THE EFFECTS OF BREED AND HOUSING SYSTEM ON THE PRODUCTION AND REPRODUCTION OF WEANER PIGLETS IN AN OUTDOOR PIG UNIT

by

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DECLARATION

I, **Daniël Pieter Visser,** declare that this thesis and all references are a true copy. I also declare that this thesis, or any part thereof, which is being submitted to the University of the Orange Free State for the degree M.Sc. (Agric.) has not been submitted to any other university or institution.

....30/1/96....

D P VISSER **DATE**

VERKLARING

Hiermee verklaar ek, **Daniël Pieter Visser**, dat hierdie werkstuk en die bronne wat geraadpleeg is, akkuraat vermeld is en dat hierdie tesis wat voorgelê word aan die Universiteit van die Oranje-Vrystaat vir die graad M.Sc. Agric. nog nie voorheen in die geheel of gedeeltelik by enige ander universiteit ter verkryging van 'n akademiese kwalifikasie voorgelê is nie.

....30/1/96.....

D P VISSER **DATUM**

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And he went and joined himself to a citizen of that country; and he sent him into his fields to feed swine. And he would fain have filled his belly with the husks that the swine did eat: and no man gave unto him.

St Luke 15: 15 & 16

CHAPTER I

BACKGROUND AND PROBLEMS OF OUTDOOR PIG FARMING

1.1 Introduction

Within the African context, paleontological records revealed that domesticated pigs existed in the Nile Valley in the last few centuries of the fifth millenium B.C. Sufficient evidence exists to indicate that the domesticated pig held a sacred position (mainly for sacrificial purposes) in ancient Egyptian religion (Holness, 1977).

According to Thornton (1988) the domestic pig probably did not undergo major changes in its evolution until the eighteenth century, which coincided with the Industrial Revolution, the accompanying enclosure of land and the first major expansion in the human population. Today approximately 15% of all breeding sows in England are kept out of doors while in South Africa probably less than 0,3% of sows (recorded), are kept out of doors.

Concerns regarding intensive farming systems have increased dramatically in recent years because of public awareness. Unfortunately pig and poultry housing systems have been the focus of much of this. The emotional debate on welfare (reflecting to a greater extent personal feelings of the general public rather than an understanding of the animal's behavioural needs) has come to stay and will continue putting the pig producer under pressure. This debate will continue until research provides a more comprehensive understanding of the biological, physiological and ethological aspects of welfare.

Outdoor pig production predominantly concerns herds in which sows farrow outside (Corning, 1990) and where wallows with adequate water supply are essential. The most fundamental difference between indoor and outdoor pigs is undoubtedly the intensity of exposure to environmental influences, especially climatic factors.

Successful outdoor pig production therefore is a function of (i) choice of suitable land (preferably light and free draining land) (ii) a favourable climate (iii) excellent stockmanship and innovative management and (iv) market outlets that are willing to pay a premium (Thornton, 1988; Pig Improvement Company (PIC), 1989).

Pig production *per se* is an international business. A phenomenon that is therefore universally applicable (acceptable) is the fact that **the pig producer operates and must survive in a very competitive market** - a market synonymous to an arena of ongoing changes. In this regard Riley (1990) warns that outdoor pig production is not a quick way of getting rich. Control of resources, motivation of staff and seasonal infertility are but a few problems associated with outdoor pig production. The advantages and disadvantages of outdoor pig production systems, are listed in more detail in Table 1.1.

1.2 The rationale behind outdoor pig production

Given the arena of competitiveness and ongoing changes as mentioned above, outdoor pig production can be objectively evaluated but, more importantly, motivated from *four* different angles of incidence:

1.2.1 *Economy of construction*

The outdoor housing of sows is a low-cost (low-input) production system. Because of the inherent nature of this system, it has a low fixed cost per breeding animal with a good return on capital (PIC, 1989). The capital cost of building new confinement housing for pigs in South Africa (making use of a contractor), has increased dramatically during the past decade. In 1983/84 the construction cost per unit of a 100-sow unit amounted to approximately R2 500/sow and in 1993/94 the cost has increased to approximately R6 500/sow (Jenkinson, 1994).

Since it is not the purpose of this study to ascertain the economic feasibility of outdoor pig production, the interested reader is referred to Sheppard (1986) and the Meat and Livestock Commission (MLC) Yearbook - 1988.

TABLE 1.1 Some advantages and disadvantages of outdoor pig production systems

ADVANTAGES	SOURCE	DISADVANTAGES	SOURCE
1. Profitability compares favourable with intensive pig production	Thornton (1988)	1. Productivity shows a slight downward trend	Thornton (1988)
2. Sows are stronger and healthier, because they are exercised	Gifford (1993)	2. Heat stress occurs in hot weather if no shade is available	Armstrong & Cermak (1990)
3. Lower labour costs compared to intensive pig production	Thornton (1988) P I C (1989)	3. Observation, close inspection or handling or treatments can be time consuming and difficult	Thornton (1988) Armstrong & Cermak (1990)
4. Slurry does not pose any logistic, health or hygiene problems	Knoesen (1988)	4. There is no effective or easy way of identifying barren sows and sterile boars.	Thornton (1988)
5. Capital outlay is lower compared to intensive pig production unit	Thornton (1988) Evans (1990) Gifford (1993)	5. Because sows may not respect the fences, fencing requirements can become a major financial outlay	Thornton (1988)
6. Lower costs compared to indoor pigs include less water, smaller requirements concerning electricity and repairs and maintenance to buildings	Thornton (1988)	6. Bullying and especially vulva biting is possible or can be linked with probable aggressive interaction	Muirhead (1991)
7. Modern transistored battery-operated fences function efficiently are relatively cheap and easy to move	Thornton (1988) Gifford (1993)	7. Theft of weaner piglets. Birds will consume food and vermin could be a threat to young piglets	Thornton (1988)
8. Early weaning (3 to 4 weeks) is practised and no creep feeding is required in the field	Goss (1990)	8. Less individual sow treatment and less control over the feeding requirements and heat spotting	Brouns & Edwards (1992)
9. Medical bill can be reduced by 25 % compared to that of indoor pigs	Gifford (1993)	9. A 10 to 15 % higher feeding requirement of the sow because of higher maintenance, wastage and exercise	Close (1990)
10. The heat period is more visible than in intensively housed animals	Roach (1981)	10. It is difficult to establish parameters such as feed intake, and bullying and they are affected by the standard of management	Corning (1990)
11. Lower incidence of the MMA syndrome	Algers (1992)	11. Summer infertility can be a major problem	Shepherd (1990)
12. Confinement reared gilts tend to be older at puberty than non-confinement reared gilts ($P < 0,05$)	Caton, Jesse, Day & Ellersieck (1986)	12. Infertile and subfertile boars are difficult to spot, especially with group mating	P I C (1989)
13. The duration of farrowing and number of stillborn piglets are reduced	Kolacz, Pilarczyk & Dobrzanski (1985)	13. Exposure to extreme weather conditions such as mud in the rainy season, freezing of water supply in winter and overheating in summer	Brouns & Edwards (1992)
14. Its compatability with the principles of environmental protection	Smidt (1994)	14. Control of disease can be more difficult (infection may be introduced by birds and vermin)	Brouns & Edwards (1992)
		15. Motivation of staff is more difficult	Corning (1990)

1.2.2 *Optimising the adaptability of pigs*

Animals can, through natural selection, develop with ***either*** the advantage of a more efficient exploitation of a prevailing resource - thus a specialist ***or*** as generalists, with the adaptability to exploit a wider range of resources and to cope with changing circumstances. According to Baxter (1989) pigs are "designed" to cope with a wide range of environmental conditions and therefore must rank as one of the ultimate generalists. Their versatility, however, does not render them to be infinitely adaptable. Ebner (1993) indicated that the economic success and good production performance should not be taken as granted indicators of the animals' health and welfare. When the natural behaviour of a sow in the farrowing house is disturbed, it may trigger MMA (Mastitis, Metritis and Agalactie), which will inhibit the transfer of milk from the sow to her piglets (Algers, 1992).

Even in confined housing, pregnant sows and gilts show a preference to farrow in environments with features typical of outdoor farrowing sites (Philips & Fraser, 1993).

1.2.3 *Ethological and welfare considerations*

Animal welfare is one of the major fields of public concern and political issues for future directions in animal husbandry.

The latest evidence of pressure from consumers, the general public and above all a powerful pressure group called the Animal Welfare Lobby, regarding the welfare of farm animals has led to British legislation which will ban the use of stalls and tethers for dry sows by December 31, 1995 (Muirhead, 1991). In Germany animal protection regulations have already been issued for the housing-cum-management of laying hens, pigs and calves during 1987, 1988 and 1992 respectively. These regulations/legislations comprised detailed instructions in terms of:

* comfort and shelter
* housing and social space
* freedom of movement
* management, water and nutrition
* supply, control and care of the different animals

Welfare can be defined as the fulfillment of the biological needs of farm animals. According to Smidt (1994) only healthy animals are able to experience welfare. Thus the consideration of animal welfare and the enhancement of animal health are almost inseparable goals in modern animal production. It is almost impossible to fulfil ***all*** the ethological requirements of an animal, therefore these needs must be evaluated with respect to different preferences and motivations for environmental situations as well as their impact and significance to animal welfare (Baxter, 1989; Smidt, 1994).

Perspectives on future directions of animal management and breeding systems to comply with existing and envisaged welfare legislations/regulations could be classified in four categories :

- Modification and improvements within existing systems
- Establishment and development of combined procedures
- Research on and development of "alternative" procedures
- Returning to "traditional" systems of animal management.

Within the last category, outdoor pig production can position itself strategically to comply with proposed legislation on animal welfare in future.

1.2.4 *Recent developments within the New South Africa*

The new political dispensation (since February 1990) has paved the way for potential black (small) farmers and entrepreneurs to not only enter but also be involved in the decision - making process. It can be expected that there will be a transfer (shift) of resources towards meeting the basic needs of the new entrants (Njobe, 1994).

The National African Farmers Union (NAFU) regards itself as an integral part of the South African agricultural milieu, is politically non-aligned and strives to promote the interests of the disadvantaged farming community. NAFU boasted a membership of 21 994 by 31 August 1993. Inclusion of the Northwest and Western Cape Provinces has recently increased the membership to 32 650. This figure is likely to increase substantially by the turn of the century.

In the middle of the 19th century, African family farming was feasible, efficient and compared and competed favourably with white - owned farms (Njobe, 1994). NAFU is of the stated opinion that the negative connotation in which subsistence (black farmers) production is viewed, will diminish as market opportunities and a streamlined national agricultural policy fits into place (NAFU, 1994).

Furthermore, cognisance should be taken of the fact that the inherent nature of small farmers is risk aversive and that the very nature of pig farming is one of ***high risk/high return***. With outdoor pig production being less capital intensive and thus less risky, it might be a favourable attraction for prospective small-scale stock farmers.

CHAPTER II

INTRODUCTION

Along with the domestication of pigs, their living, farrowing and growing environment has changed. These domestication trends resulted in housing systems where pregnant sows and sows in lactation are at present kept individually, confined to cemented floor areas without the possibility of exercise (Ebner, 1993). Because of additional exercise that sows in loose housing systems are enjoying, the duration of farrowing is reduced significantly as well as the number of stillborn piglets (Kolacz, Pilarczyk & Dobrzanski, 1985; Brouns & Edwards, 1992).

According to Svendsen (1992) the change in housing system at farrowing from group housing to individual farrowing may be a stressor, leading ***inter alia*** to MMA (Mastitis, Metritis and Agalactie) and greater piglet losses during parturition.

Therefore a fundamental survival aspect that any pig producer should respect is the fact that the farrowing environment ***must*** provide optimum conditions so as to reduce postnatal losses.

On the contrary, Dial (1991) is of the stated opinion that *of **all*** the factors that influence overall herd productivity (expressed as pigs weaned per inventoried female per year), non-productive days are the best diagnostic indicator. The number of non-productive days tend to be higher in grouped herds rather than individually housed females (the reasons being suboptimal pregnancy detection and prolonged service to culling intervals).

The application of loose and confined housing systems at farrowing can be debated from various viewpoints/schools of thought:

(i) Tethering of the sow at farrowing and during lactation, with the emphasis on construction details and the close environment, reduce piglet losses significantly during the suckling period (Svendsen, 1992).

(ii) Elst-Wahle, Vermeer & Plagge (1992) studied the effectiveness of six types of farrowing houses (three included stalls with two tethering systems within the three stalls and the other three loose houses where the sows had a greater degree of movement). Better results were obtained from the houses with stalls. The greater degree of movement resulted in more deaths, since the sows overlaid the piglets.

(iii) According to Algers (1992) postmortem data on piglet mortality indicated that a large proportion of piglets (as high as 43%) are in fact crushed by the sow. As a result of this, the traditional farrowing crate was modified and new crates developed to prevent piglet crushing. However, crushing is still a major cause of piglet mortality (Cronin & Van Amerongen, 1991) and the total piglet losses do not seem to be reduced by the crates.

(iv) Friendship, Wilson & McMillan (1986) are of the opinion that large farrowing rooms are often noisier. This might disturb the nursing sow - she would flare up and lay down more frequently and accordingly enhance the possibility of crushing her piglets. Crushing, diarrhoea and starvation (because of a poorer suckling performance) are in general regarded as the final causes of death.

(v) Neonates and little piglets develop a distinct preference for their mother's voice (Algers, 1992). If the piglets are exposed to grunts from a number of sows (for instance in large farrowing rooms) it may well be that the synchronisation of piglet suckling behaviour is impaired, resulting in a poorer suckling performance that may directly explain the higher piglet mortality (Algers, 1992).

The ***environment*** in which the breeding sow is kept, will determine the ***type of sow*** to be utilized in the system (Thornton, 1988), while the ***market*** will indicate (dictate) ***which boar*** to use to eventually produce the right product to the consumer. According to Bichard (1990), the type of animal wanted for the outdoor situation is indeed difficult to define (See Addendum I). Cognisance should therefore be taken of the "Falconer paradox" (Standal, 1977) : ***"Of two equally selected strains, developed in two environments (the one more and the other one less favourable to the desired expression of the trait) the better strain (based on the average value over both conditions) will be the one selected under the less favourable conditions".***

According to Wrathall (1990) pigs that are being kept outdoors are prone to similar reproductive problems as their mates, being kept indoors. The range of causes, however, tends to be wider for outdoor pigs as shown in Fig 2.1.

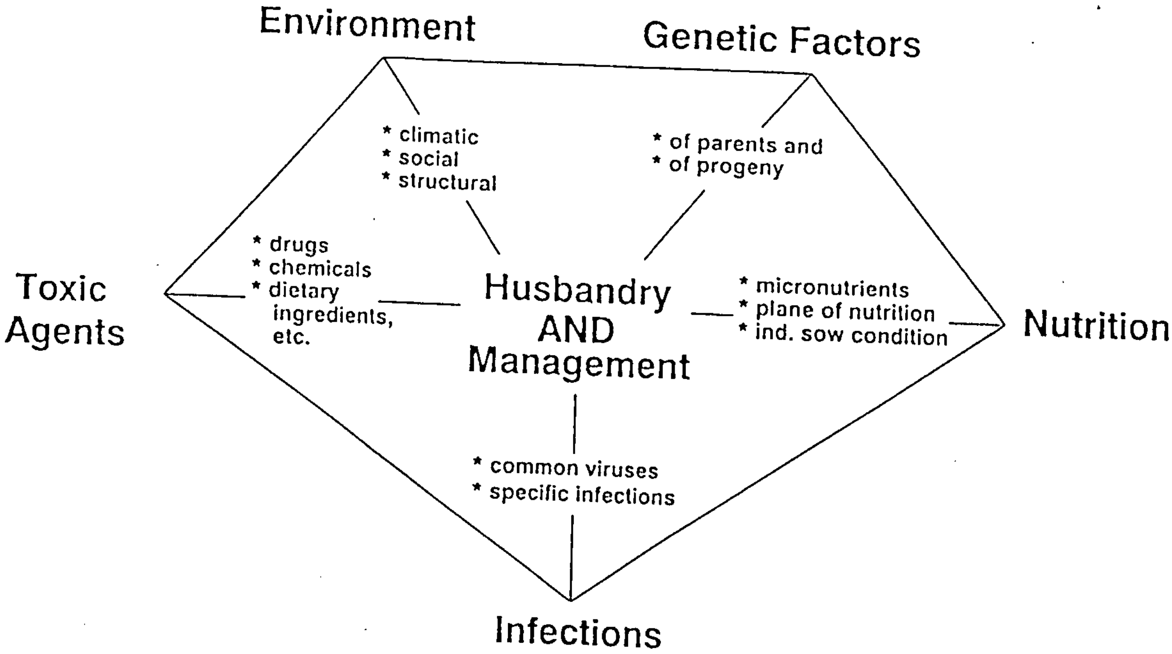

Fig 2.1 **Common categories (pertaining to indoor and outdoor pig production) of factors affecting reproductive performance (Wrathall, 1990)**

The author is of the opinion that a fundamental departure point in any breeding programme is indeed the establishment of the *breeding objective*. The *breeding objective* per definition implies the choice of a set of goals reflecting as closely as possible present and future production conditions. The *breeding objective* of outdoor pig production should combine animals that could make do with unfavourable environmental conditions within a low-cost (input) system, and should try to produce *weaner* pigs (as many as possible) with a high quality carcass acceptable to a diversified consumer market. Addendum II summarises the credentials of the ideal outdoor boar and sow.

The objectives of this study were :

(i) To evaluate the relative effectiveness of five different farrowing houses in an outdoor unit based on three reproductive traits (Y_1 = litter size at birth : Y_2 = mortality rate : Y_3 = weaning mass per litter). Weaning mass is regarded as a reproductive trait in this study.

(ii) To evaluate the reproductive efficiency of seven different genotypes (breed crosses) in this outdoor unit based on the same three reproductive traits.

(iii) To ascertain whether an interaction between farrowing house and breed (genotype) exists.

(iv) To identify the desired type of outdoor sow as well as the most effective farrowing house so as to ensure a low-cost-outdoor piggery.

CHAPTER III

MATERIAL AND METHODS

3.1 Experimental design

Reproduction data were recorded in the outdoor pig unit of Anglo America's Soetevelde PIC Piggery near the town Heidelberg in the Gauteng province of the Republic of South Africa (during the period 1988 - 1992). This unit is situated on the farm Platkopjes 28 km east of Vereeniging and 25 km south-west of Heidelberg (longitude 28° 15', latitude 26° 39'). The lowest area on the farm is 1 480 metres above sea level and the highest area 1 563 metres above sea level. During the period of the study the average rainfall of the farm was 598 mm per annum, with average maximum summer temperatures of 26,3°C and average minimum winter temperatures of 0,7°C being recorded. Old maize lands (classified as Hutton soils) were converted into camps.

A ***sow herd*** of 500 effective breeding sows, comprising seven different genotypes/breed combinations (see Addendum III) which farrowed down in five different farrowing houses/huts (See Addendum IV) were run on 38 ha divided into 50 camps. Camps were subdivided and maintained by means of electric fencing. Only the sows and boars were permanent kept out of doors, while piglets after weaning (21 days) were raised in conventional fattening pens.

Dry sows were fed a pelleted commercial ration (4 mm in diameter) and restricted to 2 kg/sow/day, except during the winter months, when the level was raised to 2,5 kg/sow/day. Another pelleted lactation ration, was fed to lactating sows on an ad lib basis.

These rations were purchased from a feeding company in Gauteng. No creep feed was fed to piglets during their suckling period.

Litter size at birth was recorded within 24 h post partum, whilst weaning mass per litter and number of piglets weaned per litter was recorded at weaning (21 days of age). The following factors were also observed and recorded during the survey:

* Year of birth
* Parity

- * Number born dead
- * Cross-fostering
- * Weaning age (days)
- * Previous weaning age (days) of the sow (N.S. Not all the piglets were weaned at exactly 21 days)
- * Weaning to servicing period (days)
- * Interfarrowing period (days)

A summary of the ***number of farrowings*** that were recorded per farrowing house, per genotype and per genotype per farrowing house is presented in Table 3.1, 3.2 and 3.3 respectively. The last column in Table 3.1 - Born alive weighted average - is the average value over the whole experiment. Thus the weighted average is the summation of the percent distribution multiplied by the average number born alive for each house.

TABLE 3.1 A summary of the total number of piglets, number of farrowings and numbers born alive in the different farrowing houses

House	Total number of piglets born	Number of farrowings observed	Percent distribution	Average number born alive	Born alive weighted average
1	22 580	2 377	60,47	9,50	5,74
2	8 707	922	23,45	9,44	2,21
3	2 984	306	7,79	9,75	0,76
4	2 581	265	6,74	9,74	0,65
5	592	61	1,55	9,70	0,15
TOTAL	**37 444**	**3 931**	**100**		**9,51**

TABLE 3.2 **A summary of the number of farrowings recorded per genotype/breed combination**

Genotype Number (Breed)	Number of farrowings that were recorded	Percentage distribution
1	1 648	41,92
2	836	21,27
3	658	16,74
5	243	6,18
6	330	8,40
7	66	1,67
8	150	3,82
TOTAL	**3 931**	**100**

TABLE 3.3 **A summary (cross classification) of the number of farrowings recorded per genotype per farrowing house**

	FARROWING HOUSE					
Genotype Number	**1**	**2**	**3**	**4**	**5**	**TOTAL**
1	1 017	417	110	85	19	1 648
2	514	181	67	62	12	836
3	374	144	63	62	15	658
5	148	57	17	17	4	243
6	199	79	23	24	5	330
7	35	15	8	5	3	66
8	90	29	18	10	3	150
TOTAL	2 377	922	306	265	61	**3 931**

The parity range in this experiment stretched over 12 parities, thus 12 classes, implying too many comparisons between the different parities had to be conducted. The 12 parities were therefore arbitrarily divided into 3 subclasses pertaining to litter size at birth and 4 subclasses each pertaining to the two traits mortality and weaning mass (See Addendum VI). By using the Tukey Kramer multiple comparison method, p-values between the different parity subclasses were then derived. Parity ***per se*** will be discussed in more detail under results and discussion.

3.2 Statistical analysis

The GLM analysis of variance procedure of S A S was used to analyse the data. The dataset however was substantially unbalanced and the range of farrowings recorded per farrowing house, per genotype and per genotype per farrowing house (see Tables 3.1, 3.2 and 3.3) was not fully represented. Out of the total dataset of 4 080 observations, 3 931 observations were included in the final analysis - 3,65% of the data were therefore omitted because of inconsistencies. Inadequate observations as recorded for house 6 (purpose made arch for hot South African conditions), house 7 and genotype 4 (Large Black x Hampshire) contributed ***inter alia*** to the above mentioned omission.

Three analyses were eventually performed for the three bio-economic reproductive traits, viz litter size at birth, mortality rate and weaning mass per litter. Weaning mass is regarded as a reproductive trait, since weaning mass reflects the milk production of the sow as well as her inherent mothering ability. Furthermore the genes for milk production are carried by the boar, thus causing the resemblance of this trait, when considering weaning mass, merely as an observed entity. In the models specified for mortality rate, and weaning mass, the ***traits*** litter size 1 and litter size 2 were in fact included as variables, given the causal effect of litter size at birth ***per se***. The reproductive related covariants interfarrowing period, weaning age and weaning to servicing (days) were initially included in the analyses. Throughout the experiment, $P \leq 0.1$ was used as level of significance. The reason being that the researcher was not primarily involved in neither the planning of the experiment, nor the gathering of the data.

Furthermore only a few treatments were signifincaly different at the 0.05 level. Contrasts among means for genotype, farrowing house and parity were calculated, using the Tukey Kramer multiple comparison method.

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Data description

The number of farrowings, overall mean, standard deviation and coefficient of variation of the three different traits is presented in Table 4.1.

TABLE 4.1 Number of farrowings (N), overall mean (x), standard deviation (S D) and coefficient of variation (C V) of the three different traits (Y_1; Y_2 and Y_3)

Trait	N	x	S D	C V
Litter size (Y_1)	3 931	9,525	2,419	25,4
Mortality (Y_2)	3 931	1,228	1,414	115,09* (17.04)
Weaning mass (Y_3) (kg)	3 931	49,949	11,511	23,046

* A more realistic calculation using piglets weaned (litter size - mortality) in order to obtain the C V is recommended (C V = 17,04%)

4.2 Factors influencing reproductive traits

Litter size at birth is defined as the number of piglets born alive plus or minus cross-fostering. Cross-fostering is a universal accepted phenomenon whereby newborn piglets are taken away from sows (or gilts) with large litters and given to sows (or gilts) with very small litters. Cognisance was taken of cross-fostering to compensate for biased assumptions given the causal effect of litter size at birth on mortality rate and weaning mass per litter.

4.2.1 *Litter size at birth*

The analysis of variance for the trait litter size at birth is presented in Table 4.2

TABLE 4.2 The analysis of variance of the type III sum of squares pertaining to litter size at birth

Source	D F	Type III SS	Mean square	F value	Pr > F
Breed	6	68,451	11,408	1,95	0.0695
Year	4	63,580	15,895	2,72	0.0283
Year x breed	24	264,401	11,016	1,88	0.0058
House	4	26,907	6,726	1,15	0.3314
Parity	2	264,137	132,068	22,56	0.0001
***P W age**	1	81,523	81,523	13,93	0.0002

*P W age = Previous weaning age

The effects of breed (genotype) (P = 0.0695) and year (P = 0.0283) were both significant.

No interaction between farrowing house and breed existed. Covariants that did not contribute significantly to the model were also omitted, for example: interfarrowing period, weaning age and weaning to servicing (days). Because the effect of breed (genotype) was significant (P = 0.0695), contrasts among means between the different breeds (genotypes) were calculated, using the Tukey Kramer multiple comparisons method.

The significance of these two effects was also reflected in a significant (P = 0.0058) year x breed interaction. The effect of house on litter size at birth (born alive) was non-significant (P = 0.3314). Finally, the effects of parity (P = 0.0001) and previous weaning age (P = 0.0002) on litter size at birth, were both highly significant. The most parismonious model describing the dataset is therefore:

$Y_{ijkl} = \mu + B_i + H_j + Y_k + BY_{ik} + P_l + b_1W + e_{ijkl}$

where:

Y_{ijklm}	=	Individual's litter size at birth
μ	=	Population mean for the trait
B_i	=	Effect of the i-th breed
H_j	=	Effect of the j-th farrowing house
Y_k	=	Effect of the k-th year
BY_{ik}	=	Interaction between breed (genotype) and year
P_l	=	Effect of the l-th parity
b_1W	=	Effect of previous weaning age (covariant)
e_{ijkl}	=	Random error

This model, despite the inclusion of what are considered relevant effects, accounted for only 5,5% of the variance.

Contrasts among means for litter size at birth between the different genotypes (breed combinations) is presented in Table 4.3.

TABLE 4.3 p-Values for pairwise comparisons between the litter sizes of the different genotypes (Pr > T / Ho : LS Mean (i) = LS Mean (j))

		GENOTYPE						
Litter size LS Means	**i/j**	**1**	**2**	**3**	**5**	**6**	**7**	**8**
9,76	1	-	0.3007	**0.0247**	0.5415	0.8247	0.4923	**0.0661**
9,94	2		-	**0.0058**	0.3455	0.7408	0.3365	**0.0331**
9,25	3			-	0.7267	0.1121	0.9116	0.3897
9,44	5				-	0.5116	0.8835	0.3550
9,83	6					-	0.4663	**0.0815**
9,32	7						-	0.4903
8,76	8							-

Litter size at birth for genotype 3 (Large Black x Landrace) was significantly lower (P = 0.0247) when compared to genotype 1 (Large White x Landrace) and highly significantly lower when compared to genotype 2 (Hampshire x Landrace) (P = 0.0058). Furthermore, genotype 8 [Duroc x (Large White x Landrace)] had a significantly lower litter size at birth when compared to genotype 1 (P = 0.0661), genotype 2 (P = 0.0331) and genotype 6 (P = 0.0815). Genotype 6 being the Landrace x (Hampshire x Large Black) cross.

Given the significant observed difference between certain genotypes in this study, these results are partly in accordance with the work of Holtman, Fahmy, MacIntyre & Moxley (1975) who studied the reproductive performance of 28 one-way crosses produced from eight different breeds of pigs. In their study the Landrace x Large White sows and the Hampshire x Landrace sows had the largest litters and the Large Black x Hampshire and the Duroc x Hampshire the smallest litters.

Kuhlers, Jungst, Edwards & Little (1982) studied the effects of sire breed, dam breed and their interaction on preweaning and postweaning performance of 274 litters of specific crosses from Duroc x Landrace, Spot x Landrace and Hampshire x Landrace sows. The best preweaning and postweaning performance were obtained where Duroc boars were mated to Hampshire x Landrace sows, while crossbred sows comprising of 50% Landrace genes proved to be superior to sows of other breeds in litter size and litter mass at 21 days. Drewry (1980) investigated the factors affecting sow productivity in crossbred sows. Duroc x Yorkshire sows (mated to Duroc boars) had the largest litter sizes and largest litter masses at 1,35 and 210 days respectively. The smallest litters were produced by Landrace x Yorkshire sows (mated to Duroc boars) and Hampshire x Yorkshire sows (mated to Hampshire boars). The findings of Drewry (1980) are partly in contrast to the results obtained in the present study.

Longevity and maternal productivity of F1-crossbred Landrace sows which were kept in ***two*** different gestation systems were evaluated by Jungst, Kühlers & Little (1988). In the ***first*** system the sows were confined to gestation stalls and in the ***second*** system to pastures during gestation. In the pasture gestation system over a duration of four parities, the following phenomenon was observed: Duroc x Landrace and Hampshire x Landrace sows produced significantly ($P < 0.1$) more total live piglets at birth, 21 days and at weaning (56 days) than their Yorkshire x Landrace counterparts.

Hampshire x Landrace F1-sows have consistently been shown to perform favourably in outdoor facilities in terms of general reproductive efficiency. The present results again confirm these findings.

Although the effect of house (Addendum IV) on litter size at birth was ***non-significant*** ($P = 0.3314$: Table 4.2) in this study, cognisance should be taken of the findings of the following researchers :

According to Curtis (1970), Roach (1981), Cronin & van Amerongen (1991) and Philips & Fraser (1993) the prefarrowing behaviour in sows consists of the following ***three*** major components:

(i) prepartum isolation and marking of the territory;
(ii) selection of a birth site and rooting; and
(iii) nesting activity

Fulfilment of these three components or behavioural patterns produces a farrowing nest that probably provides the sow with a safe and comfortable farrowing environment.

The effects of parity ($P = 0.0001$) and previous weaning age ($P = 0.0002$) were highly significant sources of variation for all three traits in this study.

Previous weaning age is synonymous with the length of the lactation period. The shorter the lactation, the more adverse the effects thereof on the three reproductive traits.

However a very low R^2 value of 0,055 was realised for the litter size model. A summary of the distribution of farrowings recorded per parity as well as the number born alive, mortality and weaning mass recorded per parity is presented in Addendum V. Contrasts among means for the number of piglets born alive per parity subclass and corresponding p-values are presented in Table 4.4. The effect of parity on litter size at birth was divided into three subclasses to enable pairwise comparisons.

TABLE 4.4 p-Values for pairwise comparisons between the different parity subclasses pertaining to litter size at birth

(Pr > T / Ho : LS Mean (i) = LS Mean (j))

		PARITY SUBCLASSES		
Born alive LS Means	**i/j Parity Subclasses**	**1**	**2**	**3**
9,04	1 (P_1 - P_2)	-	0.0001	0.0010
9,76	2 (P_3 - P_6)	-	-	0.3587
9,61	3 (P_7 - P_{12})	-	-	-

Highly significant differences were observed between the first and second parity subclass (P = 0.0001) and the first and third parity subclass (P = 0.0010). The difference between the second and third parity was non-significant (P = 0.3587). The trend for number of piglets born alive per parity (within the three subclasses) is presented in Fig. 4.1.

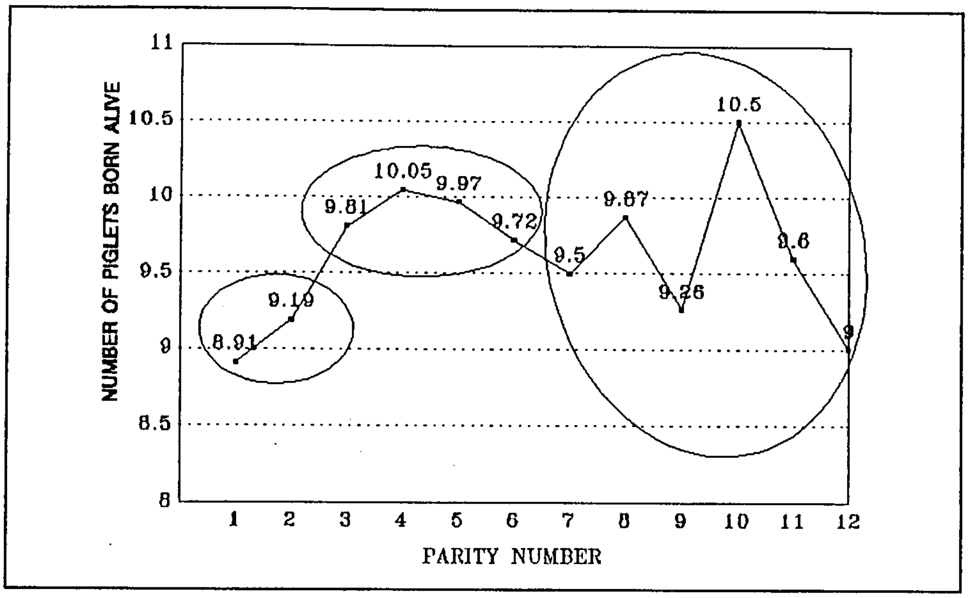

Fig. 4.1 Number of piglets born alive per parity

Johnson, Omtvedt & Walters (1978) compared the reproductive efficiency of purebred (N = 406) and crossbred (N = 429) females. Very similar conception and ovulation rates were reported for purebreds (87,1%) and crossbreds (87,9%). Both crossbred and purebred ***sows*** had consistently ***more*** piglets per litter ($P < 0.05$) than crossbred and purebred ***gilts***. The difference being 1,66 piglets at birth and 0,66 piglets at 21 days.

Other researchers have reported similar findings. Lee & Kim (1989) reported phenotypic correlations (ranging from 0,17 to 0,24) between litter sizes at different ages. English, Smith & MacLean (1984) related the lower litter sizes of gilts to uncertainties pertaining to the onset of puberty as well as to the intensity of the heat period. According to Luckbert & Gatel (1988) the difference in litter sizes and mortality rates between first and second litter sows is related to the lower birth mass of first litter piglets. The maximum number of piglets farrowed and weaned by sows normally occurs between the third and sixth parity (English *et al.*, 1984; Jungst *et al.*, 1988; Sorenson, 1990).

In the present study the maximum number of piglets born alive occurred between the third and fifth litter, i.e. within the second parity subclass (Fig. 4.1). A total of only 16 litters were recorded during the last three parities (see Addendum V) and therefore any conclusions should be drawn cautiously. As only ten litters contributes to the value of 10.5 piglets born alive in parity number ten, as opposed to 1 673 for litters three to five, little store should be placed on this result.

4.2.2 *Mortality rate*

Mortality rate is defined as the litter size at birth minus number of piglets alive at 21 days, thus weaning. Mortality can be expressed either as a percentage or as a figure, thus : piglet(s) per litter - as is used in this study.

The analysis of variance for the trait mortality rate is presented in Table 4.5. The effect of breed (genotype) was non-significant (P = 0.1592), but the effects of house (P = 0.0548), weaning age (P = 0.0478) and the interaction between year x breed (P = 0.0456) were all significant. Furthermore the effects of year (P = 0.0004), parity (P = 0.0001) and the covariant litter size 1 (P = 0.0001) were all highly significant.

The covariants interfarrowing period, previous weaning age and weaning to servicing as well as the interaction between farrowing house and breed did not contribute significantly to the variation in mortality rate. Cronin & van Amerongen (1991) studied the effects of a modified farrowing environment and concluded that the farrowing environment affects maternal behaviour of the sow.

TABLE 4.5 The analysis of variance of the type III sum of squares pertaining to mortality rate

Source	D F	Type III SS	Mean square	F value	Pr > F
Breed	6	18,547	3,091	1,55	0.1592
Year	4	41,037	10,259	5,13	0.0004
Year x breed	24	73,800	3,075	1,54	0.0456
House	4	18,552	4,638	2,32	0.0548
Parity	3	204,123	68,041	34,01	0.0001
Litter size 1	1	233,083	233,083	116,51	0.0001
Weaning age	1	7,838	7,838	3,92	0.0478

The most parsimonious model best describing the dataset is therefore :

$$Y_{ijkl} = \mu + B_i + H_j + Y_k + BY_{ik} + P_l + b_1S + b_2W + e_{ijkl}$$

where:

Y_{ijklm} = Mortality rate per indiviudal litter
μ = Population mean for the trait
B_i = Effect of the i-th breed
H_j = Effect of the j-th farrowing house
Y_k = Effect of the k-th year
BY_{ik} = Interaction between breed (genotype) and year
P_l = Effect of the l-th parity
b_1S = Effect of litter size 1, after cross-fostering and before mortalities (covariant)
b_2W = Effect of weaning age (covariant)
e_{ijkl} = Random error

This model despite the inclusion of what are considered relevant effects accounted for only 8,6% of the variance. Contrast among means for mortality rate recorded per litter between the different farrowing houses is presented in Table 4.6.

TABLE 4.6 p-Values for pairwise comparisons between the different farrowing houses : mortality rate (Pr > T / Ho : LS Mean (i) = LS Mean (j))

		FARROWING HOUSE				
Mortality LS Means	**i/j**	**1**	**2**	**3**	**4**	**5**
1,40	**1**	-	0.3208	0.5985	0.9251	**0.0060**
1,35	**2**	-	-	0.9210	0.6428	**0.0029**
1,36	**3**	-	-	-	0.7571	**0.0055**
1,39	**4**	-	-	-	-	**0.0104**
1,92	**5**	-	-	-	-	-

House 5 had a significant (P = 0.0104) higher mortality rate than house 4 and a highly significant higher mortality rate than house 1 (P = 0.0060), house 2 (P = 0.0029) and house 3 (P = 0.0055). No significant difference existed between houses 1, 2, 3 and 4. Houses 1, 2 and 3 had an earth floor and ***Eragrostis curvula*** bedding while the floor of house 4 contained wheat straw bedding. The floor of house 5 consisted of planks with wood shavings as bedding (Addendum IV). English (1989) regarded good-quality bedding such as wood shavings as essential. This type of bedding will increase the effective floor temperature to around 8°C, thereby minimising heat loss to the surface on which the piglet lies.

Stephens (1971), as quoted by Friendship, Wilson & McMillan (1986) noted that newborn piglets kept on straw at 10°C, had the same heat production as piglets kept on concrete at 18°C. If the newborn piglet is subjected to a lower temperature, its locomotive vigour declines, which renders it less competitive and thus more prone to being crushed. Glastonbury (1977) studied the preweaning mortality causes of 718 piglets - 12,8% died from starvation, 18,8% succumbed to infectious agents while 33% died of trauma or suffocation (crushing). Stolba (1981) as quoted by Roach (1981), studied the behaviour of sows, boars and piglets in natural ***"freerange"*** and ***"enriched"*** indoor environments. In the ***"enriched"*** indoor environment, the deep-strawed nesting area helped to cushion a piglet if it did get overlaid. Algers & Jensen (1990) reported that farrowing units (of free-ranging domestic pigs) that contain plenty of straw, would allow the sows to construct "nests" and also provide the optimal microclimate to the young piglets. The significant higher mortality rate (1,84 piglets/litter) in house 5 (Fig. 4.2) was probably caused by more crushing in this house because of a wooden floor and the ***absence*** of a deep-strawed nesting area and crash bars.

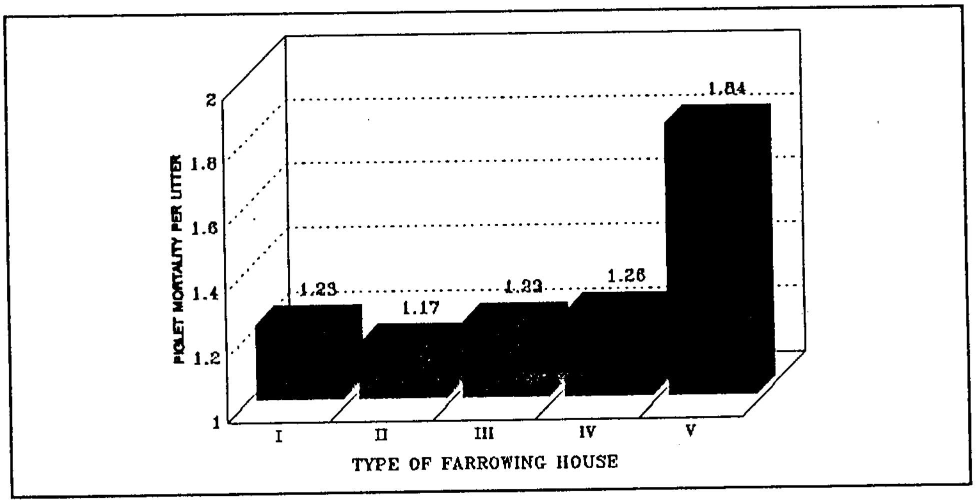

Fig. 4.2 **The effect of type of farrowing house on preweaning piglet mortality per litter**

The limited number of farrowings (N = 61) recorded in house 5 is indeed unfortunate and any final conclusion should be drawn accordingly.

TABLE 4.7 A summary of the different mortality rates in the different houses

House	Number of litters involved	% Distribution	Total deaths	Piglet mortality (per litter)	*Weighted average mortality rate
1	2 377	60,47	2 933	1,23	0,744
2	922	23,45	1 075	1,17	0,274
3	306	7,79	376	1,23	0,097
4	265	6,74	335	1,26	0,085
5	61	1,55	112	1,84	0,028
Total	**3 931**	**100**	**4 831**		**1,228**

* Weighted average mortality rate = The summation of % distribution x piglet mortality (per litter) for all five houses

The weighted average mortality rate of 12,9% (1,228 piglets per litter - Table 4.7) and the weighted average of 9,51 piglets born alive per litter (Table 3.1) reported in this study is in accordance with international findings. Sidor (1991) recorded a preweaning mortality of 14,3% in 350 litters (Landrace x Czechoslovakian Improved White sows). These sows were housed with access to a paddock. Friendship *et al.* (1986) (University of Guelph, Guelph, Ontario) reported a preweaning mortality of 20% based on surveys from many countries and under many different housing conditions.

The MLC Yearbook (April, 1988) as quoted by Corning (1990) recorded and reported a preweaning mortality of 10,6% for outdoor sows and 11,2% for indoor sows. The average herd sizes were 515 and 200 sows respectively.

The 1991 MLC winners' award for high productivity in the category ≥ 351 outdoor breeding sows, was awarded to a 1 099-sow unit (Aherne, 1991) for the following achievements:

Culling rate	:	38,8%
Successful services	:	90,0%
Litters per sow per year	:	2,27
Litter size (average born alive)	**:**	**10,96**
Piglets per sow per year	:	22,9
Preweaning mortality	**:**	**7,9%**
Average mass/piglet weaned at 20 days	:	5,3 kg

Local statistics, obtained from the recording system of the National Pig Health Scheme of the Meat Board, for 1993 revealed the following mortality figures:

R S A average	:	10,15% (1,07 piglets per litter)
R S A top 20 %	:	9,25% (1,01 piglets per litter)

With good stockmanship, management and experienced supervision (Glastonbury, 1977; Friendship *et al.,* 1986; Thornton, 1988; Corning, 1990 and Shepherd, 1991) effective outdoor pig production is indeed a reality.

The effect of parity on mortality rate was divided into four subclasses to enable pairwise comparisons. The relationship between preweaning mortality rate and parity number is presented in Fig. 4.3.

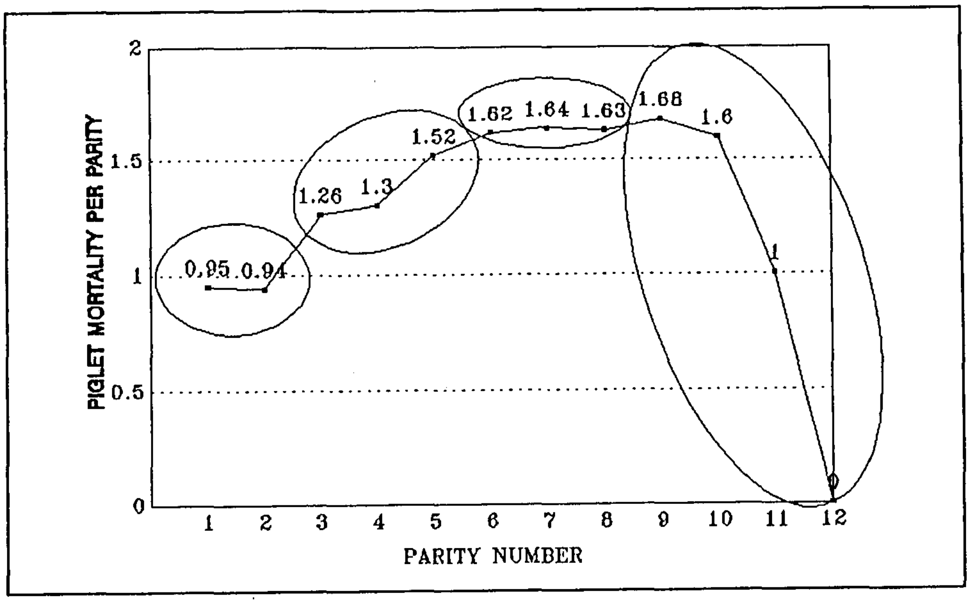

Fig 4.3 **The relationship between preweaning mortality rate and parity number**

TABLE 4.8 **p-Values for pairwise comparisons between the four parity subclasses pertaining to mortality rate (Pr > T / Ho : LS Mean (i) = LS Mean (j))**

	PARITY SUBCLASSES				
Mortality rate LS Means	**i/j (Parity subclasses)**	**1**	**2**	**3**	**4**
1,02	1 (P_1 - P_2)	-	0.0001	0.0001	0.0007
1,41	2 (P_3 - P_5)	-	-	0.0001	0.1371
1,77	3 (P_6 - P_8)	-	-	-	0.7911
1,72	4 (P_9 - P_{12})	-	-	-	-

From Table 4.8 and Fig. 4.3 it is evident that the mortality rate in the first two parities (parity subclass 1) was highly significant *lower* than parity subclasses 2 (P = 0.0001), parity subclass 3 (P = 0.0001) and parity subclass 4 (P = 0.0007). No significant difference existed between parity subclass 2 and 4 (P = 0.1371) or between and parity subclass 3 and 4 (P = 0.7911). A total number of 54 litters (Addendum V) were recorded within parity subclass 4 versus 599, 1 673 and 3 278 for parity subclasses 3, 2 and 1 respectively. Conclusions should thus be drawn accordingly for subclass 4. The smaller litter sizes obtained during the first two parities (Fig. 4.1) were associated with the smaller mortality rates (Fig. 4.3) in this study.

As indicated by Jungst *et al.* (1988) the highest number of piglets farrowed and weaned by sows normally occurs between the third and sixth parity. However, English (1989) warned the pig farmer that he/she is confronted with the unenviable challenge of achieving high survival rates in large litters. In this study the higher mortality rates were also associated with larger litters (litters 3, 4 and 5). Exceeding the optimum reproductive level (from the sixth litter onwards) resulted in smaller litters (parity subclass three Fig. 4.1) and higher mortality rates (parity subclass 3 and 4, Fig. 4.3). This is in accordance with the findings of other researchers (English *et al.,* 1984; Darneley, 1993).

Finally, the covariant weaning age, had a significant (P = 0.0478) effect on mortality rate. This phenomenon, that future litter sizes are smaller following early weaning, was also reported by English (1989); Maurer, Ford & Christenson (1989). An unenviable situation for the breeder is therefore to decide between reducing empty days per sow per year (through early weaning) and thus sacrificing reproductive efficiency on the one hand **OR** to increase the inter farrowing period, but gaining on the number of piglets/sow/litter on the other hand.

4.2.3 *Weaning mass*

Weaning mass per litter is expressed as the mass (in kg) of the litter at weaning (21 days).

The analysis of variance for the trait weaning mass is presented in Table 4.9. Neither breed (genotype) ($P = 0.1752$) nor year ($P = 0.5186$) or the interaction between breed and year ($P = 0.1392$) were significant. The effect of house on weaning mass was highly significant ($P = 0.0056$).

The effects of parity, litter size 2 and weaning age were highly significant ($P \leq 0.0001$) sources of variation.

TABLE 4.9 The analysis of variance of the type III sum of squares pertaining to weaning mass

Source	D F	Type III SS	Mean square	F value	Pr > F
Breed	6	1 189,741	198,290	1,50	0.1752
Year	4	429,314	107,328	0,81	0.5186
Year x breed	24	4 182,719	174,280	1,32	0.1392
House	4	1 938,099	484,524	3,66	0.0056
Parity	3	48 223,467	16 074,489	121,30	0.0001
Litter size 2	1	317 497,165	317 497,165	2 395,82	0.0
Weaning age	1	10 489,296	10 489,296	79,15	0.0001

The most parsimonious model best describing the data is therefore :

$$Y_{ijkl} = \mu + B_i + H_j + Y_k + P_l + b_1S + b_2W + e_{ijkl}$$

where:

Y_{ijklm}	=	Individual's weaning mass per litter
μ	=	Population mean for the trait
B_i	=	Effect of the i-th breed
H_j	=	Effect of the j-th farrowing house
Y_k	=	Effect of the k-th year
P_l	=	Effect of the l-th parity
b_1S	=	Effect of litter size 2, after cross-fostering and mortalities (covariant). This covariant is thus the size of the litter at day of weaning.
b_2W	=	Effect of weaning age (covariant)
e_{ijkl}	=	Random error

This model have accounted for 45,3% of the variance. Contrasts among means for weaning mass recorded per litter between the different farrowing houses is presented in Table 4.10.

TABLE 4.10 p-Values for pairwise comparisons between the five farrowing houses pertaining to weaning mass (Pr > T / Ho : LS Mean (i) = LS Mean (j))

		FARROWING HOUSE				
Weaning mass LS Means	**i/j (Farrowing house)**	**1**	**2**	**3**	**4**	**5**
49,58	1	-	**0.0081**	0.1650	0.5013	**0.0658**
48,38	2	-	-	**0.0046**	**0.0361**	0.2983
50,55	3	-	-	-	0.6268	**0.0214**
50,08	4	-	-	-	-	**0.0467**
46,76	5	-	-	-	-	-

The weaning mass recorded in house 5 (A frame house with a wooden floor, no crash bars and wood shavings as bedding) was significantly lower than the weaning mass in house 1 ($P = 0.0658$), house 3 ($P = 0.0214$) and house 4 ($P = 0.0467$).

Furthermore, the weaning mass recorded in house 2 was highly significant ($P = 0.0081$) lower than the weaning mass in house 1 and house 3 ($P = 0.0046$) and significantly ($P = 0.0361$) lower than in house 4. Svendsen (1992) stated that the ideal farrowing house should be draught free, easily cleaned and allow easy access to it.

The wooden floor in house 5, was probably not conducive to provide optimum preweaning growth and survival conditions (microclimate) to the young piglets. Prior to farrowing, a sow under free-ranging conditions, will naturally build a nest out of grass or straw (Algers & Jensen, 1990). The piglets will spend most of their time under artificial heaters when straw is absent in the farrowing pen (English, ***et al.,*** 1984). No artificial heaters were provided in this study. The foremost physiological barrier for the young piglets to overcome was probably the maintainance of body temperature. If these piglets were furthermore kept in an extreme and unfavourable climate, the inevitable fluctuations in temperature linked with the chilling factor, did undoubtedly delay recovery and was eventually reflected in sub-optimal weaning masses.

The effect of parity on weaning mass was divided into four subclasses to enable pairwise comparisons pertaining to weaning mass.

The average weaning mass distribution recorded per parity is presented in Fig. 4.4.

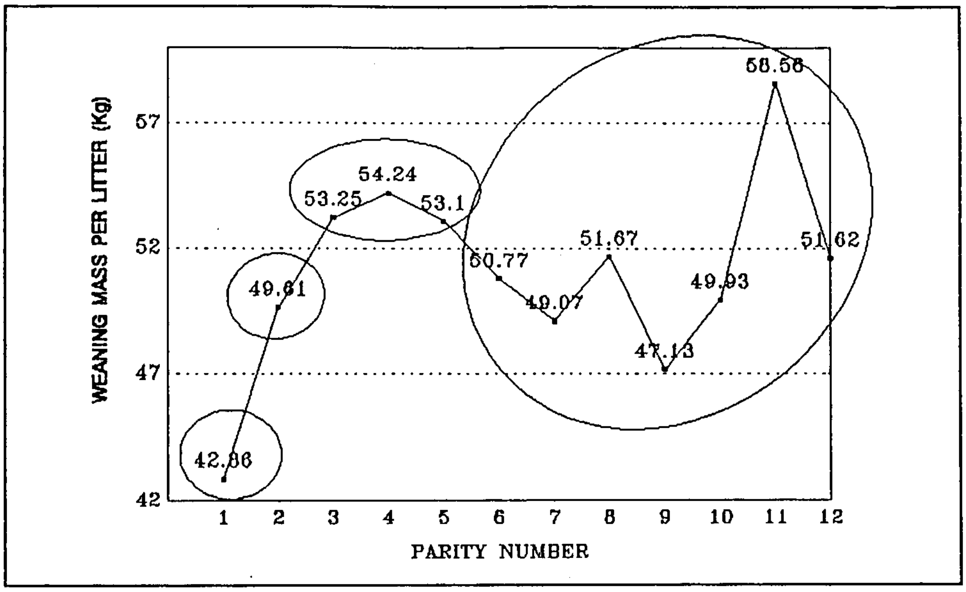

Fig 4.4 The effect of parity on weaning mass

TABLE 4.11 **p-Values for pairwise comparisons between the four parity subclasses pertaining to weaning mass**
(Pr > T / Ho : LS Mean (i) = LS Mean (j))

Weaning mass LS Means	i/j (Parity subclasses)	PARITY SUBCLASSES 1	2	3	4
42,95	1 (P_1)	-	0.0001	0.0001	0.0001
48,50	2 (P_2)	-	-	0.0001	0.0001
53,0	3 (P_3 - P_5)	-	-	-	0.0515
51,8	4 (P_6 - P_{12})	-	-	-	-

From Table 4.11 it is evident that, with the exception of parity subclasses 3 and 4 (P = 0.0515), all the parity subclasses differed highly significantly (P = 0.0001) from each other. The parity subclass where the highest weaning masses were recorded, incorporated litters 3, 4 and 5.

These findings are in accordance with the work of English *et al.* (1984) and Fraser & Thompson (1986).

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

1. Following the preceding discussions, the effects of farrowing house on firstly mortality rate (P = 0.0548) and, secondly, weaning mass (P = 0.0056) was significant and highly significant respectively. Within the context of house, ***the significant adverse effect of house 5*** (with the wooden floor instead of grass bedding) on both these two reproductive traits is alarming. The further ***utilisation*** of this housing type is indeed questionable and termination thereof must seriously be considered.

2. One of the objectives of this study was to ascertain ***whether a farrowing house - genotype interaction did exist.*** The reason being that too many breeds and housing systems are not conducive to sound management, record keeping, economic principles and genetic improvement. ***No such interaction existed*** for any of the three traits.

3. The effect of breed was only significant (P = 0.0695) for litter size at birth. However, the effect of year and the interaction between year and breed (genotype) on both Y_1 (litter size at birth) and Y_2 (mortality) were two very important (significant) ***sources of variation beyond control of the breeder.***

4. In constructing the models for Y_1, Y_2 and Y_3 (weaning mass) cognisance was taken of the most important known biological factors and covariants. ***Yet, very low R^2values of 0,05; 0,086 and 0,45 were realised from the three traits*** litter size at birth, mortality and weaning mass respectively. This implies that many more unknown factors (almost infinite) do in fact influence these traits and the present models cannot be applied for prediction purposes. On the one hand this phenomenon can partly be explained by the inherent complexity of the reproductive process, linked with low prediction of reproductive performance not only in pigs but in ***all*** livestock species. On the other hand a fundamental shortcoming of this study was the fact that ***the effect of boar*** was not specified (because of group mating) and unfortunately omitted from the study.

5. The three largest litter sizes (LS Means) were reported for : genotype 2 (Hampshire x Landrace) genotype 6 [Landrace x (Hampshire x Large Black)] and genotype 1 (Large White x Landrace) respectively.

However this trend was not sustained until weaning, implying ***no significant poorer performance from the other four genotypes in terms of relative reproduction*** efficiency. Outdoor pig producers should therefore revise the function of the Hampshire-crossbred sows as the ideal outdoor sow.

6. The ***hidden breeding objective*** of any piggery, should be to achieve positive genetic change in the end. From a reproductive point of view it was shown that little is gained by retaining sows after the fifth litter. The highly significant effect of parity is invariably associated with the age of the sow.

7. The A-frame farrowing houses with crashbars (houses 3 and 4 in Addendum IV) proved to be the most effective. The number of bars in the house didn't matter, as long as provision was made for at least one.

8. Given the highly significant ($P < 0.0002$) effect of parity subclass on all three traits the researcher is of the opinion that the ***pivotal importance of sound stockmanship*** should be extended to ***every single farrowing***. Not only to reduce piglet mortality and to improve preweaning growth conditions of all young piglets which are born and raised out of doors, but also to care for the sow as she becomes older.

9. The provision of sufficient clean dry straw should be synonymous with all of this unit's outdoor farrowing houses. Farrowing houses 1, 3 and 4 reported the highest indexes (Addendum VII) viz 84,32; 85,9 and 85,07 respectively. These houses contained ***Eragrostis curvula*** and wheat straw as bedding. Not only will the straw and or grass serve as a buffer for overlaying (since most farrowings take place overnight without supervision), but in very cold weather the extra bedding will enhance temperature consistency, avoid chilling and result in higher survival rates. Finally, the provision of sufficient straw and or grass would probably attract sows to the farrowing site, allowing them to perform their inherent nest building activities.

10. ***Nutrition of the sow*** (although not part of this study) is of crucial importance - not only to ***enhance*** optimum sow productivity, but also to enhance sound reproductive efficiency. Little is known about the effect of feeding strategy on the implantation or resorption of embryos in the outdoor situation - and this is a matter of utmost concern. The nutrient requirements of the indoor sow are known relatively precisely (Close, 1990), but for the outdoor sow, additional considerations such as maintenance, exercise, environment and wastage, should be taken into account.

11. The major income from any piggery is derived from the offspring of the breeding sows that are sold/marketed. From a generic and economic point of view it is important that this unit also monitor ***the production efficiency and carcass income*** from the offspring of these seven genotypes. Thus - the modern outdoor systems, in order ***to retain the competitive edge,*** will have to embody/embrace the accepted indoor virtues of prolificacy, reproductive efficiency, production efficiency and value added carcass quality production.

12. ***The findings of this study are not necessarily authentic of global outdoor pig production.*** It is merely the picture as portrayed by an outdoor pig unit over a period of five years (1988 - 1992) in Southern Africa on the farm Platkopjes near the town Heidelberg in the Gauteng province of South Africa.

    Similar local studies should be conducted under different topographical environments incorporating at least factors such as identification of sire(s), stockman, temperature and daylight length.

13. ***Thorough planning of experimental design is critically important*** in any research experiment and even more so where the experiment is conducted out of doors. Should it be deemed necessary to repeat and/or extend such trials in the future it should be done in close collaboration with either statisticians and geneticists or biometrical geneticists given the ***uneven distribution of recordings*** per farrowing house and per breed.

14. It can be stated unmistakably that ***the rise of the small-farmer entrepreneur*** (within the Agricultural context in South Africa) is one of the most important fundamental trends evolving at the moment in agriculture. The small-farmer's ideals, preferences and values must be known/researched and understood in order to satisfy their demands.

    Outdoor pig production should ultimately form an integral part of the agricultural reconstruction and development program (R D P). Supplying the ideal breeding animal to the serious small pig farmer at the right time, at the right place and the right price must be viewed as a fundamental marketing departure point. This fundamental marketing mix should be interwoven with aspects such as education, transfer of knowledge, transfer of technology, experience, development of human resources, productivity and managerial skills.

15. The ***most eminent change*** the pig sector (both indoors and outdoors) has to take into consideration is undoubtedly developments on the welfare front (Armstrong & Cermak, 1990; Muirhead, 1991).

Given the latest international animal welfare trends, earmarked to hit the South African pig industry probably around the turn of the century, this unit is in a favourable position to diversify outdoor pig production into either a high technology or low technology business opportunity (or both), addressing client needs accordingly.

ABSTRACT

The effects of breed and housing systems on the production and reproduction of weaner piglets in an outdoor pig unit

by

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Outdoor pigfarming is a concept which (within the 20th century) had its origin (revival) in the early 1950s in England. Today approximately 15% of all breeding sows in England are kept out of doors while in South Africa probably less than 0,3% of sows (recorded), are kept out of doors.

The rationale for outdoor pig farming was motivated from four angles of incidence: firstly an economic viewpoint, secondly the animal's adaptability to the environment, thirdly an ethological viewpoint and finally the new political dispensation - specifically the prospective small-farmer.

The ultimate aim of this study was to identify the most suitable genotype and farrowing house of outdoor pigfarming based on the reproduction information of the sow's litters. The effect of genotype was significant (P = 0.0695) only for the trait litter size at birth, implying no significant poorer performance from the other genotypes in terms of relative reproductive efficiency. The three linear models, obtained by ANOVA procedures using SAS, which were specified for the reproductive traits litter size at birth, mortality and weaning mass, could explain very little of the variation for the three traits and R^2 values of 0,05, 0,086 and 0,45 were calculated for the three traits respectively. However, the effect of parity was highly significant (P = 0.0001) for all three traits.

The effect of house was non-significant (P = 0.3314) for number of piglets born alive, but significant for mortality (P = 0.0548) and highly significant for weaning mass (P = 0.0056). The inferiority of farrowing house 5 was undoubtedly revealed in this study.

The importance of sufficient clean and fresh straw which will not only stimulate the sow's natural nesting activities, but will also form a buffer and heating mechanism for the young piglets, was clearly shown, given the significant (P = 0.0548) effect of house on mortality rate, and the highly significant (P = 0.0056) effect of house on weaning mass.

In retrospect the reproduction performance of the outdoor breeding sow is measured against the norms appliable to the modern sow, however, the outdoor sow has to reproduce while competing with ***all*** the elements of nature (Falconer's paradox).

The effect of parity was highly significant (P = 0.0001) for all three traits.

This study, especially Tables 4,4; 4.8 and 4.11, showed that three distinctive (significant) phases could be identified during a sow's reproductive lifetime (Figures 4.1; 4.3 and 4.4). The ***commencing phase*** (1st and 2nd litter) where number of piglets born alive, mortality and weaning masses are at its lowest. The ***optimising phase*** (3rd to 5th litter) when numbers of piglets born alive, and weaning mass reach their optimum while mortality rate reaches the intermediate stage. The ***diminishing*** phase (from the 6th litter onwards) where the number of piglets born alive are less than the optimising phase and more than the commencing phase, and mortality rate reaches its peak and weaning mass declines significantly.

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ADDENDUM I

The main points of conflict between characteristics which exist in breeding programmes for outdoor stock (Bichard, 1990)

Favourable trait	Associated disadvantage(s)
* Rapid growth rate	Fatter carcasses
* Heavy muscling	Lower litter size Poorer physical soundness Increased susceptibility to stress/ deaths Drip loss from carcasses
* High lean content of carcass	Reduction in flavour and juiciness of meat
* Coloured skin to protect the animal particularly against sunburn	Considered by carcass purchasers to produce a fatter carcass
* High lean growth rate	Larger mature size of boars and sows
* Self-limiting appetite in finishing pigs	Inadequate appetite in sows, leading to excessive body tissue loss in lactation and subsequent re-breeding problems

ADDENDUM II

Credentials of typical outdoor breeding animals

Typical outdoor sow	Typical outdoor boar
* Independent, quiet and she should be easily handled	* High libido index and an acceptable temperament
* Prolific with good mothering abilities	* Ability to live out of doors
* She will need adequate fat reserves to withstand the rigours of nature	* To cooperate in a group but to work consistently and effectively on his own
* She has to be a hardy animal to be able to withstand the cold of winter and the heat and sun of the summer throughout the year	* Should be performance tested * Well muscled
* Be able to farrow and rear her litters to 3 weeks of age with the minimum of supervision	* High lean tissue growth rate * High lean content of carcass
* Visually and conformationally sound	* Visually and conformationally sound

Their combined ability should be to utilise waste grain, other feedstuffs and to graze without excessive supplementation while producing fast growing, economic offspring capable of producing carcasses of good quality

ADDENDUM III

Description of the different genotypes/breed combinations used in this study

Genotype number	Percentage contribution				
	LW	LR	LB	D	H
1	50	50			
2		50			50
3		50	50		
5	50				50
6		50	25		25
7	50	25			25
8	25	25		50	

LW = Large White

LR = Landrace

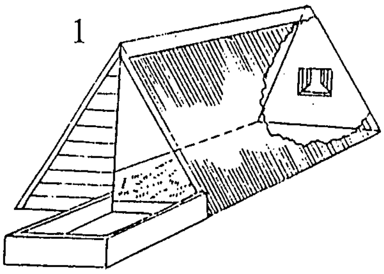
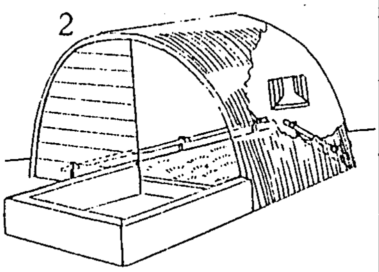
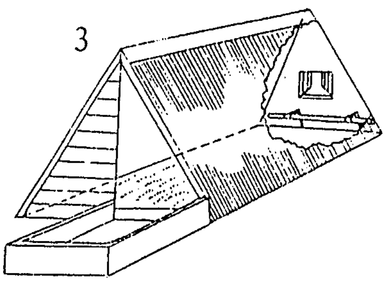
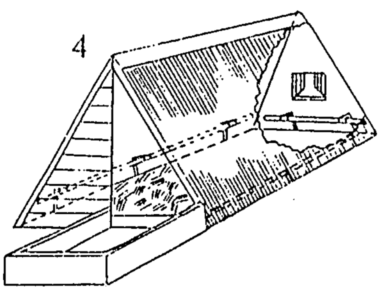
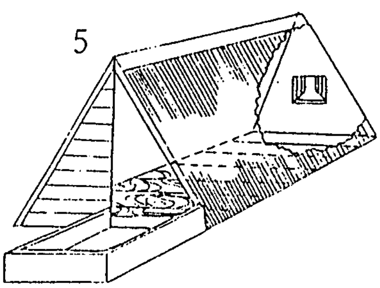
LB = Large Black

D = Duroc

H = Hampshire

ADDENDUM IV

Description of the different farrowing houses used in this study

House number	Architectual description	Detailed description	Description of floor
1		An A-frame house with inspection hole at back. The inspection hole, walls and roof were insulated. No crash bars	Earthen floor with grass bedding
2		Arched with inspection hole at back. The inspection hole, walls and roof were insulated. Crash bars at two corners away from door	Earthen floor with grass bedding
3		An A-frame house with inspection hole at back. The inspection hole, walls and roof were insulated. Only one crash bar on side away from door	Earthen floor with grass bedding
4		An A-frame house with inspection hole at back. The inspection hole, walls and roof were insulated. Crash bars were provided at three sides of the farrowing house	Earthen floor and wheat straw
5		An A-frame house with inspection hole at back. The inspection hole, walls and roof were insulated. No crash bars	Wooden floor with wood shavings as bedding

ADDENDUM V

Number of farrowings observed, number born alive, piglet mortality and weaning mass per parity

Parity	Total	Number observed	Number born alive	Piglet Mortality per litter	Weaning mass (Kg)
1	7 494	841	8,911	0,956	42,86
2	7 025	764	9,195	0,942	49,61
3	6 830	696	9,813	1,264	53,25
4	5 666	564	10,046	1,303	54,24
5	4 117	413	9,970	1,523	53,10
6	2 877	296	9,720	1,628	50,77
7	1 815	191	9,503	1,639	49,07
8	1 106	112	9,875	1,634	51,67
9	352	38	9,263	1,684	47,13
10	105	10	10,500	1,600	49,93
11	48	5	9,600	1,000	58,56
12	9	1	9,000	0,000	51,62

ADDENDUM VI

p-Values for parewise comparisons between the parity subclasses of the three reproductive traits

(Pr > / T / Ho : LS Mean (i) = LS Mean (j)

Parity Subclass	Parities involved	(Y_1) Litter size LS Means	i/j	Parity Subclass		
				1	2	3
1	(1 + 2)	9,04	1	-	0.0001	0.0010
2	(3, 4, 5 & 6)	9,76	2	0.0001	-	0.3587
3	(7 - 12)	9,61	3	0.0010	0.3587	-

Parity Subclass	Parities involved	(Y_2) Mortality LS Means	i/j	Parity Subclass			
				1	2	3	4
1	(1 + 2)	1,02	1	-	0.0001	0.0001	0.0007
2	(3, 4 & 5)	1,41	2	0.0001	-	0.0001	0.1371
3	(6, 7 & 8)	1,77	3	0.0001	0.0001	-	0.7911
4	(9, 10, 11 & 12)	1,72	4	0.0007	0.1371	0.7911	-

Parity Subclass	Parities involved	(Y_3) Wean Mass LS Means	i/j	Parity Subclass			
				1	2	3	4
1	(1)	42,95	1	-	0.0001	0.0001	0.0001
2	(2)	48,50	2	0.0001	-	0.0001	0.0001
3	(3, 4 & 5)	53,00	3	0.0001	0.0001	-	0.0515
4	(6 - 12)	51,84	4	0.0001	0.0001	0.0515	-

ADDENDUM VII

Reproduction efficiency indexes calculated for the five farrowing houses (least squares means values)

Farrowing	Litter size 1	Mortality	Litter size 2 (number of piglets weaned)	Weaning mass (kg)	Farrowing house reproduction index	Ranking
1	9,35	1,40	7,95	49,57	84,32	3
2	9,35	1,35	8,00	48,38	81,10	4
3	9,62	1,36	8,26	50,55	85,90	1
4	9,55	1,40	8,15	50,08	85,07	2
5	9,48	1,92	7,56	46,76	78,72	5

Farrowing house reproduction index = Sow reproduction index (S R I)*

S R I = (-1,25 x Litter size 1) + (0,142 x Litter size 2) + (1,914 x weaning mass)

* The above mentioned index is at presently being used by the National Pig Performance and Progeny Testing Scheme to estimate the reproductive efficiency of breeding females.