- Highly significant ($p < 0.01$); * - Significant ($p < 0.05$); ^{NS} – Non significant.

and 249.06 days, respectively. The non-genetic factors (Table 2 to 4) included in the study had significant effect on individual traits and while sow performance traits were not affected by these factors.

Mean inbreeding co-efficient: The mean inbreeding co-efficient (F) obtained for the LWY population in this study was 2.45 %. Among 7596 animals in the pedigree, 2088 were inbred and the range of individual inbreeding co-efficient (F) was from 0 to 37.5 per cent. The average inbreeding in the inbred population was 8.92 %. The proportion of inbred animals and F value were low compared to earlier study at PGRIAS (Panneerselvam *et al.*, 1991). Bereskin *et al.* (1968) and Rodriganez *et al.* (1998) observed inbreeding levels as high as 16.1 % to 23.1 % in experimental pig herds, where the population size was very low. Kumari *et al.* (2005) reported that the mean inbreeding was 5.83 per cent in

Table 2: Least squares means (S.E) for birth weight, weaning weight, pre-weaning average daily gain, pre-weaning mortality and market weight for different genetic and non-genetic factors in Large White Yorkshire pigs.

Details	Birth weight(kg)		Weaning weight (kg)		Pre-weaning average daily gain(kg)		Pre-weaning mortality(%)	
	N	Mean ± S.E	N	Mean ± S.E	N	Mean ± S.E	N	Mean ± S.E
Overall mean	7319	1.18 ± 0.01	5322	8.69 ± 0.06	5330	153.10 ± 1.28	6935	4.80 ± 0.50
Inbreeding		**		**		**		**
0	5245	1.19^{a} ± 0.00	3621	8.48^{b} ± 0.05	3628	148.81^{b} ± 0.94	4937	3.80^{b} ± 0.40
>0 – 3.125 %	757	1.15^{a} ± 0.01	616	8.76^{a} ± 0.09	615	155.55^{a} ± 1.92	738	3.50^{b} ± 0.80
3.126 – 6.125 %	202	1.17^{a} ± 0.02	126	8.59^{b} ± 0.19	126	149.99^{a} ± 3.83	193	4.90^{b} ± 1.40
6.126 – 12.5 %	551	1.18^{b} ± 0.01	469	8.80^{a} ± 0.10	469	155.59^{a} ± 2.06	517	7.30^{a} ± 0.90
12.6 % & above	564	1.20^{a} ± 0.01	490	8.81^{a} ± 0.10	492	155.58^{a} ± 1.97	550	4.30^{b} ± 0.80
Period		**		**		**		**
1990-1995	636	1.06^{c} ± 0.01	475	7.75^{b} ± 0.12	477	136.49^{c} ± 2.40	638	6.40^{a} ± 0.90
1996-2000	675	0.94^{d} ± 0.01	415	8.07^{b} ± 0.13	415	144.07^{b} ± 2.58	675	3.20^{c} ± 0.90
2001-2005	1958	1.23^{b} ± 0.01	1027	9.40^{a} ± 0.09	1032	163.84^{a} ± 1.87	1741	4.90^{bc} ± 0.60
2006-2010	1781	1.32^{a} ± 0.01	1279	8.75^{c} ± 0.08	1281	151.87^{b} ± 1.60	1741	5.50^{ab} ± 0.60
2011-2015	2269	1.33^{a} ± 0.01	2126	9.47^{c} ± 0.08	2125	169.24^{a} ± 1.65	2140	3.70^{c} ± 0.50
Season		**		*		*		**
Summer	1784	1.20^{a} ± 0.01	1200	8.64^{c} ± 0.08	1201	151.51^{bc} ± 1.63	1625	4.20^{b} ± 0.60
South west monsoon	1929	1.19^{a} ± 0.01	1441	8.63^{c} ± 0.08	1442	152.13^{c} ± 1.62	1859	6.10^{a} ± 0.60
North east monsoon	1883	1.17^{b} ± 0.01	1420	8.83^{b} ± 0.08	1423	156.18^{a} ± 1.57	1813	4.20^{b} ± 0.60
Winter	1723	1.15^{b} ± 0.01	1261	8.66^{a} ± 0.08	1264	152.59^{ab} ± 1.65	1638	4.50^{b} ± 0.60
Sex		**		*		**-		*
Male	3686	1.20 ± 0.01	2599	8.78 ± 0.07	2605	154.61 ± 1.41	3526	5.30 ± 0.50
Female	3633	1.15 ± 0.01	2723	8.60 ± 0.07	2725	151.60 ± 1.38	3409	4.30 ± 0.50
Litter size at birth		**		**		**		NS
<7	474	1.26^{a} ± 0.01	400	9.57^{a} ± 0.12	399	169.33^{a} ± 2.34	469	5.50 ± 0.10
7	734	1.22^{b} ± 0.01	562	9.10^{b} ± 0.10	565	160.91^{a} ± 2.09	699	4.80 ± 0.80
8	1069	1.21^{b} ± 0.01	822	9.02^{bc} ± 0.09	821	160.92^{a} ± 1.88	1004	5.00 ± 0.70
9	1591	1.20^{b} ± 0.01	1199	8.49^{e} ± 0.08	1199	148.32^{b} ± 1.70	1466	4.80 ± 0.70
10	1559	1.19^{c} ± 0.01	1044	8.43^{de} ± 0.08	1047	146.10^{c} ± 1.70	1468	4.50 ± 0.60
11	859	1.16^{d} ± 0.01	556	8.33^{cd} ± 0.10	558	145.91^{c} ± 2.06	811	4.10 ± 0.80
12	600	1.13^{e} ± 0.01	417	8.40^{c} ± 0.11	419	147.42^{c} ± 2.25	592	5.40 ± 0.80
13 & above	433	1.05^{f} ± 0.01	322	8.16^{bc} ± 0.13	322	145.02^{c} ± 2.62	426	4.20 ± 0.10
Parity		**		**		**		**
1	2831	1.16^{d} ± 0.01	1984	8.73^{a} ± 0.07	1987	153.98^{a} ± 1.31	2665	4.50^{b} ± 0.50
2	1639	1.18^{b} ± 0.01	1160	8.88^{a} ± 0.08	1163	157.52^{a} ± 1.54	1545	3.40^{c} ± 0.60
3	1124	1.18^{b} ± 0.01	851	8.56^{b} ± 0.09	853	151.52^{b} ± 1.73	1064	2.90^{c} ± 0.70
4	762	1.20^{a} ± 0.01	575	8.55^{b} ± 0.10	577	149.76^{b} ± 2.07	735	5.10^{a} ± 0.80
5	462	1.17^{c} ± 0.01	364	8.87^{a} ± 0.12	363	156.94^{a} ± 2.51	446	6.00^{a} ± 1.00
6 and above	501	1.16^{d} ± 0.01	388	8.53^{b} ± 0.12	387	148.89^{b} ± 2.46	480	6.80^{a} ± 1.00

**- Highly significant ($p < 0.01$); * - Significant ($p < 0.05$); NS – Non significant. Means carrying same superscript within effect did not have significant difference; N – Number of observations.

Table 3: Least squares means for litter size at birth, number born alive and litter size at weaning in Large White Yorkshire pigs.

Effects	Litter size at birth		Number born alive		Litter size at weaning	
	N	**Mean ± S.E**	**N**	**Mean ± S.E**	**N**	**Mean ± S.E**
Overall mean	580	9.41 ± 0.35	876	8.09 ± 0.24	876	7.92 ± 0.24
Period of farrowing		*		**		**
1990-1995	78	9.01^{b} ± 0.44	78	8.00^{b} ± 0.33	78	7.93^{b} ± 0.34
1996-2000	97	9.87^{a} ± 0.42	97	7.16^{c} ± 0.32	97	6.99^{c} ± 0.32
2001-2005	226	9.70^{a} ± 0.36	226	8.41^{ab} ± 0.26	226	8.20^{ab} ± 0.27
2006-2010	179	9.06^{ab} ± 0.37	212	8.25^{ab} ± 0.27	212	8.00^{ab} ± 0.27
2011-2015	-	-	263	8.63^{a} ± 0.25	263	8.48^{a} ± 0.26
Season of farrowing		NS		NS		NS
Summer	138	9.34 ± 0.39	217	7.96 ± 0.27	217	7.87 ± 0.27
South west monsoon	168	9.34 ± 0.38	239	8.03 ± 0.27	239	7.73 ± 0.27
North east monsoon	136	9.45 ± 0.40	219	8.29 ± 0.27	219	8.13 ± 0.27
Winter	138	9.51 ± 0.38	201	8.06 ± 0.27	201	7.95 ± 0.28
Parity		NS		*		**
1	260	9.12 ± 0.34	358	7.80^{b} ± 0.24	358	7.62^{c} ± 0.24
2	143	9.17 ± 0.36	197	8.08^{ab} ± 0.26	197	8.02^{abc} ± 0.27
3	79	9.81 ± 0.42	126	8.41^{a} ± 0.29	126	8.33^{a} ± 0.30
4	47	9.54 ± 0.47	86	8.35^{a} ± 0.32	86	8.14^{ab} ± 0.32
5	25	10.04 ± 0.57	54	8.12^{ab} ± 0.36	54	7.90^{abc} ± 0.36
6	26	8.78 ± 0.57	55	7.75^{ab} ± 0.36	55	7.50^{bc} ± 0.36
Inbreeding		NS		NS		NS
	474	9.37 ± 0.16	716	8.11 ± 0.11	716	7.94 ± 0.11
>0 – 3.125 %	12	9.18 ± 0. 70	29	8.03 ± 0.39	29	7.95 ± 0.39
3.126 – 6.125 %	3	10.33 ± 1.36	4	8.59 ± 1.01	4	8.35 ± 1.02
6.126 – 12.5 %	53	8.95 ± 0. 34	62	7.63 ± 0.27	62	7.34 ± 0.27
12.6 % & above	38	9.22 ± 0. 42	65	8.06 ± 0.27	65	8.01 ± 0.27

**- Highly significant ($p < 0.01$); * - Significant ($p < 0.05$); NS – Non significant. Means carrying same superscript within effect did not have significant difference; N – Number of observations.

indigenous pigs at Tirupati. Periodical introduction of new animals during the period of this study could be the possible reason for lower inbreeding. Farkas *et al.* (2007) reported slightly lower mean inbreeding coefficients of 0.50 and 0.89 per cent for Hungarian Landrace and Large White pigs, respectively. Kock *et al.* (2009) obtained mean inbreeding of 1.59 to 2.23 per cent in field herds of LWY pigs, which they described as low. Devi and Jayashankar (2014), obtained estimates as high as 13.5 per cent for inbred animals in their study on LWY at Bangalore, which was higher than the value of 8.92 per cent observed in this study. Belic *et al.,* (2002) reported the mean inbreeding of sows in a closed population was 4.66% in 72 inbred animals, in which the number of sows were low.

Effect of inbreeding: The effect of inbreeding analysed as a covariate explained the change in various traits on one per cent increase in inbreeding. The partial regression co-efficient of various individual and sow performance traits on inbreeding in LWY are summarized in Table 1. Weaning weight, pre-weaning average daily gain and litter weight at weaning were significantly influenced by inbreeding in the population studied. The positive effect on one per cent increase in inbreeding was 0.021 kg in weaning weight, 0.457 g in pre-weaning average daily gain and 0.218 kg in litter weight at weaning. The litter weight at weaning, though a sow performance trait is dependent on the individual weaning weight of the litter. Hence inbreeding showed an 'enhancement' in body weight traits. Similar observations of significant positive effect of inbreeding on weaning weight and pre-weaning average daily gain has been reported earlier in indigenous pigs maintained at Tirupati (Kumari *et al.*, 2005).

Pre-weaning mortality and other litter traits were not significantly affected by inbreeding. However, all these traits showed negative effect with increase in inbreeding, thus indicating a statistically non-significant depressive effect. The low level of inbreeding in the population could be one of the reasons for absence of significant effect of inbreeding on majority of the fitness traits. Kock *et al.*, (2009) reported a rare phenomenon of inbreeding enhancement for reproductive fitness traits. Panneerselvam *et al.* (1991) reported significant regression of litter size at birth and weaning on inbreeding. Their study showed decline in performance in these traits per 10 per cent increase in inbreeding. However, the mean inbreeding co-efficient of their study population was 9.8 % which was much higher than the present study. The non-significant effect of litter weight at birth in their study was in agreement with the

Table 4: Least squares means for litter weight at birth, litter weight at weaning and farrowing interval in Large White Yorkshire pigs.

Effects	Litter weight at birth (kg)		Litter weight at weaning (kg)		Farrowing interval (days)	
	N	Mean ± S.E	N	Mean ± S.E	N	Mean ± S.E
Overall mean	874	9.74 ± 0.24	715	68.67 ± 1.88	498	249.06 ± 17.02
Inbreeding		NS		**		NS
0	715	9.84 ± 0.11	575	64.84[bc] ± 0.98	422	222.18 ± 5.50
>0 – 3.125 %	29	9.31 ± 0.38	26	65.00[bc] ± 3.09	12	237.58 ± 22.85
3.126 – 6.125 %	4	9.68 ± 0.98	4	81.56[a] ± 7.56	1	289.67 ± 77.53
6.126 – 12.5 %	62	9.73 ± 0.26	53	60.72[c] ± 2.16	27	255.99 ± 15.51
12.6 % & above	64	10.11 ± 0.26	57	71.23[b] ± 2.13	36	239.85 ± 13.82
Period of farrowing		**		**		NS
1990-1995	78	8.97[d] ± 0.32	61	65.30[bc] ± 2.87	35	257.00 ± 21.52
1996-2000	96	6.23[e] ± 0.31	57	50.59[d] ± 2.87	34	243.22 ± 21.73
2001-2005	226	10.10[c] ± 0.26	149	70.16[a] ± 2.11	112	244.96 ± 17.72
2006-2010	212	11.36[b] ± 0.26	196	71.99[c] ± 2.08	151	261.84 ± 17.86
2011-2015	263	12.02[a] ± 0.25	252	85.31[ab] ± 2.09	166	238.26 ± 17.62
Season of farrowing		NS		*		NS
Summer	216	9.88 ± 0.26	182	67.65[b] ± 2.09	123	254.01 ± 17.64
South west monsoon	239	9.70 ± 0.26	201	66.97[b] ± 2.09	122	257.99 ± 18.22
North east monsoon	218	9.89 ± 0.26	178	71.39[a] ± 2.11	128	242.84 ± 18.21
Winter	201	9.48 ± 0.26	154	68.67[a] ± 2.17	125	241.38 ± 18.20
Parity		NS		*		*
1	358	9.61 ± 0.23	274	68.83[bc] ± 1.87	-	-
2	195	9.86 ± 0.26	151	72.85[a] ± 2.11	186	269.53[a] ± 17.04
3	126	9.77 ± 0.28	111	69.21[ab] ± 2.26	123	245.63[ab] ± 18.11
4	86	10.07 ± 0.31	78	67.08[bc] ± 2.48	83	236.13[b] ± 18.74
5	54	9.57 ± 0.35	49	68.22[abc] ± 2.79	52	245.10[ab] ± 19.84
6	55	9.54 ± 0.35	52	65.83[c] ± 2.77	54	248.89[ab] ± 19.86
Litter size at farrowing	**	**	-	**-		
<7	94	6.12[e] ± 0.30	85	45.27[f] ± 2.42	-	-
7	110	7.59[d] ± 0.29	98	55.90[e] ± 2.32	-	-
8	138	8.56[c] ± 0.28	122	61.82[d] ± 2.23	-	-
9	182	9.77[b] ± 0.28	151	67.21[c] ± 2.23	-	-
10	164	10.87[a] ± 0.27	132	73.13[c] ± 2.20	-	-
11	87	11.36[a] ± 0.31	65	77.36[b] ± 2.56	-	-
12	61	11.62[ab] ± 0.32	37	80.20[b] ± 2.85	-	-
13 & above	38	11.98[a] ± 0.39	25	88.48[a] ± 3.55	-	-
Weaning age of litter	-		-	**		
42 days	-	-	438	58.78 ± 2.19	-	-
56 days	-	-	277	78.57 ± 1.94	-	-

**- Highly significant (p < 0.01); * - Significant (p < 0.05); NS – Non significant. Means carrying same superscript within effect did not have significant difference; N – Number of observations.

present study. Hence, inbreeding is found to be significant in the population, when mean inbreeding reaches almost 10 per cent. On an average 10 per cent inbreeding in both the litter and dam was found to reduce survival in embryos up to day 25 and total pigs born alive (Rothschild, 1996). Depressive effect in fertility traits reported even in minimum inbreeding co-efficient by Belic *et al*., (2002) and Chang Hee Do *et al*., (2015), in which the population of inbred sows under their study was low and the population was a closed herd for long years without formation of new animals. Kumari *et al*. (2005) in indigenous pigs maintained at Tirupati, reported that the inbreeding had no adverse effect on productive and reproductive traits even at levels of 5.83 per cent, which was also in agreement with the present study.

Level of inbreeding: Inbreeding classified into different classes were included as an effect to understand the actual level of inbreeding beyond which different traits were affected.

Positive effect of level of inbreeding (inbreeding enhancement) on body weight traits was evident (Table 2). In birth weight, maximum value was observed in the classes with inbreeding of 6.126 and above. Similarly pre-weaning ADG was maximum in the inbred population compared to the first class of non-inbred animals. Non-significant difference between inbred and non-inbred stock in production and reproduction traits was reported by Kumari *et al*. (2005).

Significant effect of level of inbreeding on pre-weaning mortality was observed in the present study. The fourth class with 6.126 to 12.5 per cent F was found to have maximum pre-weaning mortality, which was significantly different from other classes. Rothschild *et al*. (1996) reported that about 10 % of inbreeding in both litter and dam accounted for reductions in embryo survival and number born alive. The inbreeding depression which was not observed in this study were reported various authors (Raghunandanan *et al.*, 1981 and Devi and Jayashankar, (2014) in litter traits. In this study population, inbreeding was non-significant on litter traits i.e sow performance traits and as already mentioned the possible reason could be lower mean inbreeding obtained.

CONCLUSION

The absence of depressive effect on fitness traits observed in the present study could be due to lower levels of inbreeding, which was possible due to periodic introduction of breeding animals and planned mating. The inbreeding depression can be controlled by proper selection scheme in a population.

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