# EFFECT OF ENRICHMENT OF ENVIRONMENT AND HALOTHANE SENSITIVITY ON PERFORMANCE OF LARGE WHITE YORKSHIRE AND DESI PIGS

By

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**THESIS**

**Submitted in partial fulfilment of the requirement for the degree**

# Doctor of Philosophy

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COLLEGE OF VETERINARY AND ANIMAL SCIENCES
Mannuthy-Thrissur.

**1997**

# DECLARATION

I hereby declare that this thesis entitled "EFFECT OF ENRICHMENT OF ENVIRONMENT AND HALOTHANE SENSITIVITY ON PERFORMANCE OF LARGE WHITE YORKSHIRE AND DESI PIGS" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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## CERTIFICATE

Certified that this thesis entitled "**EFFECT OF ENRICHMENT OF ENVIRONMENT AND HALOTHANE SENSITIVITY ON PERFORMANCE OF LARGE WHITE YORKSHIRE AND DESI PIGS**" is a record of research work done independently by Dr.Joseph Mathew under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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# ACKNOWLEDGEMENTS

The author is indebted to:

Dr.C.K.Thomas, Professor, Department of Livestock Production Management. and Chairman of the Advisory Committee for his valuable and inspiring guidance and constant encouragement throughout the period of study and the preparation of the thesis.

Dr.T.G.Rajagopalan, Professor and Head, Department of Livestock Production Management; Dr.K.N.Muralidharan Nayar, Prfessor and Head, Department of Surgery; Dr.J.Abraham,Professor and Head, Meat Technology Unit and Dr.K.S.Sebastian, Associate Professor, Department of Livestock Production management as members of the Advisory Committee for their valuable suggestions given from time to time.

Dr.A.Rajan, Dean, College of Veterinary and Animal Sciences, Mannuthy, for the facilities provided during the course of investigation.

Dr.T.V.Viswanathan, Associate Professor and Head, Centre for Pig Production and Research, Mannuthy for his valuable help and constant encouragement during the study.

Dr. A.P.Usha,Assistant Professor, Dr.T.P.Balagopalan, Assistant Professor and Staff of Centre for Pig Production and Research for the help and co-operation provided.

Indian Council of Agricultural Research for providing facilities in AICRP on Pigs, Mannuthy.

Beloved parents, sisters, wife and son for their constant inspiration, understanding and blessing for the successful completion of study.

Mannuthy,

22-08-1997.

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ALL TO GOD AND THEN TO ASISH

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# 1. INTRODUCTION

India has achieved a level of self-sufficiency in its cereal production. But the availability of animal protein, with high biological value and compositional similarity with human body with regard to the profile and content of aminoacids, to an average Indian is only 7.6g against the world average of 24.7g and recommended level of 34g. Based on the present trend the projected total meat production in 2000 AD will be around 4.25 million tonnes and even at this level the per capita per day availability of meat will be only 16.6g. In order to bridge this gap between demand and supply of animal protein, there is an urgent need to increase the productivity of all meat animals.

Pigs are considered to be supreme amongst meat producing livestock and are efficient converters of feed to valuable animal protein. Due to its high prolificacy, short generation interval, fast growth rate and other biological advantages pigs can play an important role to make up our animal protein deficiency.

In the above context, pork industry is likely to develop at a rapid rate in India in the coming years, for which concerted efforts are needed to encourage scientific pig rearing by organised farms and rural small scale farmers. The two basic factors needed for achieving maximum production in pigs are : (1) development of a stress resistent group of pigs with maximum adaptation potential to wide varieties of environment and (2) provision of a stress free environment for maximum exploitation of genetic potential of pigs selected for various production traits advantageous to man. There are three basic genetic groups of pigs in our country ie. desi pigs, exotic pigs and a non-standardised cross-bred of these two. Out of this the exotic pigs are now considered comparitively superior to others and seems to have adapted to our agroclimatic conditions. But a clear and composite information on their actual stress resistence and adaptation status and the "cost" they have paid in terms of production for this adaptation process is still lacking. Such an information will be very much useful for chalking out any change, if needed, in the genetic or environmental make up of these animals for achieving the final objective of optimum production status.

It is also of importance to identify individual and combined effect of certain relevant managemental practices in enriching the thermal and physical environment of these animals, which inturn may enhance the comfort and there by the production of these animals. It will be advantageous to both organised and small scale farmers, if we can recommend suitable managemental models for getting maximum benefits from these animals.

Domestic pigs have originated from its wild progenitors who were adapted to often very different environments from those in current animal production systems. Varying degree of amelioration of their genome have occured since domestication in response to selection forces and important genotype - environment interactions do occur which may result in impairment of health and temperament of animals. The long term answer may be to achieve the optimum compromise between changes in the environment and the changes in the genome of the animal. When European breeds of farm animals are introduced to tropical and subtropical countries, they are faced with many problems relating to the hot climate, particularly conditions of heat stress and a vast array of physiological and biochemical changes are induced in such animals. Many of these changes inturn lead to impairment of growth and reproduction. The acceptability of management systems for farm animals has trditionally been dominated by economic considerations. Strongly emerging ethical concerns regarding the quality of life of farm animals demand more serious attention to the animal's psychological properties and social tendancies and morally acceptable housing systems are expected to assure adequate harmoney between the genetic predisposition of farm animals and their overall environment.

Reduction of stress and stress susceptibility in pigs is a pre-requisite for high results and it serves for effective exploitation of the genetic merit in pigs. The degree of thermal strain experienced by a pig during summer in tropics depends on the genetic make up of the animal, degree of acclimatisation, environmental variables and ameliorative housing and management. There are not many reports comparing exotic breeds like Large White Yorkshire with indigenous desi pigs and the available reports indicate a significantly lower growth rate and a higher production cost in indigenous stock when compared to large White Yorkshire pigs(Saseendran and Rajagopalan,1981,1982).

The possibility of using halothane sensitivity test for assessing stress susceptibility in pigs has been investigated extensively and many of the reports support the view that halothane sensitivity is determined by a single autosomal recessive gene(Santher and Murray, 1989;Poltarsky et al.,1990). But a conclusive finding on its relation to productive and reproductive performance is still lacking due to contradictory reports in this respect.

The major quantum of work with respect to stress in pigs has been conducted in the field of meat quality and carcass charecterestics pretaining to the acceptability of meat. The findings in this field also varies considerably so that it may not be possible to say for or against the halothane sensitivity. The removal of halothane gene would lead to minor reduction in lean content and dressing percentage but would benefit at farm meat trade and consumer levels.

The importance of stress factors and stress susceptibility in animal production have been well recognised and extensive research have been conducted in this respect especially in the field of swine husbandry with a multi - disciplinary approach incorporating genetic,biochemical,physiological,production,reproduction,meat quality and ethological elements. Now it has become the task of scientists in production management to develop composite managemental devices using this knowldge for achieving the ultimate target of evolving a stress resistant animal or stress free environment or both, suitable to various agroclimatic conditions.

But most of the reports in this respect are from temperate regions on temperate breeds. As such there is an information gap on the adaptability and potential for production of Desi and acclimatized exotic pigs and their requirement in terms of management and environment modification and enrichment.An investigation on some of these aspects may bring out valuable information in this regard.

Similarly investigations on the incidence of halothane sensitivity in exotic pigs reared for many generations in a tropical environment as well as in Desi pigs and its relation to production performance may be of help in early selection and evolving management strategies.

# 2.REVIEW OF LITERATURE

A study on the effect of enrichment of environment and halothane sensitivity on performance of Large White Yorkshire and desi pigs, is basically centred on two elements of production ie.,"animal" and its"environment". The factors coming under "animal" element are mainly those associated with stress and stress susceptibility in pigs. The external devices which may reduce stress in pigs are the main components of environmental element.

The factors of stress susceptibility in pigs are classified and reviewed under genetic,biochemical,physiological,production,reproduction and ethological factors.

## 2.1:Genetic Factors

Stress susceptibility,halothane sensitivity, porcine stress syndrome (PSS), malignant hyperthermia (MH), and stress induced cardiomyopathy in pigs are now considered to certain extent synonymous and extensive research have been conducted on its genetic etiology.

A cytosine to thiamine mutation in the 1843rd nucleotide in the P11-Q21 segment of the proximal q arm of the 6th chromosome leading to an arginine 615 to cystine 615 change in the calcium release channel protein(ryanodine receptor) in sarcoplasmic reticulum of muscles resulting in a defective calcium release is reported to be the cause of halothane sensitivity in pigs. This trait is autosomal recessive with simple Mendelian inheritance and is fully penetrant in halothane sensitive(nn) pigs and with incomplete penetrance in heterozygous(Nn) pigs and the gene could be fixed in four generations of selection. The NN genotype is reported to be normal and the mutation might have occured in a common founder animal(Santher and Murray,1989;Poltarsky et al.,1990;Otsu et al.,1991;Archibald,1991;Kuryl et al.,1995;Shibata et al.,1994). The gene is reported to have linkage with loci for blood groups, enzyme systems and production charecterestics in pigs which may be used as markers for detecting stress susceptibility(Knyazev and Tikhonov,1989;Vogeli,1989;Zurkowski et al.,1989;Askam et al.,1989; Chowdhary et al.1989;LiLaiJi et al.1996).

Berg and Hausmann(1991) have suggested that a selection for high heart weight would reduce the incidence of

PSS(Stress induced cardiomyopathy). Reports of Gart et al.(1988) states that boars are more resistant to halothane stress than sows.

Incidence of halothane sensitivity and frequency of halothane gene are reported in various breeds of pigs including wild pigs from various regions in an inconsistent manner(Yablanski et al.,1989;Tse et al.,1993;Hilbert et al.,1994; Bancrova et al.,1995; Lundstrom et al.,1995; Russo et al., 1996; LiJiaQi et al.,1996; Horiuchi et al.,1996;Dovc et al.1996; Shibata,1996).

## 2.2.Biochemical Factors

Biochemical factors are considered to be phenotypic indicators of genetic pre-disposition to stress susceptibility in pigs and hence their qualitative and quantitative analysis help as a tool for diagnosis and selection with respect to stress susceptibility.

Nikitchenko et al.(1986) have found a significant difference in the blood content of lactate dehydrogenase(LDH), aspartate amino transferase, alkaline phosphatase(ALP)and cholesterol between halothane positive and halothane negative animals. Janezic et al.(1988) noticed a significantly increased creatine kinase(CK) activity after stress in halothane positive animals than halothane negative and Bulla et al.(1988) have reported that both CK activity and concentration of 17-oxy ketesteroids were significantly more in halothane susceptible animals compared with halothane resistant animals when subjected to halothane test. In this respect no sex difference was noticed by Mailander et al.(1988) and Poltarsky et al.(1989). Later Szilagyl et al.(1989) have found an elevated CK, CK-MB isoenzyme, aldolase(ALD),LDH and c-hydroxy butyrate(cHBDH) activities as an indication of enhanced susceptibility to stressors when tested with halothane and suggested its determination for detecting enhanced stress susceptibility. Accordingly Schakel(1989) has set the value for logCK as 3.1 for susceptibility.Supporting this Frenzel(1989) has found that sows with logCK values less than 2.7 has produced litters with a significantly higher piglet survival rate than sows with higher values.Consequently Schaefer et al(1990) reported that difference in levels of cortisole,creatine,aspartate aminotransferase(AST) and LDH were highly significant between H+ and H- lines with cross breds mostly showing intermediate levels.In addition red blood cell counts and serum protein levels were higher and inorganic phosphorus(Pi) were lower in H+ compared with H- and cross bred animals and hence this approach theoritically could have a significant impact on the removal of pigs causing PSE pork.

Doize et al(1990)have found a higher total aspartate aminotransferase(M-AST and C-AST) in halothane susceptible than in the resistant pigs in body weight group 41-50 and above 70 Kg. Later (1992) they have concluded that because of variation in CK actvities in both stress susceptible and resistant pigs it is difficult to use this as a predictor of stress susceptibility although high activity of CK is predictive of post-slaughter PSE.

Lahucky et al.(1993) have observed that the changes in ATP,CP,Pi and pH were faster in H + than H -ve pigs and hence Warnants(1993) have found that CK and PK were good indicators of halothane genotype; PK being more sensitive. Matthes and Schwerin(1995) also reported that stress susceptible pig has a higher blood CK value than other genotypes.

Yablanski and Zhelyazkov(1988) have found 95.1% accuracy in prediction of Halothane genotype from the blood group enzyme system S blood group(S)-Phosphohexose isomerase(Phi) -Hal- H blood group(H) and Phospho gluco mutase (pgd). More precisely Erhard et al.(1988) have stated that the only markers which could be used with accuracy to identify halothane status were those of H,S and Po2 blood group systems and they have found that a positive halothane reaction was associated with the Ha,Po2S,SS and Ma alleles and the halothane negative with the PHIA/PHIB genotype and the H,Po2F,Ss and M alleles.

Honkavaara(1989) has reported that the stress susceptible(SS) pigs had a higher percentage ($P<0.05$) of linoleic acid and linolenic acid and total polyunsaturated fatty acids in the back fat than stress resistent(SR) pigs. In the intra muscular fat, only percentage of lauric acid and arachidic acid differed ($P<0.05$) between SS and SR pigs and they have concluded that breed type had a greater effect than stress susceptibility on the fatty acid composition of sub-cutaneous and intramuscular fat. Later Otten et al.(1992) have pointed out that stress susceptible (nn) animals had a significantly lower lipid content in the longissimis thoracic muscle and in erythrocytes than stress resistent homozygotes(NN). Significantly higher levels of cholesterol were found in the muscle and erythrocyte of nn pigs and in stress resistant hetero- zygotes(Nn) and the phospholipid content did not differ among genotypes.Confirming this Hartman et al.(1992) have reported that halothane positive pigs showed significantly lower total lipid contents than halothane negative pigs and in general halothane negative pigs had a significantly higher relative amount of saturated fatty acids than halothane positive pigs.

Antanyuk et al.(1990) reported that there was no significant difference in semen traits, enzyme activity and phospholipid concentration in semen between halothane susceptible and resistant boars.

Mickelson et al.(1989) have stated that the rate of calcium release from sarcoplasmic reteculum(SR) of pigs homozygous for the halothane sensitivity gene was approximately twice that of SR from pigs homozygous for the normal allele and they have also suggested that the protein product of this gene is closely associated with and perhaps identical to the SR calcium release channel-ryanodine receptor protein.

Lengerken et al.(1991) have reported that after incubation at 39°C for 45 minutes, biopsy samples of nn pigs had significantly lower pH values than pigs of other genotypes and physical stressing of pigs prior to biopsy also resulted in the same result indicating that muscles of halothane +ve pigs have accelerated energey metabolism.

Schellander et al.(1994) have reported that there was no correlation between growth hormone and ryanodine receptor genotypes in Austrian pig breeds.

## 2.3.Physiological factors

Nyberg et al.(1988) have reported that the halothane gene showed no major influence on concentration of cortisole and corticosteroid binding globulin(CBG) in blood plasms and on glucocorticoid receptor concentrations in muscle cytosole. However the responses of each halothane genotype differed depending on whether or not the pigs had been transported.

Stefanova et al.(1990) have observed that when the East Balkan pigs kept at Standzha were subjected to ACTH stress test(3.5ug Synaethen/kg.body weight),the stress reaction to the test as indicated by hematological parameters was greater in the halothane positive than in the negative pigs and they suggested that the ACTH stress test provides usefull information on stress susceptibility in addition to that provided by the halothane test.

Wolf-Schwerin and Kallweit(1991) studied the stress reactions and performance traits of German Landrace barrows with known halothane genotype, by exposing them sequentially to three types of stress namely 32-34°C for 1hr., injection of 2ml Myostress and 5 minutes on a tread mill at 5-6 day interval. The biochemical studies revealed that halothane susceptible pigs (hh) showed greatest reaction to stress and halothane resistant (HH) pigs the least.

On explaining the physiological mechanisms involved in stress, Einarsson et al. ( 1996 ) have stated that the manifestation of stress , defined as disturbences of homeostasis, are commonly linked to increased activity of hypothalamo-pituitory-adrenal(HPA) axis and the activation of the sympathetic adreno-medullary system. Activation of the HPA system results in the secretion of peptides from the hypothalamus(principally corticotropin releasing hormone) which stimulate the release of B-endorphin and ACTH induces the secretion of corticosteroids from the adrenal cortex which can be seen in pigs exposed to acute physical or physiological stressors.

Gallant et al.(1989) have stated that malignant hyperthermia(MH) results from the presence of halothane sensitivity gene and is charecterised by abnormalities in muscle function. The invivo and invitro expression of this gene in both homozygous and heterozygous condition were studied and on exposure to halothane, isolated muscle bundles from the homozygous halohane sensitive pigs exhibited decreased tetanus tension and increased tetanus half relaxation time and contracture and were clearly distinguished from homozygous normal muscles.The heterozygous and homozygous normal muscles were similar in contractile responses except for the occurence of halothane induced contractures in the heterozygotes. The heterozygous halothane negative pigs did not exihibit the charecterestic signs of an MH episode in response to halothane, although some metabolic responses were significantly altered (eg.increased venous partial pressure of $CO_2$ and arterial and venous $K^+$ concentration). Thus the heterozygous pigs were not MH susceptible but did represent a phenotype distinct from the homozygous normal pigs invitro and invivo. These data provide the first convincing evidence for the expression of the halothane sensitivity gene in heterozygotes.

Fiedler et al.(1993) have revealed that there was a low physiological capacity in muscles of the halothane positive animals indicated by higher diameter of muscle fibres higher numbers of white fibres, lower number of nuclei and number of capillaries per unit of muscle area and higher incidence of angular fibres. According to Davies(1994), Malignant hyperthermia is triggered in some pigs by environmental stress or by administration of inhalation anaesthetic halothane and typical reaction involve muscle stiffness, irregular respiration,acidosis and death,with resulting low intramuscular pH leading to inferior meat quality.

Sather et al.(1990) studied the muscle and rectal temperature response curves to a short term halothane challenge in 8 week old Lacombe piglets with known genotype at the halothane locus, by exposing them to a 4.5% concentration of halothane for up to 5 minutes and found that with each additional substitution of the N (normal) allele with n allele(sensitive) in the NN genotype, the pigs appeared to be progressively less able to cope with halothane challenges as judged by thermal stability.

Reiner et al.(1990)have reported that there was a large increase in ham temperature of halothane positive pigs compared to halothane negative when subjected to halothane test.

Martin et al.(1991) noticed a significant difference in heart rate between individual boars when subjected to tread mill stress and he has suggested this method for selecting stress resistant young breeding boars. Geers et al. (1994) observed line differences between groups of homozygous Halothane positive, negative and heterozygotes with respect to body temperature,heart rate and cortisole.

According to Maak. et al.(1992) the ability of calcium controlling mechanism to maintain homeostasis when exposed to hlothane expressed as an index (the higher values of which indicated greater susceptibility) was higher in nn pigs when compared to NN and Nn pigs.Klont et al.(1994) reported that Dantrolone (a muscle relaxant known to prevent malignant hyperthermia in H + ve pigs) influenced muscle metabolism of all halothane positive genotypes to the same extent leading to higher glycogen and creatine phosphate concentrations and lower lactate and creatine concentrations. Halothane positive pigs had lower glycogen and CP content than halothane negative.

Consequently, Scholz et al.(1995) reported that the changes in muscle metabolism during halothane exposure were much more marked in nn pigs than in other two genotypes.

Otten and Eichinger(1996) reported that the malignant hyperthermia mutation in pigs affected the metabolic pathways of energey metabolism, resulting in higher plasma glucose concentration at rest and higher lipolytic activity under physical load conditions.

## 2.4.Production Factors

Extensive work have been undertaken to assess the relationship between halothane genotype and production performance in pigs. Reinecke and Kalm(1988) have reported a significantly better feed conversion efficiency(FCE) of halothane susceptible Pietrains compared to non-reactors. But Southwood and Mercer(1989) could not find any significant difference in this trait.Koliandr (1988) has reported that the body weight at 184 days of age and daily gain were significantly higher in halothane resistant pigs than halothane susceptible which was later supported by Reik(1989) who have found that halothane negative pigs grow faster than halothane positive pigs. But in contrast to this Rundgren(1988) could find a higher growth rate in reactor pigs. But according to Poltarsky (1989) there was no significant difference in daily gain between halothane positive and halothane negative barrows which was later supported by Fewson et al.(1993).

Blendl et al.(1989) have reported that selection of stress resistant NN halothane genotype animals has resulted in a significant improvement compared with Nn animals in age at the end of fattening and slightly higher daily gain and this was again supported by the findings of Podogaev(1989).

Pfeiffer and Lengerken(1991) in an investigation on the effects of the movement of pigs to different houses during their life cycle on performance have concluded that reduction of stress and stress susceptibility in pigs is a pre-requisite for high results and it serves for effective exploitation of the genetic merit in pigs.

McPhee et al. (1994) have pointed out that the halothane allele reduced appetite, growth rate and food conversion which was later supported by Matthes and

Schwerin(1995). Labroue(1995) identified breed as an important source of variation in feed intake in pigs and differences in feed intake between genotypes at the halothane susceptibility locus are 5-15%

Gueblez et al.(1995) reported that the growth rate was similar for three halothane genotypes, but feed consumption tended to be low in nn pigs. Later Leach et al.(1996) reported a better feed conversion efficiency in halothane gene carrier pigs(Nn) compared with halothane resistant pigs(NN).

According to Dovc et al.(1996), compared with NN and Nn animals ,nn pigs were older at 30,60 and 100 kg. body weight and had lower daily weight gain between 30 and 60 kg.

2.5.Reproduction Factors

Puonti and Schulman(1988) have reported that selection against halothane susceptibility significantly reduced the mortality rate in Landrace and Yorkshire pigs. Later Kojima et al.(1996) identified that heat stress impaired survival of porcine embryos assessed by differences in the number of viable nuclei. But according to Beckova and Holkova(1988) for litter performance traits the differences among the different halothane genotype were nonsignificant.

Wechsler et al.(1991) have reported that on providing a natural and nonstressful surroundings ie.the litters remaining with the dams until the birth of next litters and provision for nest activity and rooting areas, produce sow with an average production of 2.47 litters per year.

Rundgren et al.(1990) have observed that piglet weight at birth and at 9 weeks did not differ among the halothane genotypes. But Angelov and Stoikov(1990) have reported that halothane negative sows had significantly higher conception rate,litter size at birth and at 21 days and litter weight at 21 days and this was later supported by Gart et al.(1992). According to Nystrom and Andersson(1993) Nn sows had higher still - birth rate and lower litter size at weaning than NN sows.Litter weights were lower at 3,6, and 9 weeks of age for Nn than for NN sows.

Observations of Gart et al.(1992) indicated that although halothane negative sows had significantly higher litter size at birth and number of normal piglets per litter,

litter weight at birth, litter size and weight at 21 days of age were not affected by halothane sensitivity in gilts. Later McPhee et al. (1994) have found that the mortality rate was increased by the n allele and its effect on mortality was greater in a selected line in summer while pigs were on road to the abbotoir.

Tse et al.(1993) have reported that in halothane susceptible and resistant sows the number of live born piglets per litter averaged 9.92 and 11.33(P<0.01) and piglet weight at 21 days of age 5.7 and 5.6kg.

Matthes and Schwerin (1995) reported that stress susceptible sows had lower litter size at birth and weaning compared to stress resistant and heterozygous sows.

Einarsson et al.(1996) have stated that stress which may be in the form of social grouping, food deprivation and poor thermoregulation is associated with a decrease in reproductive function.

Lengerken et al.(1988) have noticed that halothane negative boars had a significantly higher ejaculate volume but having no difference in sperm concentration or sperm motility when compared to halothane positive. On the other hand

Antanyuk et al.(1990)have not observed any significant difference in semen traits, conception rate or litter performance of inseminated sows between halothane positive and negative boars.

Gregor and Hardge(1995) observed that boars resistant to malignant hyperthermia (NN genotype) had 22% more spermatozoa and five more insemination dose per ejaculate than susceptible boars(nn).

## 2.6.Meat Quality and Carcass Charecterestics

The major quantum of work with respect to stress in pigs has been conducted in the field of meat quality and carcass charecterestics pretaining to the acceptability of meat.

Sellier et al.(1988) have reported that the final pH of meat was not significantly affected by halothane phenotype. Sehested et al.(1988) have noticed that the halothane gene have a highly significant unfavourable effect on meat colour and weight loss after slaughter and it was associated with a shorter and fatter carcass . Jones et al.(1988) have found that relative to live weight, nn pigs had a significantly higher proportion of carcass and lower proportion of body organs, body fat deposit, alimentary tract and gut fill than NN pigs with Nn pigs in between. The nn pigs had a lower proportion of fat, bone and skin and a higher proportion of lean in their carcass than had NN pigs. This was supported by the findings of Rundgren(1988). According to Beckova and Holkova(1988) the meat quality (pH, meat colour and water binding capacity) was significantly poorer in nn pig than in NN and Nn pigs.

Sencic(1989) reported that halothane positive pigs had a lower pH, meat colour rating and water retention capacity. Blasco and Webb(1989) have suggested that selection for slower reaction to halothane could reduce the stress susceptibility while retaining the advantage of the gene in lean content. Podogaev(1989) indicated that the stress resistant animal had more intramuscular fat, dressing percentage, ham weight,low eye muscle area but the traits such as the solids and protein percentage of lean and some technological traits were better in the susceptible than in the resistant pigs. Mickelenas et al.(1989) have found that the carcass quality was best in stress susceptible pigs which was concurrently supported by the findings of Janciene(1989).

Timofeev and Luk'Yane (1990) have noticed that stress resistant pigs had a significantly lower meat drip loss, a higher meat pH and a better meat colour score than stress susceptible. Boles et al.(1991) have reported that stress susceptibility in pigs decreased the tenderness score and had no effect on intramuscular fat and moisture in the longissimis muscle and in a later work(1992) they have stated that a positive stress classification significantly reduced the juiciness but had no effect on tenderness and flavour.

Hope(1993) argued that the removal of halothane gene would lead to minor reduction in lean content and dressing percentage but would be far out weighted by benefits at farm meat trade and consumer levels. Observations of Olives et al.(1993) showed that all meat quality traits such as muscle pH, electrical conductivity and light scattering, muscle reflectance, muscle protein solubility and intramuscular fat content are affected by halothane sensitivity.

Murray and Jones(1994) have reported that in comparison to NN genotype, pigs of nn genotype had higher warm and cold carcass yield and lean yield of major cuts, but quality of meat was poor. Mixing with other pigs with or without fasting improved the muscle quality in nn and Nn pigs by decreasing the incidence of PSE meat.Gispert et al.(1994) reported that H+ pigs had a higher percentage of carcass lean and lower percentage of subcutaneous and internal fat and significantly higher percentage of ham and lower percentage of ribs and shoulder than H-ve. There was no halothane susceptibility x breed interaction except for the percentage of intramuscular fat and ribs. Dvorak (1994) advocated meat pH value of < 5.8 as a tool to diagnose PSE meat and he found 14% PSE in Large whites and 38% in Landrace.

Rempel et al.(1995) have reported that within breed groups of similar genetic background the ryrl genotype has positive effect on all measures of the amount of fat and leans with associated negative effect on meat quality. According to McPhee and Trout(1995) the n allele had little effect on carcass traits and for lean quality the n allele acted additively to increase acidity, paleness, water loss through drip, centrifugation and cooking and to reduce cured yield. Independantly of the n allele, selection for lean growth increased the incidence of dark firm dry pork.

Matthes and Schwerin(1995) reported that stress susceptible pigs had higher eye muscle area, lower back fat thickness, higher carcass lean content, lower meat pH, higher drip loss, paler meat colours and a lower percentage of intramuscular fat.

Hanset et al.(1995a) have stated that the effects of halothane locus(NN,Nn and nn) related mainly to confirmation, lean percentage or carcass length and pH measurement in eye muscle. The partial expression in the heterozygotes of the effects in confirmation explains why even a single copy of the gene was favoured by selection during the course of breed formation. He has concluded that the nn genotype is a necessary but insufficient condition to make pietrain, the other genes being involved whose action on carcass composition is similar to that of n allele.Lundstrom et al.(1995) reported that pigs which were heterozygous for halothane mutation were leaner and had meat with a higher reflectance value,lower water holding capacity, lower pH, higher protein denaturation and higher shear force value than meat from pigs without halothane mutation. Concurrently Scholz et al.(1995) reported that nn pigs had a significantly large longissimis dorsi volume at 10 kg body weight than Nn and NN pigs.

Pommier(1995) has suggested that although heterozygotes for halothane gene have better FCE, carcass yield and yield of lean meat in the ham than non-carriers, there is an adverse effect on meat colour and water holding capacity which can be controlled by pre-slaughter management. According to Gueblez et al.(1995) nn pigs had lower back fat thickness, higher loin eye area and lean percentage. The halothane genotype had a large effect on pH, colour and water holding capacity of meat with NN pigs being superior. There was marked difference among genotypes for ultimate pH and technological/cooking yield of meat. For most carcass and meat traits the N allele showed a small degree of partial dominance.

Wenzlawowic et al. (1996) stated that measurement of meat pH resulted in significantly more accurate detection of PSE meat than visual appraisal of meat colour or electrical conductivity tests. He also found that pigs with PSE meat had a higher carcass weight and higher percentage of carcass lean than normal pigs. In this respect Santos and Roseiro(1995) advocated a pH of <5.9 and > 6.0 for indicating PSE or DFD condition in pork.

Leach et al.(1996) found that halothane gene carrier(Nn) pigs had higher carcass yields, fat free lean content and commercial lean cut yields, but a higher incidence of PSE than halothane negative(NN) pigs. Jiang Siwen et al.(1996) reported very significant differences between the three RYRI genotypes in lean percentage, pH value, water holding capacity and reflectance. Lean percentage was high and meat quality was poor in RYRITT pigs. This was supported by Dovc et al.(1996) who found a significant effect of RYRI genotype on some fattening traits and that nn pigs had a lower back fat thickness at 100 kg. body weight compared with NN and Nn animals.

Horiuchi et al.(1996) have reported that the meat quality(transmission value, spreadability and colour lightness of the NN genotype was superior to that of nn genotype and that of Nn was between that of NN and nn. The percentage of PSE meat in NN,Nn, and nn samples were 3.3,20, and 80% respectively indicating that meat quality was highly correlated with RYRI genotype in pigs.

## 2.7.Ethological Factors

On studying the behaviour in pigs from three genotypes seggregating at the halothane locus Schaefer et al.(1989) made time lapse vedeo recordings over 24 h. periods on

32 halothane negative (NN) and halothane positive pigs(nn) and on 16 of their progeny(Nn).Ethograms constructed from the tapes revealed that, halothane +ve pigs drank and ate less frequently and spent longer investigating their pen than negative pigs or the progeny(P<0.01). Hal.+ve pigs also slept more frequently in groups and were less aggressive than the other two genotypes(P<0.01). Halothane +ve pigs and the progeny displayed a greater level of neutral/non-aggressive acts, including nose-nose and nose body contact than the progeny. However, when fasted for 24-48 h all genotypes behaved similarily with a low level of most of these behavioural traits. These results suggested that there are differences in behaviour among the three genotypes.

Rundgren et al.(1990) have indicated an inter-action of halothane genotype with sex for agonistic behaviour and he has advised amperozide treatment for decreasing agonistic behaviour in pigs during transportation.

On studying the implications of individual behavioural charecterestics on performnce in pigs, Hessing et al.(1994) reported that behaviour affected daily weight gain, carcass weight, meat percentage, carcass classification and financial benefits. Labroue et al.(1995) observed differences in feeding behaviour with respect to daily feed intake, rate of feed intake and number of meals per day between Large White and Pietrain pigs and these behavioural differences increased as body weight increased.

On analysing the farrowing and suckling behaviour in pigs Roy Choudhury et al.(1995) have found that the position adopted by the sows during farrowing was mostly lateral recumbency, although some sows changed their position to standing before returning to lateral recumbency. Majority of the piglets were born head first and farrowing duration averaged 5h. 8 min. The interval between the birth of scccessive piglets being 5 to 47min. Teat order of the piglets were estblished within 48-72 h. of farrowing. The stronger or earlier born piglets tended to occupy the most anterior teats. The piglets sucked every 40-60 min.the interval being longer at night than day and increasing as lactation progressed. In the first three weeks of life milk intake per suckling averaged 21.6,26.6 and 30g respectively.

## 2.8. Environmental Factors

### 2.8.1. Season

Environmental factors include season, environmental variables like temperature and relative humidity and physical environmental elements consisting of housing system, structures and facilities in the styes and also social environment.

Lee et al.(1993) reported that age at sexual maturity and the percentage of gilts reaching puberty by 300 days of age were significantly lower in hoter than in the cooler months revealing the effect of season on this trait. Bardoloi et al.(1993) have found that birth weight and body weight at different ages from 4-32 weeks were significantly affected by season and year period. According to Yu et al.(1994) the number of piglets born alive, born dead and mummified were significantly different between matings in the hot and cool seasons. The effect of season was lower for adapted strains of pigs when compared to unadapted ones. Shostak and Metodiev(1994) reported that season had significant effect on litter weight at birth and 21 days, the highest and lowest values being for farrowings in autumn and summer respectively.

Falkowski and Groszkowska(1994) reported that interval from weaning to conception was significantly longer in summer than in other seasons.Vazquez et al.(1994) reported that floor type had no significant effect on performance in summer, but pigs in pens with rubber floors had lower daily gain and food consumption . Season of fattening had a significant effect on daily gain, FCE and duration of fattening.

Ray et al.(1994) has found that litter weight at birth was not significantly affected by season, but average weekly weight gain was significantly affected by season, being highest in winter and lowest in summer.A significant genetic group x season interaction for pre-weaning growth rate was also noted in this study.Concurrently Philip and Hughes(1995) could not find any significant effect of season on the timing of gilt puberty. But Kim et al.(1995) found a significant effect of farrowing month and year on age at 30kg and 90 kg body weights, average daily gain, feed conversion and back fat thickness.

According to Baik et al.(1995) the growth rate of pigs born in autumn and winter was significantly higher than that of those born in spring and summer.On reviewing the environmental and seasonal influence on the return to oestrus after weaning in primiparous sows, Prunier et al.(1996) have detected that the weaning to oestrus interval is longer in sows weaned in summer and early autumn than in other seasons and a high ambient temperature may cause anoestrus which may be in part due to reduced feed intake and nutritional defficiency.

According to Sebastian(1992) pigs born in dry season were superior to animals born in rainy season in parameters like growth rate, feed efficiency, average daily gain and carcass charecterestics.

2.8.2.Environmental Variables

Huhn et al.(1995) have reported that even the temperature in the pre-weaning period affected the reproductive traits in pigs.

On studying the summer infertility in foreign pig breeds WuHuaDong(1994) found that, compared with the sows mated at a high ambient temperature(>22.5 °C) than mated at optimum temperature(15-22 °C or low)had an increase in litter size and decrease in the percentage of deformed and weak piglets. Messias et al.(1995) reported that ambient temperature had significant effect on body weight loss of sows and litter daily growth rate.Supporting this view Kuriahara et al.(1996) found that the growth and daily gain in piglets were affected by variation in environmental temperature, but FCE and digestibility were not significantly affected.

2.8.3.Housing System and other Enrichments

Matte(1993) reported that feed conversion tended to be improved by deep litter housing which appears to be linked to the thermal comfort of the animal. But carcass measurements were not affected by stall floor or deep litter.

Lou and Hurnik (1994) have found that an ellipsoid farrowing crate with oval horizontal frame and bowed vertical bars when compared to conventional rectangular crate had lower still birth, better behaviour of sows which permitted easier visual and tactile contact of dams with their piglets and offered piglets better access to the sows teats.

Simonsen(1995) has reported that rearing environment had a significant effect on later behaviour of pigs, but relative growth was not significantly affected by rearing environment.

On comparing the physiological responses of growing Large white boars in three management environments ie. a concrete floored shed, an open space with a concrete floor and an open space with an earthen floor, Fasheun et al.(1994) found that the ambient temperature, RH and solar radiation differed significantly among the environments. Ambient temperature and radiation were significantly higher in third environment in which RH was significantly low. Growth rate of the pigs did not differ significantly among the environments. Mean respiratory rate and rectal temperature were significantly lower in first treatment.

Oldigs et al.(1995) reported that housing pregnant sows in an outdoor system may have some advantages in respect of animal welfare and in general piglet production traits were not markedly affected by housing system. The physiological traits also indicated some advantages for outdoor rearing particularly in respect of skeletal traits and muscle metabolism. Farrowing results tended to be better in outdoor than in indoor system although physiological traits indicated that sows still expressed some stress in outdoor systems.

Earnst and Abramowsky(1993) reported that litter size at birth, number of liveborn piglets weaned were lower for sows under extensive management in a free range when compard to sows managed indoors. For range sows litter size at weaning were lower in winter than in summer.

Weber(1995) indicated that rearing of piglets in litter straw in loose housing barns brought well being and good performance.Honeyman(1995) reported a management intensive system of pig production that relies on straw,the animal's natural behaviour, group housing and a high level of stockmanship with excellent reproductive and growth performance developed by Sweedish pig farmers. But Costa et al.(1995) have found no significant difference between two groups of pigs managed outdoors or indoors with respect to percentage of still births, live born piglets, piglet mortality, piglet birth weight, dam body weight on day 107 of gestation and at weaning, dam's weight_gain during gestation and weight loss during lactation, farrowing interval and the annual number of piglets born and weaned per sow. However, sows managed outdoors in comparison to confined had larger litter at weaning, hevier piglet at 21 days and weaning, a lower body weight at mating, a longer weaning to oestrus interval and higher feed consumption during lactation.

**2.8.4.Social Environment**

Nakamura et al. (1993) has reported that animals in group pens had higher average piglet weight, weaning weight,weaning percentage and shorter age at puberty, inter _ oestrus interval and body weight at service when compared to those in individual pens. Later Hacker et al.(1994) have found that group penning to be the best means for housing young boars with respect to sexual behaviour.

According to Bunger and Schlichting(1995) , a housing environment which provided social contact and free movement of sows gave similar or better results in relation to neonatal behaviour, health, body weight gain and survival of piglets in the suckling period compared with two types of farrowing crates.But the change of housing 10 days after farrowing from farrowing crate to a group housing system resulted in growth retardation of piglets.

Vermeer and Hoofs(1994) found that group size and position of feeding troughs in the pen had no significant effect on final fattening weight, FCE or feed intake which was later supported by the findings of Lembeck et al.(1995) who have reported that housing system with respect to group size had no significant effect on litter size traits, birth weight of piglets,litter weight and body condition.

Wechsler(1994) could not find any significant difference between modified stolba family pens and conventional pens in economic return or labour requirements.

According to Ramakrishnan(1996) social environment enriched with the presence of a boar helps in early onset of oestrus resulting in economic piglet production.

Samples of Large White Yorkshire(LWY) and Desi Pigs belonging to Centre for Pig Production and Research, Mannuthy (CPPR) and AICRP on Pigs, Mannuthy(UPBF) were used for the study. Available production and reproduction data of Pigs from these stations were collected. Similarly environmental data were collected from Department of Agriculture Meteorology, KAU, Vellanikkara for five years(1992-96).

**3.1 Assessment of production performance of LWY and Desi pigs and its relation to environmental variables.**

The production performance of exotic and Desi pigs in UPBF were assessed based on the farm records available for a period of five years (1992-96). Important production and reproduction traits such as litter size and weight at birth, birth weight, litter size and weight at weaning, average weaning weight, pre_weaning and post_weaning mortality, daily weight gain, feed conversion ratio, age and weight at slaughter were collected and subjected to analysis. These traits were compared between breeds. They were also correlated to relevant environmental variables such as average temperature, humidity, rainfall, sunshine and wind speed on monthly and seasonal basis. The classification of season was done as per Somanathan(1980) ie.rainy season from May to November and dry season from December to April.

The depression in performance of exotic LWY pigs was arbitrarily estimated based on two important pedigree traits available(ie.number of piglets born and reared) on the basic stock imported during 1977.

### 3.2. Screening for halothane sensitivity

A sample of 205 apparently healthy weaned piglets (134 LWY and 71 Desi) which were available during the year 1995-96 were screened for halothane sensitivity using the method described by Hall(1976) utilising the facilities available in Department of Surgery, College of Veterinary and Animal Sciences,Mannuthy. The animals were exposed to induction of anaesthesia using halothane B.P.(Fluothane, a product of ICI India Limited, Ennore, Madras_600 057) oxygen mixture at a flow rate of 300ml/min.through a face mask. Concentration of halothane in the mixture was maintained using a Fluotec - 3(Ohmeda, BOC Health Care,Boyle Tec IOL Limited) vapourizer at 3% for the first one minute and reduced to 2.5% subsequently for four minutes and the animals were observed for possible hypersensitivity reactions stipulated by McGrath et al.(1984) and Thurmon and Benson(1987) such as rapid onset of rigidity of limbs and hyperthermia. The animals showing hypersensitivity reactions were classified as halothane positive (H+/Halothane susceptible/stress susceptible) and those which did not show any hypersensitivity reactions were classified as halothane negative(H-/halothane resistant/stress resistant) and the incidence of halothane sensitivity in both LWY and Desi pigs were worked out.

In samples of H+ and H- animals belonging to both breeds, biochemical traits relevant to halothane sensitivity such as lactate dehydrogenase(LDH), creatine kinase(CK), alkaline Phosphatase(ALP), serum total protein, albumin, serum glucose,calcium and haemoglobin were estimated using kinetic methods and photospectrometry.

**3.3.Assessment of effect of enrichment of environment and halothane sensitivity on performance of LWY and Desi pigs.**

Thirty-two halothane screened female weanling pigs each from exotic and desi groups maintained in UPBF were selected in quadruplets within the breed on the basis of litter,sex and live weight. Pigs were dewormed and sprayed against ectoparasites.They were reared as per the managemental practices followed in the Farm.One animal from each breed - quadruplet was allotted at random to one of the four groups. Thus in each group there were eight animals from each breed.

The four groups were again randomly assigned to the four treatments as indicated below.

T1 - Housing in open stye without facility for wallowing or water sprinkling.

T2 - Housing in open stye with facility for wallowing and water sprinkling at hot hours of the day.

T3 - Housing in open stye without facility for wallowing and water sprinkling, but are left out to a shaded range during day time.

T4 - Housing in open stye with facility for wallowing and water sprinkling and are left out to a shaded range during day time.

Each Treatment group was considered as independant trial models of housing and management for both LWY and Desi pigs.

Feed was provided to pigs in all the groups both in the morning and evening and allowed to consume as much as they could within a period of one hour. Drinking water was made available at all times.Growth of pigs was studied by measuring gains in live weight and body dimensions.

When the animals attained slaughter weight (Average 85 kg.-283.5 days age in LWY and 33.25 Kg.-250.9 days age in Desi)two pigs from each group were slaughtered utilising the facilities available at Kerala Agricultural University Meat Technology Unit, Mannuthy to study the carcass charecterestics. The remaining pigs were continued in the experiment and their reproductive performance was studied. The first litter produced by them was retained up to weaning and the performance of the sow and the litter assessed.

The following observations were recorded during the course of experiment.

a.Monthly body weight and the body measurements(Length,height and girth).

b.Feed intake on two days in a week.

c.Rectal temperature, respiration rate and pulse rate at weekly intervals at 2pm.

d.Onset of oestrus.

e.Carcass charecterestics like dressing percentage, back fat thickness,loin eye area,weight of gut,head,feet and internal organs(heart,lungs,diaphragm,liver,spleen and kidney) carcass weight and length.

f.Weight and body measurements of sows 15 days prior to expected day of farrowing, seven days after farrowing and at weaning.

g.Litter traits including litter size and weight at birth and weaning.

h.Birth weight and fortnightly body weights of piglets till weaning at 56 days of age.

The observations on feeding,maternal and female sex behaviour in pigs were quantified by scores as described in Table 3.1 to 3.3(Thomas and Joseph,1994).

Table 3.1. Feeding Behaviour

| Sl.No. | Discription | Score |
|---|---|---|
| 1. | Excitement,restlessness,eagerness,grunting,gnawing, drooling of saliva etc. at feeding | 3 |
| 2. | Moving around in the pen,grunting,drooling saliva etc. | 2 |
| 3. | Quite with casual interest towards feed | 1 |

Table 3.2. Maternal Behaviour

| Sl.No. | Description | Score + | Score - |
|---|---|---|---|
| 1. | Good temperament,docile and confidence on attendant. | 1 | 0 |
| 2. | Teats and udder engorged with milk | 1 | 0 |
| 3. | Early completion of parturition - (3 hrs or less) | 1 | 0 |
| 4. | Early expulsion of placenta -(2.5hrs.or less) | 1 | 0 |
| 5. | Alertness towards safety of piglings | 1 | 0 |
| 6. | Fondling piglings before and after suckling | 1 | 0 |
| 7. | An interval of 90 mts. or less between suckling during first 14 days | 1 | 0 |
| 8. | Steady,progressive and uniform gain in weight of piglings | 1 | 0 |
| 9. | Overlying,biting,injuring and killing the piglings and hostile to attendant | 0 | 1 |
| 10. | Placentophagy | 0 | 1 |

Table 3.3.Female Sex Behaviour

| Sl.No. | Description | Score + | Score - |
|---|---|---|---|
| 1. | Restlessness,excitement,swollen and moist vulva | 1 | 0 |
| 2. | Oestrus grunt and eagerly searching for boar | 1 | 0 |
| 3. | Mounting on other pigs | 1 | 0 |
| 4. | Sniffing and fondling of boar and genitalia | 1 | 0 |
| 5. | Typical mating stance on the first sight of boar and allowing mating without any ill will | 1 | 0 |

The play behaviour was quantified by recording average number of nose to nose or nose to body playful acts per one hour before feeding and the agonistic behaviour was quantified by recording average number of agonistic encounters per one hour at feeding time- both observations being taken along with recording of feed intake two days in a week.

The production and reproduction traits were compared based on breed,enrichment treatments and halothane sensitivity.

The cost of feeding for unit weight of meat and weaned piglet were estimated.On that basis the relative economic efficiency of the four systems of management were compared in both breeds.

The overall performance and the relative productive adaptability of animals in each treatment groups and also those of halothane positive and halothane negative animals, were measured by means of a Composite Sow Index (Thomas and Joseph, 1994; Table 3.4). It was based on the assumption that production and reproduction performance are valid indicators of adaptability ( Smirnov,1991; Pfeiffer and Lengerken, 1991 and Thomas and Joseph, 1994).

Table 3.4. Composite Sow Index

| Trait | Score |
|---|---|
| 1.Average daily gain (in Kg.) | x |
| 2.Feed conversion efficiency | xx |
| 3.Age at first farrowing -12 months | 1 |
| Deduct/add 0.1 point for every one month change | |
| 4.Live litter size at birth - 8 piglets | 1 |
| Deduct/add 0.2 point for every piglet | |
| (maximum suckling piglet limited to number of teats - 7 pairs) | |
| 5.Litter size at weaning -8 piglets | 1 |
| Deduct/add 0.2 point for every piglet | |

| | |
|---|---|
| 6. Live litter weight at birth - 10 kg | 1 |
| Deduct/add 0.2 points for every kg | |
| 7. Litter weight at weaning - 72 kg | 1 |
| Deduct/add 0.2 points for every 10 kg | |

The data collected were statistically analysed as per methods described by Snedecor and Cochran(1967) and results interpretted.

Based on the observations and results suitable management systems with appropriate combinations of environmental enrichments were recommended for both the breeds.

# 4.RESULTS

The results and data obtained during the course of study are summarised in Tables 4.1 to 4.15 and Fig.4.1 to 4.6.

## 4.1.1. Production traits in LWY and Desi pigs

The production and reproduction performance of LWY and Desi pigs maintained in UPBF Mannuthy, expressed as mean ± S.E of relevant traits such as litter size at birth (total and Live),litter weight at birth(live),birth weight, litter size and weight at weaning,average weight at weaning,pre-weaning and post weaning mortality percentage,daily weight gain, feed conversion ratio and age and weight at slaughter are presented in Table 4.1.. The correlation between various traits and environmental variable are graphically depicted in Fig. 4.1. The depression in performance of LWY pigs when compared to basic stock imported during 1977 is graphically presented in Fig. 4.2..

## 4.1.2. Environmental Variables

Monthly averages of environmental variables such as maximum and minimum temperature , rainfall (monthly total), Relative humidity(RH),sunshine,and wind speed are presented in Table 4.2 and its relation to various production traits are graphically depicted in Fig.4.1. The correlation coefficients are furnished in Table 4.2.2.

**4.2. Incidence of Halothane sensitivity**

Out of 205 animals screened(134 LWY and 71 Desi), 59 LWY and 28 Desi were halothane positive and rest were halothane negative.The relative incidence of halothane sensitivity in LWY and Desi pigs are depicted graphically in Fig.4.3.. LWY had higher incidence of sensitivity when compared to Desi pigs.

**4.3. Body weight**

The post-weaning monthly body weights, body weights at different stages of growth and reproduction and average daily weight gain in LWY and Desi pigs reared under treatments T1,T2,T3 and T4 are furnished in Table 4.3. The body weights at all post weaning months/stages and daily weight gain in different treatment groups of LWY were higher than respective figures for Desi.

### 4.4. Body measurements

The post weaning monthly and stage wise body measurements (length,height,girth) of LWY and Desi pigs maintained in different treatment groups are presented in Table 4.4.1 to 4.4.3. The figures for LWY at all stages in various treatment groups were more than that of desi at respective stages and treatment.

### 4.5.Feed intake

The average daily feed intake at grower,breeding and lactating stages and feed conversion efficiency(FCE) in LWY and Desi pigs reared under different treatments are presented in Table 4.5..The variation in FCE between breeds and various treatment groups are depicted graphically in Fig.4.4..The feed intake of LWY pigs at all stages and treatments were higher than that of Desi in the respective stage and treatment.The FCE measured as Feed conversion ratio (FCR) was higher in LWY pigs when compared to desi in all the treatments.

### 4.6.Rectal temperature,respiration rate and pulse rate

The mean rectal temperature,respiration rate and pulse rate of LWY and Desi pigs in different treatment groups are furnished in Table 4.6.Although pulse rate had no significant variation between treatment groups, rectal temperature and respiration rate revealed certain degree of significant variation between treatment groups under same breed.

## 4.7. Reproduction Traits

Age at onset of recognisible oestrus,age at conception,conception rate,age at farrowing and gestation period in LWY and Desi pigs reared under different treatment groups are presented in Table 4.7.The figures for all the traits were higher in LWY when compared to that of Desi in the respective treatments and traits.

## 4.8.Litter Traits and Composite Sow Index

The litter size and weight at birth(live and dead),birth weight,litter size and weight at weaning,average weaning weight and composite sow index in LWY and Desi pigs maintained in various treatment groups are furnished in Table 4.8. The birth weight,litter weight at weaning and average weaning weight revealed significant variation between breeds and treatment groups at varying levels.The composite sow index which may be considered as a measure of productive and reproductive adaptability showed clear variation between treatment groups and breeds which is depicted in Fig.4.5.

### 4.9. Pre_weaning Litter weights and mortality

The pre – weaning fortnightly litter weights,daily weight gain and pre weaning mortality rate in Lwy and Desi pigs of different treatment groups are given in Table4.9.The body weights and weight gain revealed significant difference between breeds and certain treatment groups. The pre-weaning mortality rate was in an increasing order in treatments T3,T1,T2 and T4 with minimum mortality in T3 in the case of LWY and T1,T4,T2, and T3 with minimum mortality in T1 in Desi respectively.

### 4.10. Carcass Traits

The dressing percentage,back fat thickness,loin-eye area,weight of gut and feet, meat bone ratio and weight of internal organs such as lungs,diaphragm,liver spleen and kidney are presented in Table 4.10.For almost all the traits LWY had higher values than that of desi. Significant group differences existed with respect to dressing percentage.

4.11.1. Behaviour

The behavioural scores with respect to ethological factors such as pre-partum and post-partum feeding behaviour,play and agonistic behaviour, female sex behaviour and maternal behaviour of LWY and Desi pigs of different treatment groups are furnished in Table 4.11. Apparently clear difference existed in almost all the behavioural traits.

4.11.2.Cost of Production

The cost of production per kg meat and per kg weaned piglet for LWY and Desi pigs under various treatment groups are prsented in Table 4.11. and are graphically depicted in fig.4.6..The costs of production per kg meat were in the decreasing order of treatments T2>T1>T4>T3 in the case of LWY and T3>T1>T2>T4 in the case of Desi.But the costs of production per kg weaned piglet were in the decreasing order T1>T3>T4>T2 in LWY and T3>T2>T4>T1 in the case of Desi.The cost of production per kg meat was lower in all treatments in LWY when compared to that of Desi in the respective treatments.But the cost of production of per kg weaned piglet in all the treatments in Desi were lower when compared to that of LWY in the respective treatment groups.

## 4.12. Performance of Halothane Positive and Halothane Negative Animals.

The litter size at birth(total and live), Litter weight at birth(live), birth weight,litter size and weight at weaning,average weaning weight, preweaning mortality,daily weight gain, FCR, dry matter digestibility,age at farrowing,dressing percentage and composite sow index of halothane positive and negative animals in LWY and Desi pigs are presented in Table 4.12. An apparently clear variation was seen between breeds and groups in relation to halothane sensitivity especially with respect to litter weight at birth and weaning, daily weight gain,DM digestibility, FCR, age at farrowing and composite sow index.The difference in composite sow index between H+ and H- LWY and Desi pigs is depicted in Fig.4.5.

The total litter size at birth and weaning,daily body weight gain, age at farrowing and FCR of H+ and H- animals of LWY and Desi breeds in different Treatment groups are furnished in Table 4.13..The FCR, age at farrowing, and daily weight gain revealed apparently clear favourable/unfavourable trends in H+ and H- animals especially in LWY.

### 4.13.Biochemical Traits

The biochemical traits such as lactate dehydrogenase(LDH),creatine kinase(CK),alkaline phosphatase(ALP), total protein,serum albumen,glucose,calcium and haemoglobin(Hb) in H+ and H - animals in LWY and Desi pigs are presented in Table 4.14. There were apparently clear trends in most of the traits between groups and breeds especially with respect to CK,LDH and ALP.

### 4.14. Management systems for pigs under various situations.

The management systems developed with different combinations of environmental enrichments, for both LWY and Desi pigs from different genetic group under various considerations and purposes are furnished in Table 4.15.

Table 4.1. Production Traits(Mean ± S.E) in UPBF LWY and Desi herds for the years 1992 - 96

| Breed | LWY | | | | | | Desi | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1992 | 1993 | 1994 | 1995 | 1996 | Mean | 1992 | 1993 | 1994 | 1995 | 1996 | Mean |
| **Trait** | | | | | | | | | | | | |
| Litter size at birth Total | 7.538± 0.224 | 8.110± 0.148 | 7.624± 0.169 | 7.413± 0.227 | 6.703± 0.108 | 7.477± 0.227 | * | * | 5.250± 1.507 | 6.295± 0.574 | 5.897± 0.732 | 5.814± 0.304 |
| Live | 6.766± 0.388 | 7.523± 0.219 | 6.811± 0.288 | 6.695± 0.285 | 6.324± 0.125 | 6.824± 0.195 | | | 4.844± 1.248 | 5.378± 0.718 | 4.897± 0.581 | 5.040± 0.170 |
| Litter wt. at birth (kg ) Live | 9.207± 0.471 | 9.475± 0.281 | 7.927± 0.373 | 8.131± 0.242 | 8.540± 0.201 | 8.656± 0.299 | * | * | 3.665± 0.882 | 3.939± 0.487 | 3.599± 0.512 | 3.734± 0.104 |
| Birth wt.(kg ) | 1.367± 0.019 | 1.243± 0.021 | 1.163± 0.011 | 1.222± 0.021 | 1.352± 0.025 | 1.269± 0.039 | * | * | 0.788± 0.066 | 0.738± 0.010 | 0.723± 0.041 | 0.750± 0.020 |
| Litter size at weaning | 5.902± 0.273+ | 6.514± 0.215 | 5.527± 0.230 | 6.074± 0.191 | 5.418± 0.162 | 5.887± 0.441 | * | * | 3.500± 0.000 | 4.833± 0.507 | 5.222± 0.761 | 4.518± 0.521 |
| Litter weight at weaning(kg ) | 52.512± 2.692 | 58.528± 2.257 | 49.419± 2.461 | 54.984± 1.535 | 47.485± 2.321 | 52.586± 4.391 | * | * | 29.225± 0.000 | 35.247± 3.364 | 31.904± 5.812 | 32.125± 1.742 |
| Average weaning wt.(kg ) | 8.882± 0.147 | 9.003± 0.262 | 8.942± 0.234 | 9.088± 0.194 | 8.725± 0.229 | 8.928± 0.061 | * | * | 8.350± 0.000 | 7.362± 0.159 | 5.922± 0.554 | 7.211± 0.705 |
| Pre weaning mortality ** | 2.724± 0.547 | 1.797± 0.262 | 2.637± 0.532 | 1.866± 0.306 | 3.237± 0.527 | 2.452± 0.274 | * | * | 3.989± 0.093 | 1.405± 0.417 | 1.821± 0.511 | 2.405± 0.801 |
| Post weaning mortality ** | 0.673± 0.172 | 0.746± 0.115 | 1.876± 0.757 | 0.522± 0.080 | 1.055± 0.123 | 0.974± 0.242 | * | 26.230± 0.000 | 9.265± 3.368 | 1.523± 0.331 | 1.823± 0.340 | 9.710± 5.790 |
| Daily weight gain(g) | 214.524± 17.333 | 276.472± 11.144 | 258.125± 13.979 | 233.333± 6.245 | 217.080± 11.141 | 239.907± 11.995 | * | * | * | 142.250± 7.454 | 138.153± 7.165 | 140.202± 2.049 |
| Feed conversion ratio *** 1: | * | * | 7.72 | 5.07 | 5.27 | 6.02± 0.852 | * | * | 7.77 | * | 7.75 | 7.76± 0.010 |
| Slaughter age(months) | 24.932± 3.333 | 24.101± 2.099 | 24.489± 2.513 | 23.788± 2.586 | 22.184± 2.846 | 23.899± 0.470 | * * | * * | * * | 22.292± 1.855 | 16.660± 1.868 | 19.476± 2.816 |
| Slaughter weight(kg) | 101.199± 11.460 | 102.809± 4.544 | 110.207± 6.486 | 95.635± 8.295 | 89.515± 8.548 | 99.873± 3.482 | * | * | * | 72.025± 3.907 | 53.484± 5.398 | 62.755± 9.272 |

*Data not available ** % of average herd strength *** on group basis

Fig.4.1. Environmental Variables and Production Traits

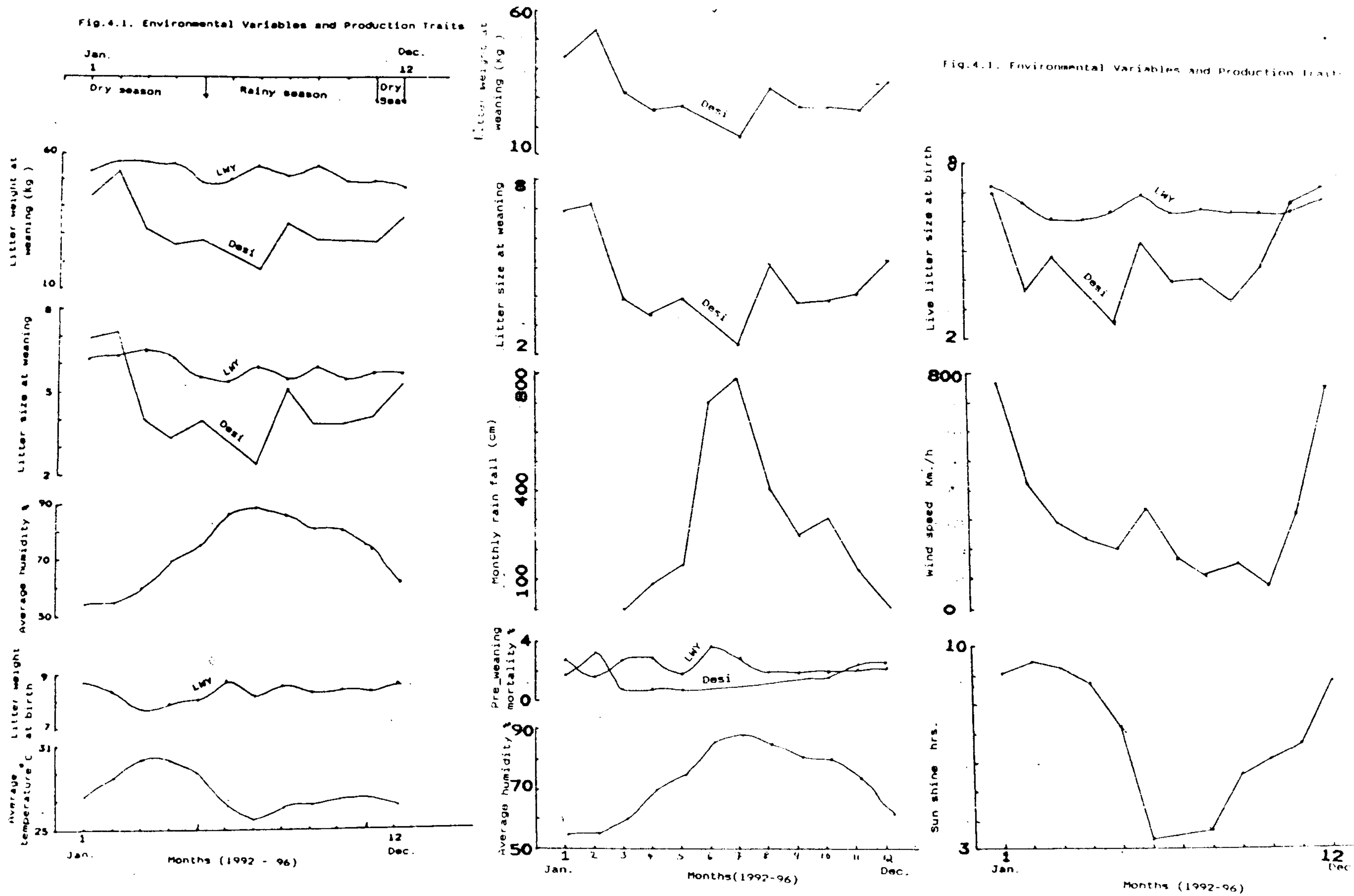


Fig.4.1. Environmental Variables and Production Traits

Table 4.2.1. Environmental Variables

| | Dry season | | | | Rainy season | | | | | | | Dry |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Element | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
| | | | | | Year:1992 | | | | | | | |
| Max. t | 32.6 | 34.5 | 36.9 | 36.3 | 33.8 | 30.1 | 28.8 | 28.9 | 30.1 | 30.7 | 31.0 | 31.1 |
| Min. t | 20.9 | 21.8 | 22.8 | 24.4 | 24.8 | 23.7 | 22.7 | 23.3 | 23.1 | 22.9 | 23.1 | 22.3 |
| Rain | 0.0 | 0.0 | 0.0 | 48.6 | 90.6 | 979.8 | 874.5 | 562.9 | 302.9 | 386.7 | 376.7 | 2.0 |
| RH-1 (%) | 69 | 87 | 84 | 82 | 85 | 92 | 95 | 94 | 91 | 92 | 86 | 72 |
| RH-2 (%) | 36 | 42 | 38 | 48 | 61 | 77 | 80 | 81 | 73 | 72 | 68 | 49 |
| S.Shine h | 9.0 | 9.2 | 9.2 | 8.8 | 7.4 | 3.3 | 2.1 | 2.7 | 4.1 | 4.6 | 5.5 | 8.9 |
| W.spdkm/h | 11.7 | 5.0 | 5.0 | 5.8 | 4.4 | 5.3 | 4.3 | 4.3 | 3.8 | 3.2 | 5.8 | 13.7 |
| | | | | | Year:1993 | | | | | | | |
| Max. t | 32.6 | 34.1 | 35.4 | 34.5 | 34.4 | 30.1 | 28.5 | 29.6 | 30.6 | 30.7 | 31.5 | 31.6 |
| Min. t | 20.7 | 22.0 | 23.7 | 25.0 | 24.8 | 23.9 | 22.9 | 23.4 | 23.1 | 23.4 | 23.6 | 23.1 |
| Rain | 0.0 | 6.6 | 0.0 | 32.1 | 131.1 | 700.3 | 661.6 | 286.7 | 85.3 | 519.0 | 74.6 | 18.0 |
| RH-1 (%) | 71 | 78 | 81 | 83 | 86 | 94 | 93 | 95 | 93 | 91 | 82 | 76 |
| RH-2 (%) | 35 | 42 | 44 | 55 | 61 | 77 | 80 | 78 | 68 | 74 | 64 | 55 |
| S.Shine h | 8.1 | 9.4 | 9.0 | 9.1 | 6.5 | 3.3 | 2.4 | 4.8 | 6.4 | 4.8 | 5.8 | 7.5 |
| W.spdkm/h | 10.0 | 7.8 | 6.0 | 5.0 | 5.0 | 4.5 | 4.6 | 4.5 | 3.8 | 3.6 | 7.4 | 10.5 |
| | | | | | Year:1994 | | | | | | | |
| Max. t | 32.9 | 34.8 | 36.2 | 34.9 | 33.6 | 28.9 | 28.6 | 30.0 | 31.8 | 32.3 | 31.8 | 32.2 |
| Min. t | 22.6 | 23.1 | 23.7 | 24.4 | 24.7 | 22.9 | 22.4 | 22.8 | 23.2 | 22.7 | 23.3 | 22.2 |
| Rain | 19.4 | 1.7 | 21.0 | 165.2 | 124.2 | 955.1 | 1002.1 | 509.2 | 240.5 | 358.2 | 125.3 | 0.0 |
| RH-1 (%) | 74 | 79 | 79 | 88 | 88 | 96 | 96 | 95 | 92 | 92 | 77 | 71 |
| RH-2 (%) | 42 | 38 | 38 | 59 | 61 | 83 | 85 | 75 | 64 | 68 | 58 | 45 |
| S.Shine h | 9.1 | 8.7 | 9.3 | 8.0 | 8.0 | 2.1 | 1.4 | 3.6 | 7.3 | 6.7 | 8.1 | 10.6 |
| W.spdkm/h | 10.5 | 6.3 | 5.6 | 4.3 | 4.5 | 4.2 | 5.0 | 2.1 | 3.5 | 3.4 | 7.9 | 10.1 |
| | | | | | Year:1995 | | | | | | | |
| Max. t | 32.9 | 35.4 | 37.6 | 36.6 | 33.5 | 31.6 | 29.9 | 30.6 | 30.1 | 33.2 | 31.3 | 32.5 |
| Min. t | 22.4 | 23.4 | 23.8 | 24.9 | 23.9 | 23.1 | 23.2 | 23.7 | 23.5 | 23.2 | 22.5 | 21.3 |
| Rain | 0.0 | 0.5 | 2.8 | 118.7 | 370.5 | 500.4 | 884.7 | 448.7 | 282.5 | 110.4 | 88.4 | 0.0 |
| RH-1 (%) | 76 | 79 | 83 | 87 | 91 | 94 | 96 | 94 | 94 | 91 | 91 | 71 |
| RH-2 (%) | 41 | 41 | 37 | 55 | 65 | 77 | 81 | 78 | 70 | 65 | 69 | 43 |
| S.Shine h | 9.6 | 10.0 | 9.3 | 9.1 | 6.5 | 3.7 | 2.1 | 3.7 | 6.1 | 8.3 | 6.5 | 10.3 |
| W.spdkm/h | 9.1 | 6.4 | 4.4 | 4.0 | 3.8 | 10.1 | 1.7 | 2.0 | 2.0 | 1.8 | 1.1 | 6.7 |
| | | | | | Year:1996 | | | | | | | |
| Max. t | 33.1 | 34.7 | 36.4 | 34.6 | 32.8 | 30.5 | 28.8 | 29.1 | 29.2 | 30.1 | 31.5 | 30.5 |
| Min. t | 22.4 | 23.4 | 24.3 | 25.0 | 25.2 | 23.8 | 23.1 | 23.6 | 23.7 | 22.9 | 23.6 | 21.8 |
| Rain | 0.0 | 0.0 | 0.0 | 152.0 | 95.4 | 400.3 | 588.7 | 310.0 | 391.6 | 219.3 | 22.1 | 60.4 |
| RH-1 (%) | 71 | 72 | 82 | 87 | 91 | 94 | 96 | 95 | 94 | 93 | 84 | 80 |
| RH-2 (%) | 35 | 34 | 37 | 59 | 63 | 75 | 83 | 78 | 74 | 70 | 59 | 55 |
| S.Shine h | 9.4 | 9.9 | 9.3 | 8.3 | 7.7 | 4.7 | 2.7 | 3.7 | 4.3 | 6.0 | 7.1 | 6.8 |
| W.spdkm/h | 7.1 | 5.9 | 3.6 | 3.0 | 2.4 | 3.0 | 2.7 | 3.0 | 2.7 | 2.0 | 3.7 | 6.4 |

Table 4.2.2. Correlation Coefficients Between Environmental variables and Performance Traits.

| Performance Traits | Live litter size at birth | | Litter wt. at birth | | Litter size at weaning | | Litter wt. at weaning | | Pre-weaning mortality % | |
|---|---|---|---|---|---|---|---|---|---|---|
| Environmental Variables | LWY | Desi | LWY | Desi | LWY | Desi | LWY | Desi | LWY | Desi |
| Av. Temperature C | -0.431 | -0.507 | -0.578* | -0.496 | +0.562 | +0.137 | +0.287 | +0.255 | -0.091 | +0.194 |
| Av. Humidity % | -0.261 | -0.243 | +0.030 | -0.232 | -0.676* | -0.713** | -0.053 | -0.742** | +0.194 | -0.730** |
| Rainfall | -0.004 | -0.083 | +0.169 | -0.055 | -0.532 | -0.737** | +0.009 | -0.762** | +0.479 | -0.687* |
| Sun shine | -0.047 | +0.035 | -0.186 | +0.022 | +0.618* | +0.645* | +0.044 | +0.692* | -0.300 | +0.687* |
| Wind speed | +0.710** | +0.618* | +0.454 | +0.620* | +0.281 | +0.472 | -0.256 | +0.407 | +0.140 | +0.558 |

** P<0.01 * P<0.05

Fig. 4.2. Deterioration in production performance of LWY Pigs

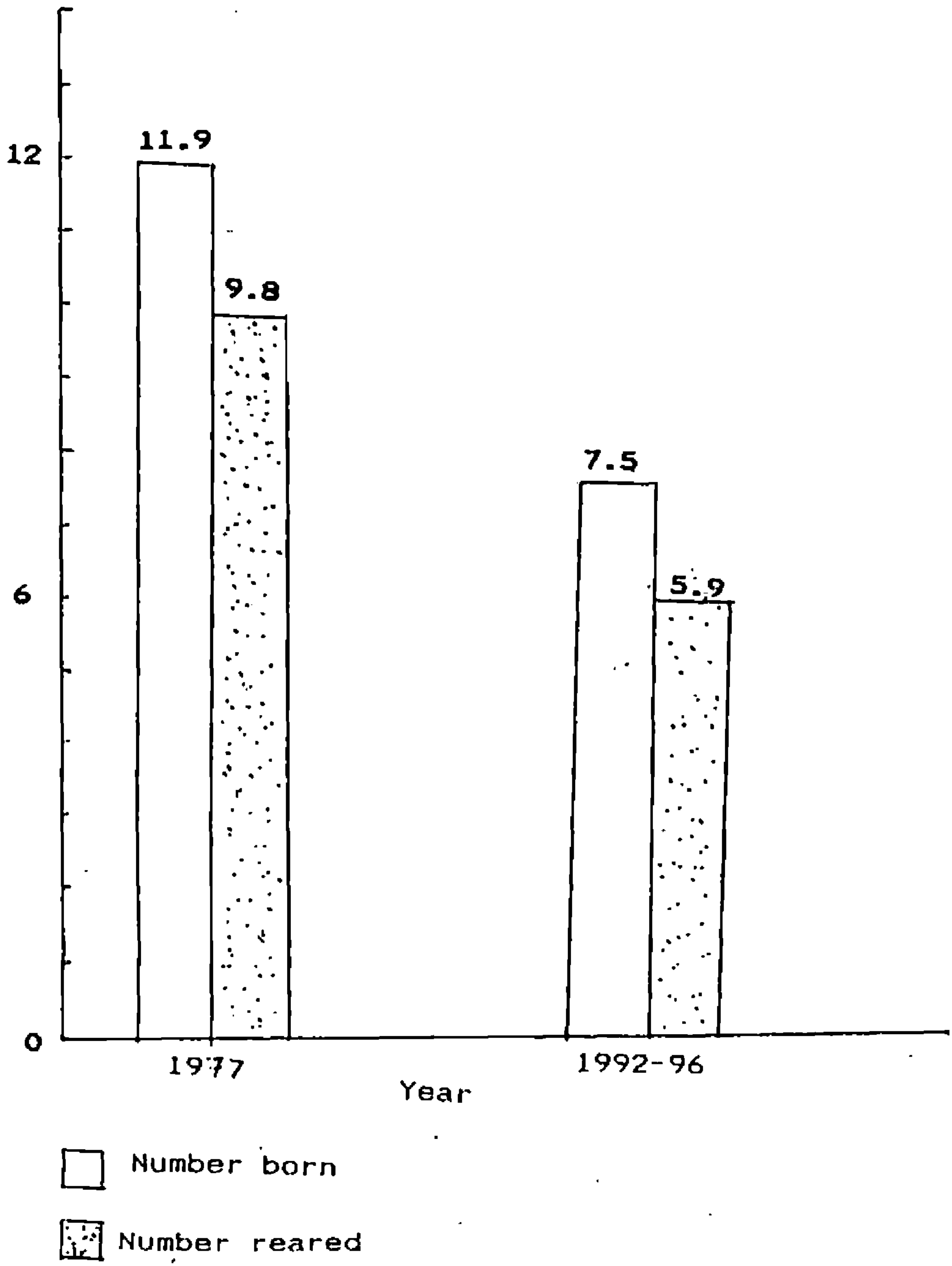

Fig.4.3. Incidence of halothane sensitivity in LWY and Desi Pigs

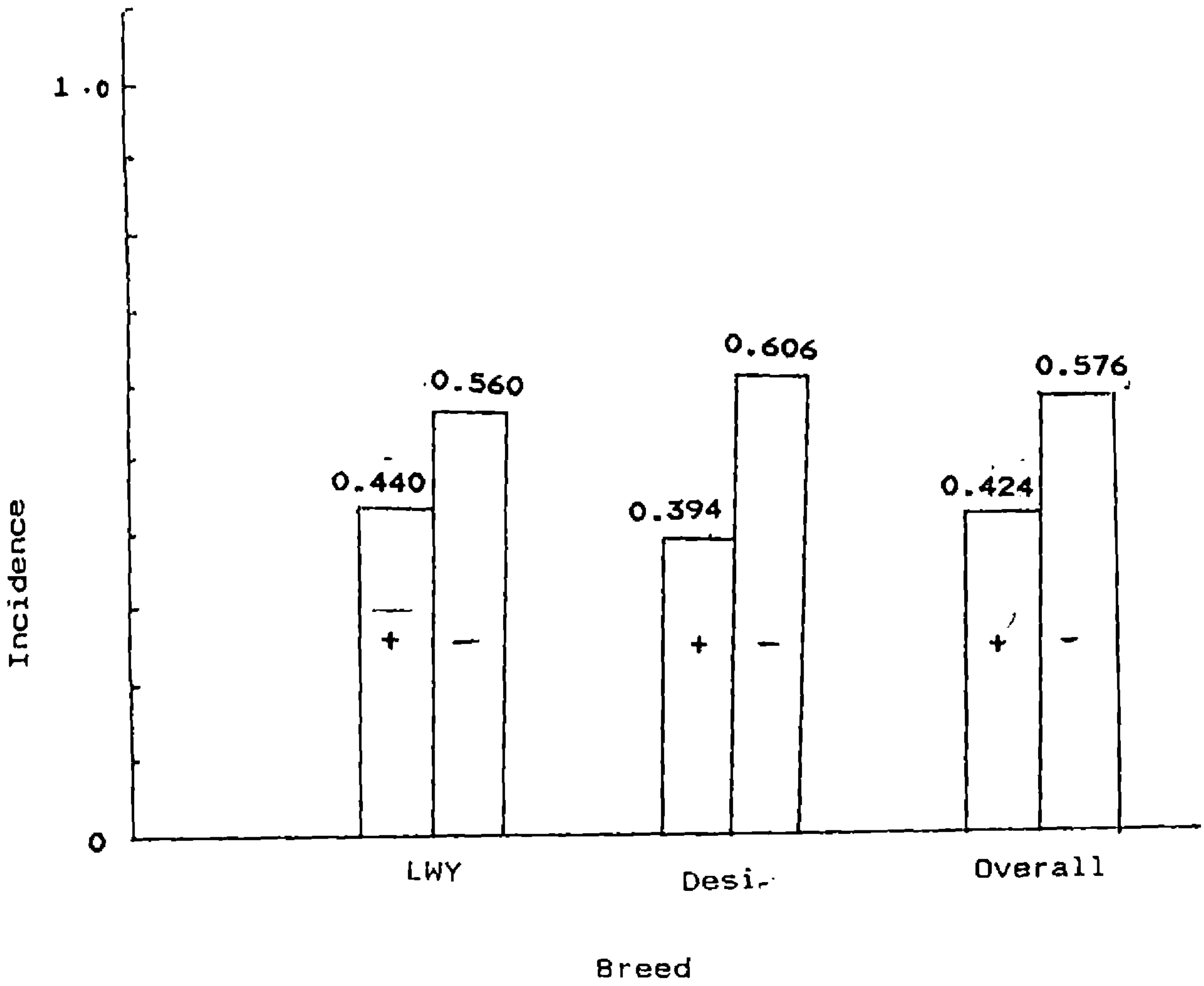

Table 4.3. Mean & S.E. of body weights(kg ) at different stages and weight gain(g) of Large White Yorkshire (LWY) and Desi pigs.

| Breed | LWY | | | | Desi | | | |
|---|---|---|---|---|---|---|---|---|
| Treatments | T1 | T2 | T3 | T4 | T1 | T2 | T3 | T4 |
| Post-weaning month/stage | | | | | | | | |
| I | 11.938±0.458$^{a}$ | 12.063±0.651$^{a}$ | 13.125±0.387$^{a}$ | 12.060±0.504$^{a}$ | 09.688±0.674$^{b}$ | 09.875±0.789$^{b}$ | 09.125±0.516$^{b}$ | 10.188±0.490$^{b}$ |
| II | 15.500±0.714$^{a}$ | 15.625±1.017$^{a}$ | 17.063±1.104$^{a}$ | 15.875±0.761$^{a}$ | 13.375±1.064$^{b}$ | 12.875±1.030$^{b}$ | 12.250±0.824$^{b}$ | 14.375±1.003$^{b}$ |
| III | 21.688±1.243$^{a}$ | 21.625±2.187$^{a}$ | 26.250±2.025$^{a}$ | 23.125±1.079$^{a}$ | 16.375±1.342$^{b}$ | 16.813±1.631$^{b}$ | 16.563±1.605$^{b}$ | 19.063±1.668$^{b}$ |
| IV | 31.875±2.279$^{a}$ | 30.250±3.913$^{a}$ | 36.813±3.210$^{a}$ | 33.938±2.164$^{a}$ | 20.188±1.461$^{b}$ | 21.813±1.950$^{b}$ | 21.313±2.086$^{b}$ | 23.438±2.512$^{b}$ |
| V | 42.813±3.752$^{a}$ | 41.060±6.571$^{a}$ | 49.000±5.035$^{a}$ | 46.813±3.885$^{a}$ | 25.063±1.627$^{b}$ | 26.688±2.297$^{b}$ | 26.813±2.192$^{b}$ | 28.563±3.412$^{b}$ |
| Stage I * | 108.000±6.684$^{a}$ | 116.500±5.679$^{a}$ | 117.833±10.517$^{a}$ | 119.900±7.875$^{a}$ | 64.667±5.897$^{b}$ | 57.333±8.686$^{b}$ | 46.400±3.296$^{b}$ | 62.500±5.844$^{b}$ |
| Stage II * | 95.000±3.764$^{a}$ | 98.500±4.942$^{a}$ | 96.000±9.793$^{a}$ | 98.200±7.235$^{a}$ | 52.333±5.175$^{b}$ | 49.667±8.253$^{b}$ | 42.400±4.445$^{b}$ | 52.400±5.250$^{b}$ |
| Stage III * | 86.500±6.198$^{a}$ | 86.625±6.190$^{a}$ | 100.167±7.597$^{a}$ | 89.500±8.983$^{a}$ | 41.000±6.110$^{b}$ | 45.667±12.441$^{b}$ | 39.200±5.208$^{b}$ | 50.400±2.909$^{b}$ |
| Daily weight gain(g) | 253.074±31.767$^{a}$ | 237.705±49.534$^{a}$ | 294.057±40.775$^{a}$ | 284.836±31.140$^{a}$ | 124.488±10.787$^{b}$ | 137.807±16.739$^{b}$ | 144.98±14.757$^{b}$ | 150.615±24.846$^{b}$ |

* Stage I = 15 days prior to expected date of farrowing
Stage II = 7 days after farrowing
Stage III= at weaning

Figures having different superscripts in a row varies significantly(P<0.01).

Table 4.4.1. Mean and S.E. of body length(cm) of LWY and Desi pigs at different stages.

| Breed | LWY | | | | Desi | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment groups | T1 | T2 | T3 | T4 | T1 | T2 | T3 | T4 |
| Post_weaning month/stage | | | | | | | | |
| I | 47.25+ 0.62 $^{a}$ | 46.75+ 1.39 $^{a}$ | 46.13+ 0.64 $^{a}$ | 45.75+ 1.05 $^{a}$ | 34.25+ 0.84 $^{m}$ | 33.63+ 0.80 $^{m}$ | 34.44+ 0.44 $^{m}$ | 35.43+ 0.43 $^{m}$ |
| II | 54.63+ 0.60 $^{a}$ | 53.00+ 1.21 $^{a}$ | 51.50+ 0.68 $^{a}$ | 52.25+ 1.03 $^{a}$ | 40.00+ 1.35 $^{m}$ | 39.63+ 1.50 $^{m}$ | 39.50+ 0.98 $^{m}$ | 41.31+ 1.55 $^{m}$ |
| III | 59.13+ 1.84 $^{a}$ | 57.88+ 1.79 $^{a}$ | 57.39+ 1.21 $^{a}$ | 59.50+ 1.50 $^{a}$ | 50.00+ 1.90 $^{m}$ | 50.50+ 1.31 $^{m}$ | 48.385+ 1.52 $^{m}$ | 52.12+ 2.28 $^{m}$ |
| IV | 63.00+ 1.80 $^{a}$ | 64.13+ 2.85 $^{a}$ | 62.88+ 2.68 $^{a}$ | 64.38+ 2.52 $^{a}$ | 57.75+ 2.74 $^{a}$ | 58.25+ 1.79 $^{a}$ | 55.13+ 2.03 $^{a}$ | 58.87+ 1.63 $^{a}$ |
| V | 69.88+ 2.49 $^{a}$ | 72.50+ 2.65 $^{a}$ | 66.64+ 2.67 $^{a}$ | 68.00+ 2.41 $^{a}$ | 60.63+ 2.49 $^{m}$ | 62.00+ 1.97 $^{m}$ | 58.38+ 1.98 $^{m}$ | 62.00+ 1.55 $^{m}$ |
| Stage I | 89.00+ 3.21 $^{a}$ | 87.75+ 0.75 $^{a}$ | 87.00+ 3.70 $^{a}$ | 91.30+ 3.02 $^{a}$ | 69.00+ 1.538 $^{m}$ | 67.50+ 2.26 $^{m}$ | 62.70+ 2.06 $^{m}$ | 68.40+ 2.41 $^{m}$ |
| Stage II | 90.63+ 4.89 $^{a}$ | 88.50+ 1.19 $^{a}$ | 88.17+ 3.67 $^{a}$ | 91.50+ 3.19 $^{a}$ | 70.00+ 1.26 $^{m}$ | 68.33+ 2.83 $^{m}$ | 63.10+ 2.11 $^{m}$ | 69.30+ 3.11 $^{m}$ |
| StageIII | 94.75+ 4.46 $^{a}$ | 90.00+ 1.47 $^{a}$ | 92.83+ 3.40 $^{a}$ | 93.00+ 3.21 $^{a}$ | 70.33+ 1.33 $^{m}$ | 69.00+ 2.52 $^{m}$ | 63.60+ 1.91 $^{m}$ | 70.20+ 2.96 $^{m}$ |

Figures having different superscript in a row vary significantly ($P<0.01$). For stage III $P<0.05$.

Table 4.4.2. Mean and S.E. of body height(cm) of LWY and Desi pigs at different stages.

| Breed | LWY | | | | Desi | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment groups | T1 | T2 | T3 | T4 | T1 | T2 | T3 | T4 |
| Post-weaning month/stage | | | | | | | | |
| I | 29.63+ 1.18$^{b}$ | 32.00+ 0.54$^{b}$ | 29.38+ 0.89$^{b}$ | 30.75+ 0.49$^{b}$ | 22.94+ 0.45$^{n}$ | 22.44+ 0.27$^{n}$ | 22.25+ 0.44$^{n}$ | 22.68+ 0.50$^{n}$ |
| II | 35.00+ 1.23$^{b}$ | 36.88+ 0.93$^{b}$ | 34.38+ 1.09$^{b}$ | 34.25+ 0.59$^{b}$ | 27.38+ 1.09$^{n}$ | 26.81+ 1.32$^{n}$ | 26.31+ 1.12$^{n}$ | 26.68+ 1.44$^{n}$ |
| III | 39.88+ 1.46$^{b}$ | 42.13+ 2.03$^{b}$ | 41.50+ 1.2$^{b}$ | 41.38+ 1.09$^{b}$ | 36.00+ 1.35$^{n}$ | 37.19+ 1.47$^{n}$ | 35.75+ 1.65$^{n}$ | 36.50+ 2.19$^{n}$ |
| IV | 45.75+ 1.97$^{b}$ | 46.38+ 2.43$^{b}$ | 45.25+ 1.68$^{b}$ | 47.38+ 1.18$^{b}$ | 41.44+ 1.60$^{b}$ | 44.38+ 1.78$^{b}$ | 41.37+ 1.69$^{b}$ | 42.12+ 1.24$^{b}$ |
| V | 52.38+ 2.64$^{b}$ | 53.63+ 2.95$^{b}$ | 49.00+ 2.04$^{b}$ | 53.63+ 1.38$^{b}$ | 43.38+ 1.28$^{n}$ | 47.00+ 1.52$^{n}$ | 44.25+ 1.13$^{n}$ | 44.93+ 1.12$^{n}$ |
| Stage I | 63.00+ 0.71$^{b}$ | 68.25+ 1.38$^{b}$ | 67.83+ 1.92$^{b}$ | 66.60+ 1.33$^{b}$ | 49.50+ 3.82$^{n}$ | 51.83+ 3.44$^{n}$ | 47.40+ 0.60$^{n}$ | 48.00+ 2.05$^{n}$ |
| Stage II | 64.00+ 0.58$^{b}$ | 70.00+ 1.41$^{b}$ | 68.33+ 2.11$^{b}$ | 67.60+ 1.29$^{b}$ | 50.00+ 3.55$^{n}$ | 52.33+ 3.18$^{n}$ | 47.90+ 0.40$^{n}$ | 49.30+ 2.42$^{n}$ |
| Stage III | 65.25+ 1.11$^{b}$ | 71.00+ 1.00$^{b}$ | 69.50+ 1.96$^{b}$ | 68.00+ 1.30$^{b}$ | 50.67+ 3.84$^{n}$ | 53.50+ 2.26$^{n}$ | 48.30+ 0.37$^{n}$ | 50.40+ 2.38$^{n}$ |

Figures having different superscript in a row vary significantly ($P<0.01$). For stage III $P<0.05$.

Table 4.4.3. Mean and S.E. of body girth* (cm) of LWY and Desi pigs at different stages.

| Breed | LWY | | | | Desi | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment groups | T1 | T2 | T3 | T4 | T1 | T2 | T3 | T4 |
| Post-weaning/ month/stage | | | | | | | | |
| I | 50.88+ 1.13$^{c}$ | 49.38+ 1.24$^{c}$ | 50.25+ 1.39$^{c}$ | 48.13+ 1.22$^{c}$ | 44.50+ 0.66$^{p}$ | 44.75+ 0.37$^{p}$ | 43.25+ 0.75$^{p}$ | 44.43+ 0.74$^{p}$ |
| II | 59.63+ 1.07$^{c}$ | 56.00+ 1.36$^{c}$ | 57.38+ 1.39$^{c}$ | 55.63+ 1.28$^{c}$ | 48.25+ 0.80$^{p}$ | 48.19+ 0.52$^{p}$ | 47.25+ 0.95$^{p}$ | 49.31+ 1.36$^{p}$ |
| III | 64.88+ 1.48$^{c}$ | 63.88+ 2.97$^{c}$ | 67.50+ 2.08$^{c}$ | 63.75+ 1.73$^{c}$ | 55.13+ 1.59$^{p}$ | 55.00+ 1.67$^{p}$ | 53.75+ 1.65$^{p}$ | 57.25+ 2.24$^{p}$ |
| IV | 70.38+ 1.84$^{c}$ | 68.88+ 3.67$^{c}$ | 73.75+ 2.99$^{c}$ | 71.38+ 1.82$^{c}$ | 62.38+ 2.37$^{c}$ | 63.13+ 2.64$^{c}$ | 61.37+ 2.23$^{c}$ | 63.62+ 2.61$^{c}$ |
| V | 80.00+ 2.68$^{c}$ | 78.00+ 3.71$^{c}$ | 81.00+ 3.81$^{c}$ | 80.50+ 2.46$^{c}$ | 70.50+ 2.38$^{p}$ | 67.25+ 2.37$^{p}$ | 67.75+ 2.76$^{p}$ | 68.25+ 2.06$^{p}$ |
| Stage I | 120.00+ 3.11$^{c}$ | 118.50+ 2.60$^{c}$ | 118.83+ 2.60$^{c}$ | 118.60+ 3.17$^{c}$ | 102.33+ 4.33$^{p}$ | 107.00+ 4.58$^{p}$ | 91.60+ 3.72$^{p}$ | 104.80+ 5.58$^{p}$ |
| Stage II | 111.75+ 3.17$^{c}$ | 109.25+ 1.65$^{c}$ | 113.50+ 3.77$^{c}$ | 110.00+ 2.90$^{c}$ | 94.33+ 6.89$^{p}$ | 99.67+ 6.17$^{p}$ | 87.40+ 4.05$^{p}$ | 95.80+ 3.92$^{p}$ |
| Stage III | 105.75+ 4.87$^{c}$ | 104.00+ 2.68$^{c}$ | 109.00+ 3.60$^{c}$ | 103.40+ 4.36$^{c}$ | 84.67+ 4.48$^{p}$ | 88.33+ 10.17$^{p}$ | 85.50+ 4.31$^{p}$ | 88.60+ 1.08$^{p}$ |

Figures having different superscript in a row vary significantly ($P<0.01$). For stage III $P<0.05$. * chest girth

Table.4.5.Average daily feed intake(kg) at different stages and Feed Conversion Efficiency (FCE) of Large White Yorkshire and Desi Pigs.

| Breed | LWY | | | | Desi | | | |
|---|---|---|---|---|---|---|---|---|
| Treatments | T1 | T2 | T3 | T4 | T1 | T2 | T3 | T4 |
| Stages I | 1.280 | 1.319 | 1.074 | 1.249 | 1.053 | 1.100 | 1.050 | 1.104 |
| Stage II | 2.901 | 2.967 | 2.852 | 2.850 | 1.321 | 1.393 | 1.241 | 1.301 |
| Stage III | 3.091±0.162 [a] | 3.004±0.242 [a] | 3.191±0.125 [a] | 2.972±0.048 [a] | 1.745±0.137 [b] | 1.683±0.103 [b] | 1.946±0.056 [b] | 1.575±0.116 [b] |
| FCR(Stage I)1: | 5.059 | 5.542 | 3.653 | 4.398 | 8.492 | 7.971 | 7.241 | 7.311 |
| FCE | 0.198 | 0.180 | 0.274 | 0.227 | 0.118 | 0.125 | 0.138 | 0.137 |

Stage I :Grower stage (weaning to 5 months post_weaning on group basis)
Stage II :Breeding stage (5 months post-weaning to 7 days prior to farrowing on group basis)
Stage III:Lactation stage (farrowing to weaning at 56 days of farrowing - individual feed intake).
Figures having different superscript in a row varies significantly($P<0.01$).

Fig.4.4. Feed conversion efficiency in LWY and Desi Pigs

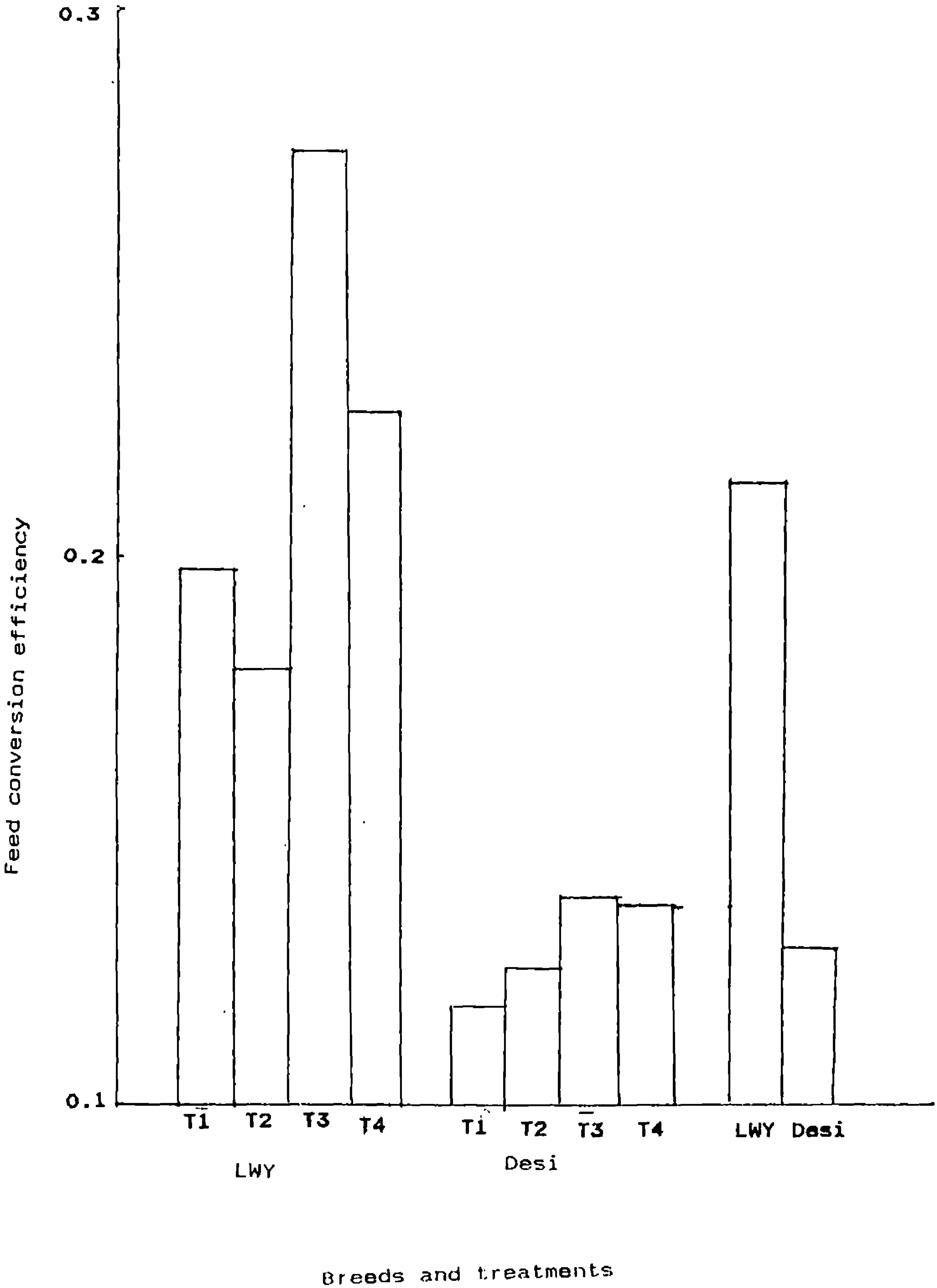

Table 4.6. Mean & S.E. of Rectal Temperature, Respiration rate and Pulse rate of Large White Yorkshire (LWY) and Desi Pigs

| Breed | LWY | | | | Desi | | | |
|---|---|---|---|---|---|---|---|---|
| Treatments | T1 | T2 | T3 | T4 | T1 | T2 | T3 | T4 |
| Rectal Temperature ($^{\circ}C$) | $38.228^{a}$ ± 0.092 | $37.760^{b}$ ± 0.047 | $38.242^{a}$ ± 0.053 | $37.836^{b}$ ± 0.062 | $38.162^{a}$ ± 0.130 | $37.672^{b}$ ± 0.055 | $38.139^{a}$ ± 0.058 | $37.721^{b}$ ± 0.087 |
| Respiration rate/min. | $46.526^{a}$ ± 0.814 | $42.771^{b}$ ± 0.464 | $46.964^{a}$ ± 0.630 | $45.484^{a}$ ± 0.883 | $46.616^{a}$ ± 0.711 | $43.901^{b}$ ± 0.720 | $46.038^{a}$ ± 0.431 | $43.153^{b}$ ± 0.837 |
| Pulse rate/min. | $66.878^{a}$ ± 0.681 | $65.219^{a}$ ± 0.537 | $67.394^{a}$ ± 0.665 | $66.113^{a}$ ± 0.634 | $66.444^{a}$ ± 0.820 | $64.541^{a}$ ± 0.689 | $65.132^{a}$ ± 0.644 | $64.134^{a}$ ± 0.655 |

Figures having different superscript in a row varies significantly ($P<0.01$)

Table 4.7. Reproduction Traits in Large White Yorkshire and Desi Pigs

| Breed | LWY | | | | Desi | | | |
|---|---|---|---|---|---|---|---|---|
| Treatments | T1 | T2 | T3 | T4 | T1 | T2 | T3 | T4 |
| **Trait** | | | | | | | | |
| Onset of recogn_isable oestrus(age in days mean+S.E) | $308.50 \pm 15.95^{a}$ | $318.80 \pm 21.16^{a}$ | $284.57 \pm 18.28^{ac}$ | $287.60 \pm 6.69^{ac}$ | $213.63 \pm 10.93^{b}$ | $195.50 \pm 19.22^{b}$ | $199.38 \pm 12.60^{b}$ | $239.80 \pm 26.89^{bc}$ |
| Age at Conception (days, mean+S.E.) | $313.25 \pm 14.15^{ac}$ | $311.75 \pm 25.76^{acd}$ | $319.17 \pm 20.26^{ac}$ | $315.20 \pm 20.97^{ac}$ | $218.00 \pm 15.28^{b}$ | $254.00 \pm 17.62^{bd}$ | $195.00 \pm 13.94^{b}$ | $261.80 \pm 23.58^{bc}$ |
| Conception rate | 0.667 | 0.667 | 1.000 | 1.000 | 0.600 | 0.500 | 0.833 | 0.833 |
| Age at farrowing (days,mean+S.E.) | $427.25 \pm 14.27^{ac}$ | $428.00 \pm 25.34^{ac}$ | $434.00 \pm 20.36^{a}$ | $429.20 \pm 20.80^{ac}$ | $331.33 \pm 16.05^{b}$ | $368.00 \pm 17.90^{bc}$ | $307.80 \pm 14.29^{bb}$ | $375.21 \pm 23.92^{c}$ |
| Gestation period (days) | $114.00 \pm 0.41^{a}$ | $116.25 \pm 0.48^{a}$ | $114.83 \pm 0.87^{a}$ | $114.00 \pm 0.45^{a}$ | $113.33 \pm 0.88^{a}$ | $114.00 \pm 0.58^{a}$ | $112.80 \pm 0.97^{a}$ | $113.40 \pm 0.75^{a}$ |

Figures having different superscript in a row varies significantly ($P<0.01$)

Table 4.8 Litter Traits and Composite Sow Index in LWY and Desi Pigs

| Breed | LWY | | | | Desi | | | |
|---|---|---|---|---|---|---|---|---|
| Treatments | T1 | T2 | T3 | T4 | T1 | T2 | T3 | T4 |
| **Trait** | | | | | | | | |
| Litter size at birth live | 4.75±1.11 $^{a}$ | 5.75±1.49 $^{a}$ | 4.83±1.05 $^{a}$ | 6.60±1.12 $^{a}$ | 7.67±0.88 $^{a}$ | 9.00±1.00 $^{a}$ | 5.80±1.24 $^{a}$ | 8.50±1.44 $^{a}$ |
| dead | 1.00±0.71 $^{a}$ | 0.00±0.00 $^{a}$ | 1.17±0.31 $^{a}$ | 0.20±0.20 $^{a}$ | 0.00±0.00 $^{a}$ | 2.33±0.79 $^{a}$ | 0.00±0.00 $^{a}$ | 1.20±0.83 $^{a}$ |
| Litter weight at birth -live(kg) | 5.875±1.352 $^{a}$ | 9.815±2.927 $^{a}$ | 8.180±2.153 $^{a}$ | 10.112±1.452 $^{a}$ | 4.900±0.208 $^{a}$ | 7.350±0.650 $^{a}$ | 3.630±0.806 $^{a}$ | 6.690±0.932 $^{a}$ |
| Dead(kg) | 2.050±1.450 $^{a}$ | 0.000±0.000 $^{a}$ | 1.920±0.450 $^{a}$ | 1.500±1.500 $^{a}$ | 0.000±0.000 $^{a}$ | 2.400±0.000 $^{a}$ | 0.000±0.000 $^{a}$ | 3.000±0.000 $^{a}$ |
| Birth weight live(kg) | 1.229±0.043 $^{a}$ | 1.614±0.129 $^{a}$ | 1.656±0.152 $^{a}$ | 1.586±0.097 $^{a}$ | 0.662±0.103 $^{b}$ | 0.819±0.019 $^{b}$ | 0.611±0.057 $^{b}$ | 0.802±0.032 $^{b}$ |
| Dead(kg) | 1.284±0.083 $^{a}$ | 0.000±0.000 | 1.340±0.132 $^{a}$ | 1.500±0.000 $^{a}$ | 0.000±0.000 | 0.343±0.000 $^{b}$ | 0.000±0.000 | 0.500±0.000 $^{b}$ |
| Litter size at weaning | 4.50±1.32 $^{a}$ | 4.50±1.56 $^{a}$ | 4.50±1.18 $^{a}$ | 5.00±0.89 $^{a}$ | 7.00±1.00 $^{a}$ | 5.00±2.65 $^{a}$ | 3.80±0.86 $^{a}$ | 5.60±1.50 $^{a}$ |
| Litter weight at weaning(kg) * | 31.925±7.755 $^{a}$ | 50.000±3.884 $^{bc}$ | 38.200±7.804 $^{a}$ | 43.600±5.682 $^{ac}$ | 33.533±2.122 $^{a}$ | 32.200±1.901 $^{a}$ | 18.660±3.861 $^{d}$ | 36.800±3.730 $^{a}$ |
| Average weaning weight (kg) | 8.154±1.314 $^{a}$ | 7.939±1.318 $^{a}$ | 9.487±0.864 $^{a}$ | 8.450±0.851 $^{a}$ | 4.924±0.468 $^{b}$ | 4.096±0.286 $^{b}$ | 5.430±0.784 $^{b}$ | 5.269±0.154 $^{b}$ |
| Composite Sow Index | 2.450 | 3.818 | 3.168 | 3.912 | 3.342 | 3.463 | 2.083 | 3.788 |

Figures having different superscript in a row differ significantly ($P<0.01$). * $P<0.05$

Fig.4.5. Composite Sow Index in LWY and Desi Pigs

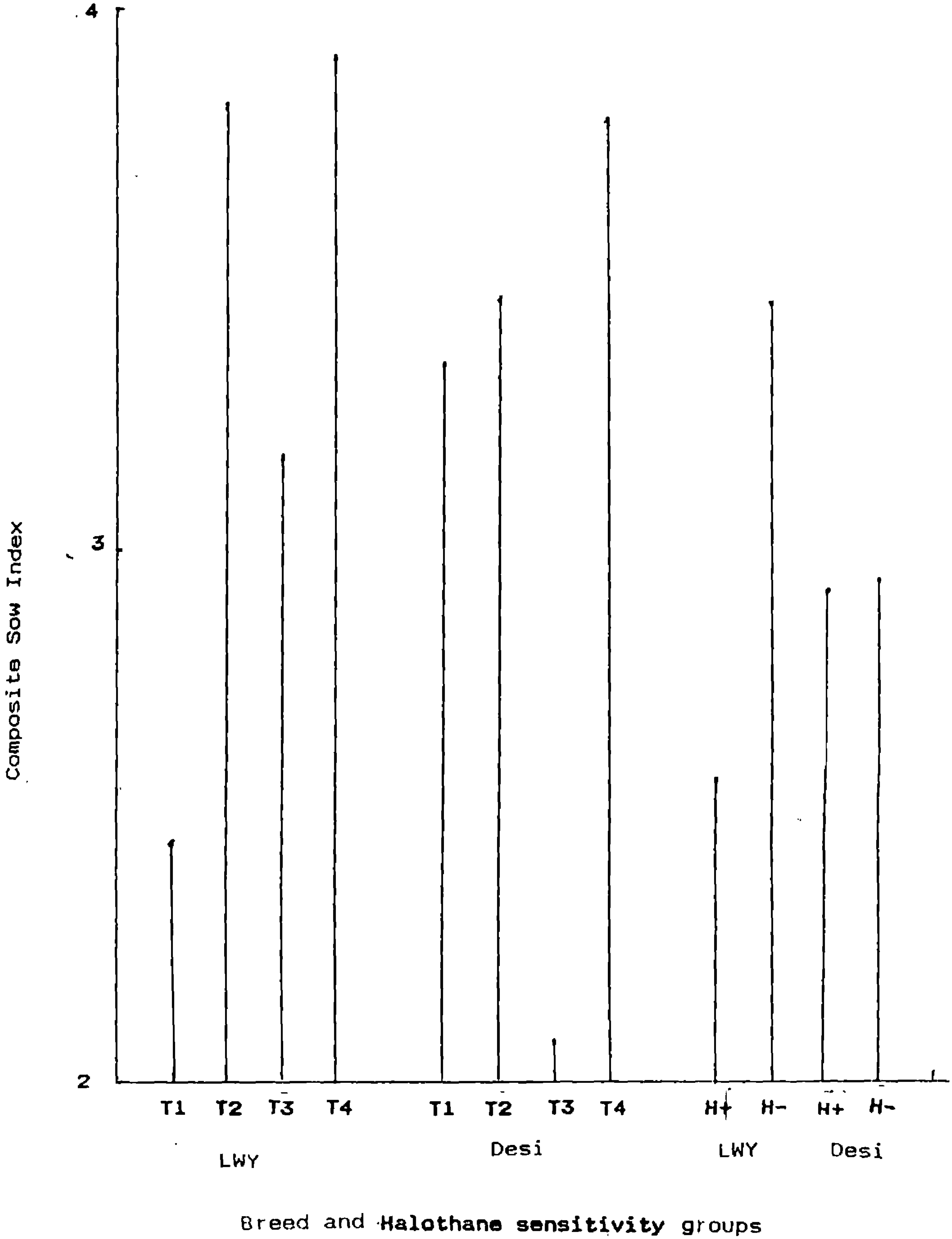

Table 4.9. Mean & S.E. of Pre_weaning fortnightly litter weights (Kg.) and daily weight gain & Mortality(%) of Large White Yorkshire and Desi Pigs

| Breed | LWY | | | | Desi | | | |
|---|---|---|---|---|---|---|---|---|
| Treatments | T1 | T2 | T3 | T4 | T1 | T2 | T3 | T4 |
| Fortnight | | | | | | | | |
| I | $16.725^{a} \pm$ 4.921 | $30.167^{bc} \pm$ 2.956 | $19.150^{ac} \pm$ 5.214 | $23.720^{ac} \pm$ 3.256 | $16.467^{a} \pm$ 3.110 | $13.300^{a} \pm$ 4.401 | $7.300^{a} \pm$ 1.425 | $15.420^{a} \pm$ 1.873 |
| II | $23.650^{ab} \pm$ 5.378 | $34.233^{a} \pm$ 2.118 | $27.500^{ab} \pm$ 6.154 | $34.060^{a} \pm$ 4.566 | $22.733^{ab} \pm$ 2.204 | $18.950^{b} \pm$ 6.651 | $9.940^{c} \pm$ 1.665 | $20.250^{ac} \pm$ 2.672 |
| III | $29.525^{a} \pm$ 6.052 | $42.333^{a} \pm$ 1.922 | $32.283^{a} \pm$ 7.053 | $38.000^{a} \pm$ 5.369 | $26.933^{ac} \pm$ 1.233 | $25.300^{ac} \pm$ 6.401 | $13.460^{bc} \pm$ 2.531 | $26.350^{ac} \pm$ 3.201 |
| Pre_weaning weight gain (kg /Day) | $0.124^{a} \pm$ 0.023 | $0.111^{a} \pm$ 0.024 | $0.140^{a} \pm$ 0.016 | $0.121^{a} \pm$ 0.013 | $0.076^{b} \pm$ 0.006 | $0.059^{b} \pm$ 0.004 | $0.086^{b} \pm$ 0.014 | $0.080^{b} \pm$ 0.003 |
| Pre-weaning * Mortality % | 5.260 | 13.040 | 3.450 | 24.240 | 8.700 | 16.670 | 41.380 | 14.710 |

Figures having different superscript in a row varies significantly(P<0.01)

* Includes neonatal mortality also.

Table 4.10. Mean & S.E. of Carcass Traits in Large White Yorkshire and Desi Pigs

| Breed | LWY | | | | Desi | | | |
|---|---|---|---|---|---|---|---|---|
| Treatments | T1 | T2 | T3 | T4 | T1 | T2 | T3 | T4 |
| Carcass Trait Dressing%(without head) | 71.41± 1.67[a] | 66.76± 0.74[b] | 71.17± 0.56[a] | 66.29± 0.38[b] | 63.53± 0.50[bc] | 58.82± 0.00[cd] | 55.55± 0.71[d] | 54.50± 2.33[d] |
| Backfat thickness (cm) | 2.25± 0.08[a] | 2.47± 0.20[a] | 2.34± 0.14[a] | 2.05± 0.48[a] | 2.18± 0.65[a] | 1.62± 0.72[a] | 1.70± 0.30[a] | 1.23± 0.60[a] |
| Loin eye area(cm2) | 36.24± 7.56[a] | 40.41± 2.97[a] | 36.61± 1.75[a] | 31.62± 1.12[a] | 18.35± 4.06[b] | 15.68± 0.41[b] | 14.48± 2.36[b] | 15.95± 3.38[b] |
| Weight of gut(kg ) | 9.250± 0.750[a] | 11.250± 1.250[a] | 11.250± 0.750[a] | 9.750± 0.250[a] | 4.750± 1.250[b] | 4.750± 0.250[b] | 5.750± 0.750[b] | 6.250± 2.250[b] |
| Carcass weight(kg ) | 55.000± 2.000[a] | 61.000± 7.001[a] | 63.000± 3.001[a] | 55.000± 3.001[a] | 21.500± 2.501[b] | 20.000± 0.000[b] | 17.500± 0.500[b] | 18.500± 6.500[b] |
| Carcass length(cm) * | 77.50± 0.50[a] | 72.00± 4.00[a] | 76.00± 2.00[a] | 70.00± 4.00[a] | 58.00± 7.00[bc] | 58.50± 5.50[bc] | 58.00± 7.00[bc] | 61.50± 12.50[ac] |
| Weight of head(kg ) | 5.000± 0.000[a] | 5.500± 1.000[a] | 6.000± 0.000[a] | 4.750± 0.250[a] | 2.500± 0.500[b] | 2.750± 0.250[b] | 2.500± 0.000[b] | 2.500± 1.000[b] |
| Weight of feet(kg ) | 1.865± 0.065[a] | 1.700± 0.100[a] | 2.040± 0.240[a] | 1.545± 0.045[a] | 0.615± 0.065[b] | 0.720± 0.010[b] | 0.625± 0.075[b] | 0.675± 0.175[b] |
| Meat_bone ratio | 5.719± 0.531[a] | 6.194± 0.394[a] | 6.243± 0.007[a] | 6.665± 0.050[a] | 6.159± 0.507[a] | 6.095± 0.306[a] | 4.745± 0.346[a] | 5.750± 0.250[a] |
| Weight of internal organs(kg ) Heart | 0.240± 0.100[a] | 0.255± 0.450[a] | 0.225± 0.250[a] | 0.220± 0.200[a] | 0.100± 0.000[b] | 0.105± 0.005[b] | 0.105± 0.015[b] | 0.115± 0.005[b] |
| Lungs * | 0.830± 0.120[a] | 0.910± 0.250[a] | 0.975± 0.175[a] | 0.765± 0.150[a] | 0.315± 0.115[b] | 0.475± 0.075[b] | 0.280± 0.030[b] | 0.265± 0.015[b] |
| Diaphragm * | 0.160± 0.060[a] | 0.145± 0.045[a] | 0.145± 0.005[a] | 0.110± 0.030[a] | 0.035± 0.005[b] | 0.030± 0.020[b] | 0.025± 0.005[b] | 0.040± 0.010[b] |
| Liver | 1.215± 0.025[a] | 1.435± 0.115[a] | 1.465± 0.065[a] | 1.375± 0.025[a] | 0.650± 0.150[b] | 0.640± 0.040[b] | 0.690± 0.060[b] | 0.895± 0.205[b] |
| Spleen | 0.220± 0.078[a] | 0.145± 0.005[a] | 0.140± 0.000[a] | 0.125± 0.015[a] | 0.065± 0.005[b] | 0.060± 0.010[b] | 0.075± 0.015[b] | 0.070± 0.000[b] |
| Kidney | 0.180± 0.020[a] | 0.180± 0.010[a] | 0.205± 0.005[a] | 0.180± 0.010[a] | 0.093± 0.003[b] | 0.105± 0.025[b] | 0.105± 0.025[b] | 0.095± 0.005[b] |

Figures having different superscript in a row varies significantly ($P<0.01$). * $P<0.05$

Table 4.11 Behavioural scores and cost of production per kg meat and weaned piglet in LWY and Desi pigs

| Breed | LWY | | | | Desi | | | |
|---|---|---|---|---|---|---|---|---|
| Treatments | T1 | T2 | T3 | T4 | T1 | T2 | T3 | T4 |
| Behavioural Trait | | | | | | | | |
| Feeding _Pre-partum* | 1.975 | 2.803 | 1.967 | 2.884 | 1.226 | 1.358 | 1.538 | 1.566 |
| Post-partum | $2.275^{a} \pm 0.248$ | $2.455^{a} \pm 0.172$ | $2.516^{a} \pm 0.169$ | $2.889^{a} \pm 0.050$ | $1.394^{b} \pm 0.132$ | $1.349^{b} \pm 0.076$ | $1.313^{b} \pm 0.097$ | $1.516^{b} \pm 0.168$ |
| Play* | 0.895 | 1.561 | 3.228 | 4.772 | 2.35 | 2.425 | 3.000 | 3.200 |
| Agonistic* | 1.825 | 1.298 | 1.263 | 0.860 | 0.575 | 0.625 | 0.600 | 0.500 |
| Female sex behaviour | $2.750^{ac} \pm 0.250$ | $3.600^{ab} \pm 0.678$ | $2.167^{c} \pm 0.307$ | $4.000^{b} \pm 0.447$ | $2.000^{c} \pm 0.316$ | $2.800^{ac} \pm 0.374$ | $4.167^{b} \pm 0.477$ | $2.000^{c} \pm 0.316$ |
| Maternal behaviour | $7.000^{a} \pm 1.472$ | $8.250^{a} \pm 1.109$ | $8.000^{a} \pm 0.775$ | $8.400^{a} \pm 0.400$ | $9.000^{b} \pm 0.000$ | $6.000^{b} \pm 2.512$ | $8.000^{b} \pm 0.316$ | $7.800^{b} \pm 1.715$ |
| Cost of production(Rs.)** | | | | | | | | |
| Per kg of meat | 75.00 | 86.00 | 52.00 | 68.00 | 131.00 | 125.00 | 137.00 | 117.00 |
| Per kg weaned piglet | 294.00 | 191.00 | 244.00 | 210.00 | 116.00 | 138.00 | 199.00 | 120.00 |

*group averages ** cost of production is calculated based on the assumptions (1)feed constitute 75% of total cost of production in pigs. (2)cost of weaned piglet and cost of maintanance of boar is identitical for all pigs and hence not included in the cost of production.

Fig. 4.6. Cost of production per unit(kg ) meat and per unit(kg ) weaned piglet in LWY and Desi pigs

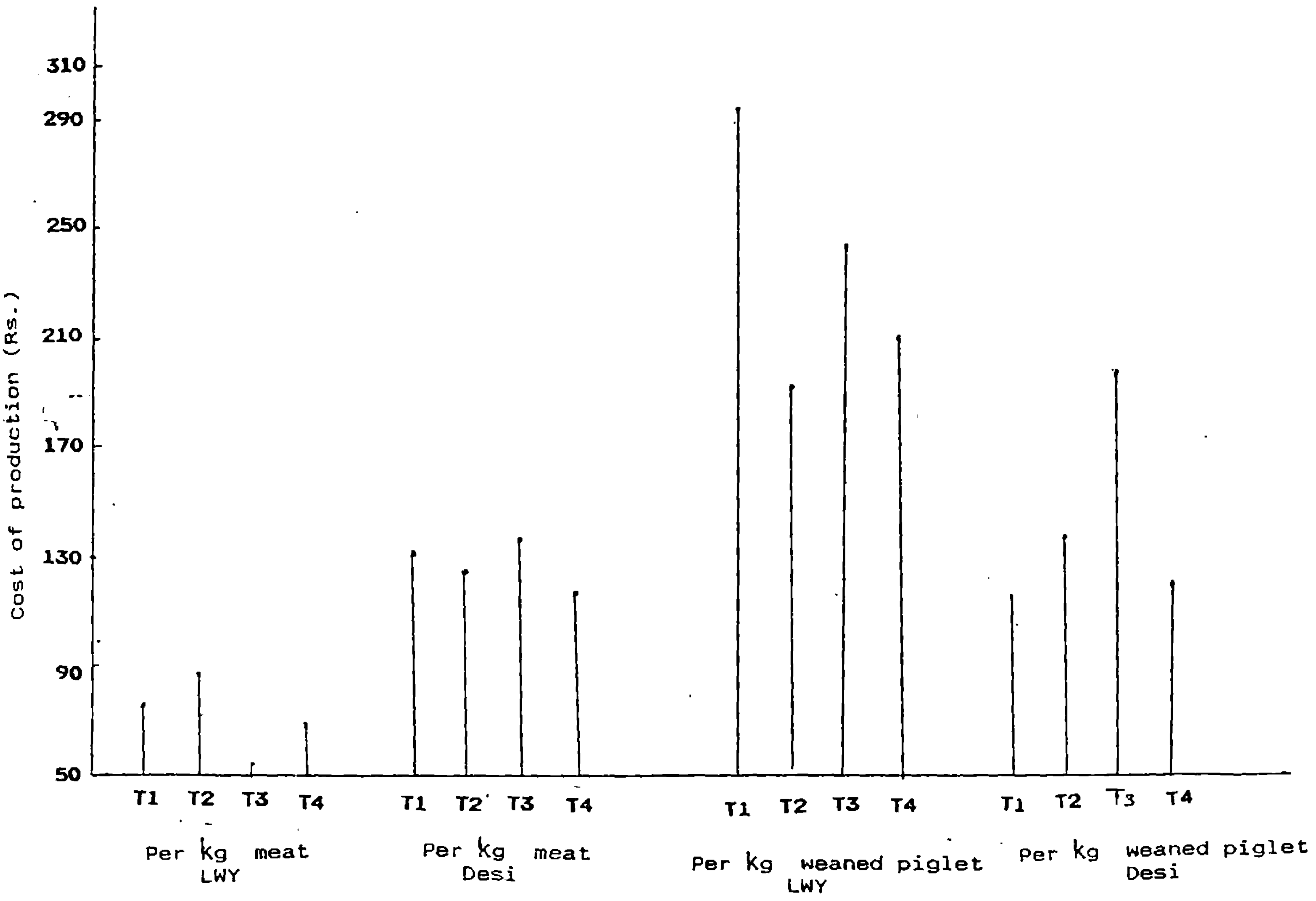

Table 4.12. Performance (Mean & S.E.) of Halothane Positive and Negative Large White Yorkshire and Desi Pigs

| Breed | LWY | | Desi | |
|---|---|---|---|---|
| Halothane reaction | Positive | Negative | Positive | Negative |
| **Performance Trait** | | | | |
| Litter size at birth Total | 5.667±0.687[a] | 6.500±0.833[a] | 7.200±0.583[a] | 7.364±0.856[a] |
| Live | 5.111±0.735[a] | 5.800±0.880[a] | 5.800±1.562[a] | 6.889±1.338[a] |
| Litter wt. at birth (kg) Live | 8.349±1.375[a] | 8.726±1.553[a] | 5.589±0.616[b] | 5.196±0.746[b] |
| Birth weight (kg) | 1.629±0.113[a] | 1.489±0.058[a] | 0.781±0.068[b] | 0.676±0.043[b] |
| Litter size at weaning | 4.556±0.709[a] | 5.222±0.813[a] | 5.500±0.646[a] | 6.100±0.823[a] |
| Litter wt. at weaning (kg) | 16.622±6.677[a] | 43.189±5.190[b] | 26.600±3.182[a] | 29.91±3.755[a] |
| Average weaning wt. (kg) | 8.944±0.793[a] | 7.973±1.067[a] | 4.846±0.245[b] | 5.223±0.405[b] |
| Pre_weaning mortality(%) | 8.70 | 15.52 | 27.59 | 18.67 |
| Daily weight gain (g) | 269.979±28.497[a] | 264.857±26.055[a] | 168.033±15.590[b] | 126.490±9.103[c] |
| Feed conversion ratio 1: | 5.113 | 5.421 | 6.411 | 8.548 |
| Dry matter digestibility(%) | 73.518±1.122[a] | 70.419±1.461[a] | 86.604±0.753[b] | 80.652±0.917[c] |
| Age at farrowing(days) | 444.44±15.61[a] | 417.10±10.69[a] | 362.40±20.657[b] | 336.45±14.049[b] |
| Dressing % in slaughter | 68.128±1.69[a] | 69.685±1.086[a] | 59.06±1.368[b] | 57.52±2.271[b] |
| Composite sow index | 2.566 | 3.449 | 2.924 | 2.943 |

Figures having different superscripts in a row varies significantly (P<0.05)

Table 4.13. Comparitive Performance of Halothane Positive and Negative LWY and Desi pigs in different Treatment Groups

| Breed | | LWY | | | | Desi | | | |
|---|---|---|---|---|---|---|---|---|---|
| Treatment | | T1 | T2 | T3 | T4 | T1 | T2 | T3 | T4 |
| Total litter size at birth | + | $5.000^{a} \pm 1.000$ | $7.000^{a} \pm 0.000$ | $5.750^{a} \pm 1.182$ | $5.500^{a} \pm 2.504$ | _ | $7.500^{a} \pm 0.502$ | $8.000^{a} \pm 0.000$ | $6.500^{a} \pm 1.499$ |
| | _ | $6.500^{a} \pm 1.500$ | $5.330^{a} \pm 2.027$ | $6.500^{a} \pm 2.504$ | $7.670^{a} \pm 1.455$ | $7.670^{a} \pm 0.883$ | $10.000^{a} \pm 0.000$ | $5.250^{a} \pm 1.435$ | $9.000^{a} \pm 1.000$ |
| Litter size at weaning | + | $5.000^{b} \pm 1.000$ | $6.000^{b} \pm 0.000$ | $4.000^{b} \pm 1.472$ | $4.500^{b} \pm 1.500$ | _ | $6.000^{b} \pm 0.000$ | $4.000^{b} \pm 0.000$ | $6.000^{b} \pm 1.000$ |
| | _ | $4.000^{b} \pm 3.000$ | $4.000^{b} \pm 2.082$ | $5.500^{b} \pm 2.501$ | $5.330^{b} \pm 1.333$ | $7.000^{b} \pm 1.000$ | $9.000^{b} \pm 0.000$ | $3.750^{b} \pm 0.000$ | $5.333^{b} \pm 2.667$ |
| Litter weight at weaning(kg ) | + | $33.550^{d} \pm 1.450$ | $57.500^{d} \pm 0.000$ | $34.875^{d} \pm 10.659$ | $36.050^{d} \pm 1.550$ | _ | $26.600^{d} \pm 0.000$ | $18.500^{d} \pm 0.000$ | $30.800^{d} \pm 3.200$ |
| | _ | $30.300^{d} \pm 18.803$ | $46.250^{d} \pm 1.750$ | $44.850^{d} \pm 12.852$ | $48.633^{d} \pm 8.668$ | $33.533^{d} \pm 2.599$ | $38.100^{d} \pm 0.000$ | $18.700^{d} \pm 4.984$ | $36.800^{d} \pm 5.275$ |
| Daily body weight gain(g) | + | $286.000^{c} \pm 34.685$ | $279.750^{c} \pm 95.623$ | $227.250^{c} \pm 54.878$ | $286.750^{c} \pm 45.443$ | $125.667^{c} \pm 26.823$ | $168.000^{c} \pm 49.007$ | $182.500^{c} \pm 34.505$ | $200.667^{c} \pm 14.380$ |
| | _ | $220.000^{c} \pm 52.808$ | $195.750^{c} \pm 33.570$ | $360.500^{c} \pm 42.296$ | $282.750^{c} \pm 49.409$ | $123.400^{c} \pm 10.395$ | $127.833^{c} \pm 16.737$ | $132.333^{c} \pm 14.021$ | $120.400^{c} \pm 32.523$ |
| Age at farrowing(days) | + | $445.50^{e} \pm 22.50$ | $503.00^{e} \pm 0.00$ | $450.50^{e} \pm 27.63$ | $402.00^{e} \pm 10.00$ | _ | $368.00^{e} \pm 31.01$ | $293.00^{e} \pm 0.00$ | $391.50^{e} \pm 4.50$ |
| | _ | $409.00^{e} \pm 7.00$ | $403.00^{h} \pm 5.86$ | $401.00^{e} \pm 2.00$ | $447.33^{e} \pm 31.59$ | $331.33^{e} \pm 16.05$ | $368.00^{e} \pm 0.00$ | $311.50^{e} \pm 17.82$ | $364.33^{e} \pm 41.88$ |
| Feedconversion ratio | +1: | 4.476 | 4.715 | 4.726 | 4.356 | 8.379 | 6.548 | 5.753 | 5.502 |
| | _1: | 5.818 | 6.738 | 2.979 | 4.417 | 8.533 | 8.605 | 7.935 | 9.169 |

Figures having different superscript in a row or column for the same trait varies significantly ($P<0.05$).

Table 4.14 Biochemical Traits in Halothane positive and Negative LWY and Desi Pigs

| Breed | LWY | | Desi | |
|---|---|---|---|---|
| Halothane reaction | H+ | H- | H+ | H- |
| **Biochemical Traits** | | | | |
| Lactate dehydrogenase (IU/L) | 87.101±26.203 [a] | 40.270±14.200 [a] | 2.532±0.844 [b] | 19.412±5.909 [a] |
| Creatine kinase(IU/L) | 98.223±15.212 [a] | 126.714±27.369 [ac] | 194.794±25.882 [bc] | 213.228±63.601 [ab] |
| Alkaline Phosphatase (IU/L) | 174.420±23.921 [a] | 159.608±77.927 [a] | 306.245±61.077 [a] | 201.348±44.555 [a] |
| Serum Total Protein (g/dl) | 6.992±1.246 [a] | 9.575±1.506 [a] | 6.122±0.447 [a] | 8.347±2.309 [a] |
| Serum albumen (g/dl) | 5.750±0.407 [a] | 5.946±0.429 [a] | 4.066±0.363 [a] | 4.142±0.368 [a] |
| Serum glucose(mg/dl) | 105.438±30.040 [a] | 76.359±19.081 [a] | 22.095±10.568 [a] | 12.017±5.646 [a] |
| Serum Calcium(mg/dl) | 9.315±0.522 [a] | 10.144±0.269 [a] | 8.193±0.551 [a] | 9.291±0.452 [a] |
| Haemoglobin (g/dl) | 10.557±2.295 [a] | 15.227±1.264 [a] | 17.862±1.557 [a] | 17.960±0.370 [a] |

Figures having different superscript in a row varies significantly ($P<0.05$).

Table 4.15. Management systems for pigs under various situations

| Breed | LWY | | | | | | | | | | | | Desi | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Genetic group | H+ | | | | | | H- | | | | | | H+ | | | | | | H- | | | | | |
| Purpose | Fattening | | | Breeding | | | Fattening | | | Breeding | | | Fattening | | | Breeding | | | Fattening | | | Breeding | | |
| Consideration | E | W | C | E | W | C | E | W | C | E | W | C | E | W | C | E | W | C | E | W | C | E | W | C |
| Environmental enrichments | | | | | | | | | | | | | | | | | | | | | | | | |
| Wallowing and water sprinkling | + | + | + | + | + | + | - | + | - | + | + | + | + | + | - | + | + | + | - | + | - | - | + | + |
| Access to range[@] | + | + | + | - | + | - | + | + | + | + | + | - | + | + | + | + | + | + | + | + | + | - | + | + |

E _ Economic W _ Welfare C _ Compromise

+ - Present - - Absent

# 5.DISCUSSION

The observations and the results obtained during the course of study are discussed hereunder.

## 5.1 Production and Reproduction Traits of Large White Yorkshire and Desi Pigs and their Relation to Environmental Variables.

The yearly variation and trends in various production and reproduction traits in LWY and Desi Pigs as shown in Table 4.1 and Fig.4.1 are in accordance with the previous findings of Kaplon and Rozycki(1988) and Gutiev(1991) on this account, especially with respect to daily weight gain.The LWY pigs were found to have a relatively better performance in almost all the favourable traits.This observation is in agreement with the reports of Saseendran and Rajagopalan(1981,1982). An yearly zig _ zag trends observed in the traits may be atributed to herd inbreeding,periodic exchange of boars with resultant heterosis,level of adaptation,season and varying degrees and forms of interacion between these elements. This was more evident in Desi pigs which were introduced to the farm during 1993. The analysis of long term production and reproduction data in a herd may help to study the changes and trends in performance and appropriate interventions in the genetic make up or environment can be advocated to alleviate deterioration , if any, noticed in the herd.

It can be seen from Table 4.2.1 that, apparently clear trends for variations in all the environmental variables existed between the dry and rainy seasons. The alterations in temperature combined with humidity and other variables seems to excert reasonable stress on animals there by affecting the production and reproduction traits which is evident from Table 4.2.2.

The environmental variables ( average temperature, humidity, rainfall, sunshihe and wind speed. Table 4.2) showed significant ( $P < 0.05$ ) influence on traits such as litter size and weight at birth and weaning, pre-weaning and post-weaning mortality in LWY and Desi pigs whicl graphically enunciated in Fig.4.1. This is in line with si findings of Shostak et al.(1990) and Sebastian (1992) . observations indicate the need of environmental enrichr which may alleviate the stress on animals due to clir variations and there by stabilising the production a reproduction performance.

Deterioration in two important pedigree traits -ie.number of piglets born and reared - in LWY pigs which is depicted in Fig.4.2 may be atributed to the cost of adaptation paid by them on introduction to Tropical Environment. This is in line with the reports of Clive Philips and David Piggins(1992). The amelioration of this may be achieved through environmental enrichments and reduction of stress as envisaged by Pfeiffer and Lengerken(1991).

At present exotic pigs like LWY and Landrace are reared in tropical and humid tropical climates under conventional systems of housing and management assuming that they are well adapted to this climate. But the deterioration in the production traits noticed above calls for a re _ consideration with respect to their genetic make up and adaptability to conventional systems of management.

**5.2. Incidence of Halothane Sensitivity**

The relative incidence of halothane sensitivity in LWY and Desi pigs depicted in Fig.4.3 is in accordance with the findings of Lundstrom et al.(1995) but seems to be little high when compared to the reports of LiJiaQi et al. (1996) and Dovc et al.(1996). This may be due to the fact that the basic stocks of LWY in UPBF had its origin from British Large White in which the frequency of H+ allele is considered to be very high(Yablanski et al.(1989).

Halothane sensitivity is being reported to have relation to various production, reproduction and carcass traits in pigs from temperate regions and this is being used as a tool for genetic selection of pigs for better performance. A reasonably high incidence noticed in this study may help to develop certain yardstick in early selection for productive adaptability of various genomes with respect to halothane sensitivity.

**5.3.Body weight and daily weight gain**

From Table 4.3 it can be seen that the monthly body weight,body weight at different stages of reproduction and daily weight gain of LWY pigs were significantly higher (P<0.01) than that of Desi in all treatment groups supporting the previous reports of Saseendran and Rajagopalan(1982) and AICRP(1996). A trend for higher body weight in growing stage in T3 and T4 groups in both LWY and Desi Pigs is indicative of the beneficial effect of environmental enrichments in the form of wallowing,water sprinkling and access to range.

This finding is in agreement with the findings of Tripathi et al. (1972), Starr(1981), Hahn(1981), Mehta(1976) and Gulyani(1984) in various livestock in Tropics. The relatively higher body weight and daily weight gain in T3 in comparison to T2 and T4 may be due to the fact that , habitual wallowing (wallowing for the sake of wallowing even at cold hours of the day) in treatments T2 and T4 might have lead to certain degrees of body depletion for maintanance of body temperature resulting in less body weight in these groups. But in Desi animals where habitual wallowing is less frequent, higher body weights and weight gain are seen in T4 (where the animals enjoy maximum environmental enrichments). These findings tally with that of Arganosa et al.(1988).

The changes in body weights at different stages of reproduction(stageI, II and III) in both LWY and Desi Pigs were highly related to their litter performance shown in Table 4.8 which inturn was related to the environmental enrichments provided during growing and breeding stage. A relatively higher body weight kinetics was observed in T2 and T3 in LWY and T1, T2 and T4 in Desi where there were high litter weight at weaning. These observations were in accordance with that of Weber(1995) but in contrast to that of Earnst and Abramowsky(1993). The trends and kinetics of body weight in different treatment groups in both LWY and Desi pigs were in favour of qualitative additions of environmental enrichments.The relatively higher monthly body weight in T3 of LWY when compared to T1 and T2 may be due to access to range and availability of additional nutrients and microelements along with comfort and alleviation of stress.

Daily weight gain is considered as an important production trait both in fattening and breeding stock of pigs as it determines the age at slaughter and breeding. A high daily rate of growth facilitate early attainment of slaughter and breeding body weight thereby saving expenditure on floor space, labour and other rearing expenditure and it results in early return from the enterprise.

In the current conventional pig rearing systems in tropics, wallowing and water sprinkling are recommended for both fattening and breeding stock, with the assumption that this may alleviate stress and may come up with good production results. But the above findings in favour of access to range instead of provision for wallowing and water sprinkling call for the re _ consideration of recommending wallowing for fattening stock in the economic point of view and water saving.

### 5.4. Body Measurements

The monthly biometric changes in various treatment groups in LWY and Desi pigs followed the same trend as that of body weight except in fourth month where there was no significant difference between two breeds in all the treatment groups(Table 4.4.1 to 4.4.3). This may be due to the biometric changes associated with puberty which occurs in Desi animals at an early age when compared to LWY. The body dimensions at all other months and stages were significantly higher($P<0.01$, stage III-$P<0.05$)in LWY than that of Desi. The above observations are in accordance with the related reports of Brody(1945) and Saseendran (1979).

A combined study on body weight and body dimensions in both breeds may help to assess the relative body density and effective surface area per unit weight for heat dissipation. This may also help for ascertaining actual floor space requirement based on biometrics.

### 5.5. Feed intake and Feed Conversion Efficiency

It can be seen from Table 4.5 that the maximum feed intake durihg grower stage was noticed in T2(LWY) and T4(Desi)indicating that environmental enrichments may augment feed intake supporting the findings of Weber(1995). The feed intake is an indirect measure of gut capacity (shown in Table 4.10) as envisaged by Colin(1980).Feed intake is also controlled by environmental elements and type of feed. The animals which had an approach to a range might have a part of its gut fill from the range and partial satisfaction of appetite and hence the feed consumption seem to be low in T3 of both breeds in which wallowing was absent. But a relatively higher feed intake in T4 may be due to increased physiological demand to meet excess energey need arising from habitual wallowing. Feed intake in stage II and III in each group seems to be the result of interaction between physiological needs arising from growth,breeding,lactation (assessed by litter size and milk production,Table 4.8), environmental enrichments and gut capacity designed during pre-partum stage supporting the related reports of Colin(1980) and Joseph(1992).

The apparently high Feed Conversion Efficiency (FCE) noticed in T3 and T4 of LWY and Desi pigs clearly indicate the beneficial effects of environmental enrichments on this trait.The better efficiency in T3 of both LWY and Desi (Fig.4.4) is atributable to efficient utilisation of feed by access to range and lack of loss of energy by habitual wallowing.The FCE noted were relatively less than that reported by Saseendran and Rajagopalan(1981) which may be atributable to genetic make up of animals used for the study, difference in feeding regime adopted, environmental enrichments and environmental influences.

Since feed represents about 70-75% of the total cost of production in swine ( Krider and Carrol, 1971) an elevation in FCE by provision of environmental enrichments call for the need of reconsideration and remodelling of present systems of management for efficient exploitation of its genetic merit. This view supports the arguement of Pfeiffer and Lengerken(1991), Clive Philips and David Piggins (1992) and John (1996).

Provision of wallowing and water sprinkling are considered to be beneficial for both fattening and breeding exotic stock of pigs as a measure of stress alleviation. But the negative effect of habitual wallowing on FCE and beneficial effect of access to range without wallowing facility, indicate that some of the beliefs traditionally held by us may be wrong. Wallowing may not be usefull for fattner pigs. Instead, provision of a shaded range can result in better growth and FCE.

**5.6.Rectal Temperature, Respiration Rate and Pulse Rate**

A significantly higher ($P<0.01$) rectal temperature and respiration rate and a trend for higher pulse rate in T1 and T3 in both LWY and Desi (Table 4.6) during hot hours of the day indicate certain level of thermal stress on animals in these groups where there was no provision for wallowing. Although this has not reached the level of growth impairment (Table 4.3) it has got great relevance with respect to animal comfort and impairment of future reproduction as revealed in Table 4.7.These findings are in support to that of Tripathi et al.(1972) and Mehta(1976) in other livestock in tropics and in contrast to Arganosa et al.(1988).

Removal of stress and stressfull conditions are considered as pre_requisites for maximum expression of genetic merits in livestock.Body temperature, pulse rate and respiration rate are valid indicators of stress especially thermal stress. Any environmental modifications which beneficially influence these physiological traits are considered contributing to the production performance of animals. In this context the above findings stress the need for wallowing to alleviate stress on animals especially exotic ones brought to tropical environment.

### 5.7 Reproduction Traits

It can be seen from Table 4.7 that the age at onset of oestrus, age at conception and age at farrowing in Desi pigs were significantly lower (P<0.01) than that of LWY pigs. This may be due to the reason that indigenous pigs are early maturing and reach adult body weight early as observed by Saseendran (1979). An apparently low age at onset of oestrus in T3 and T4 of LWY indicate that exotic pigs are benefitted by environmental enrichments like wallowing and provision of a range. Absence of any significant difference between treatments in Desi pigs with respect to physiological reactions points to the fact that Desi pigs are not seriously affected by the hot-humid climate where as the LWY pigs need thermal stress alleviation through wallowing and provision of a shaded range.

The conception rate in groups T1 and T2 in both breeds (Table 4.7) were low when compared to other groups indicating that enrichment in the form of a range beneficially contribute to this trait.

A significantly higher ($P<0.01$) age at farrowing(Table 4.7) in T4 and a trend for higher value in T2 of Desi breed indicate that wallowing has got less beneficial effect on these traits when compared to that on LWY . The gestation period did not show any significant variation between breeds or treatments.

The swine industry in humid tropics nowadays tend to depend largely on exotic pigs like LWY and Landrace under the assumption that they grow and breed well in the conventional system of management. But the findings in this study indicate that there is a clear deterioration in the reproduction traits of exotic pigs brought to humid tropics and conventional system of management seems to be inadequate for optimum exploitation of their reproductive efficiency. A re_consideration either in the suitability of genetic make up of animals reared in the tropics or appropriate modification in the management systems by providing suitable environmental enrichments may be thought of highly essential in this context.

## 5.8. Litter Traits and Composite Sow Index

The litter size at birth did not show any significant variation between breeds or treatment groups(Table 4.8).Similar observations were reported by Ripple et al. (1965), Anonymous(1978) and Hammel(1974). It appears that total litter size is determined mostly by heredity and less influenced by environment and nutrition. But a trend for higher live litter size and low stillbirth in T2 and T4 in both breeds indicate that environmental enrichments during growing and breeding stages may have effect on these traits supporting the related findings of John (1996), Borisenko(1974) and Simonsen(1995).

A progressive trend for litter weight at birth for every qualitative additions of enrichments especially in LWY is indicative of its beneficial effect on this trait supporting the observations of Costa et al.(1995), Huhn et al.(1995) and Kuriahara et al.(1996).

The observation of having significantly higher birth weight ($P<0.01$) in LWY in all the treatment groups when compared to that of Desi is in line with previous reports on the same (Bhat , 1977 ). An apparently clear (non significant) increasing trend for birth weight in T2 , T3 and T4 in Desi clearly reveals the beneficial effects of environmental enrichments on this trait. This finding is in accordance with that of Elsley et al.(1969). It was also noticed that the average birth weight of piglets born dead was lower when compared to their live contemporaries especially in T3 and T4 of LWY and T2 and T4 of Desi. This observation is in full support to that of Holness and Smith(1974). It indicates that the chances for becoming still birth is more for piglets with low birth weight and hence it will be advantageous if the dam can be given certain level of environmental enrichments during breeding and pregnancy period.

Litter size at weaning did not differ significantly between breeds or treatments lending support to similar findings of Oldigs et al.(1995) and in disagreement with that of Earnst and Abramowsky(1993). This may be due to the reason that all the animals were deprived off from their environmental enrichments from seven day pre-partum and were housed in farrowing houses with similar environmental constituitions. However a trend for higher size at weaning in T4 in both breeds indicates the carry over effect of environmental enrichments on mothering ability of sows lending support to John (1996).

A significantly progressing trend in litter weight at weaning (P<0.05) with additions of environmental enrichments especially wallowing and water sprinkling in both breeds may be atributed to the beneficial effect of enrichments on the milk production and mothering ability of dams.This is in support to the related findings of Dyck(1988) and Costa et al. (1995) but in contrast to that of Oldigs et al.(1995).

The average weaning weight of LWY pigs in all treatments were significantly higher(P<0.01) than that of Desi. Obviously this is the reflection of the genetically determined larger body size of LWY pigs.Similar observations were reported by Bhat(1977) and Saseendran(1979). But a tendancy for heavier piglet in T3 and T4 in both breeds throws light on to the beneficial effects of environmental enrichments during pre-partum period on this trait lending support to the findings of Costa et al.(1995) but in contrast to that of John(1996).

The Composite Sow Index which may be considered as a measure of productive adaptability (Fig.4.5) revealed a clear tendancy in favour of environmental enrichments especially wallowing and water sprinkling in both the breeds.This is in line with the view that the productive and reproductive adaptation in exotic animals can be improved by a logical intervention in its environment by providing appropriate enrichments lending support to the arguements of Clive Philips and David Piggins (1992).

The systems of management of sow and litter generally adopted in humid tropics are true copies of those in the temperate regions with very little modifications, under the assumption that animals perform well in these systems. But the findings in this study indicate a beneficial carry over effect of environmental enrichments provided during growing and breeding stage and a deleterious effect of withdrawal of such enrichments in the farrowing houses on the final litter performance. This further reveals the inadequacy of present management systems for optimum performance of sow and litter. Provision of environmental enrichments to sow and litter may ameliorate the deterioration in litter traits occured in exotic pigs reared in humid tropics.

## 5.9. Pre-weaning Litter Weights and Mortality

A significant (P<0.01) or apparently clear trend for higher litter weight in T2 and T4 in LWY(Table 4.9) throws light in to the carry over effect of pre-partum environmental enrichments on the litter performance supporting the similar observations of Costa et al.(1995) and Dyck(1988) but in contrast to that of Oldigs et al.(1995). A relatively better performance of Desi T1 may be atributed to the fact that Desi pigs are well adapted to the environmental conditions and that they can perform well without environmental enrichments.

The pre-weaning weight gain in all treatments in LWY were significantly higher (P<0.01) than that of Desi supporting early related reports in this respect(Saseendran 1979).

It can be seen from Table 4.4 that the pre-weaning mortality rates were in the increasing order of

T3,T1,T2 and T4 in LWY and T1,T4,T2 and T3 in Desi which may be due to the sudden withdrawal of enrichments during lactation thereby adversely affecting the mothering ability and litter survivability. An incremental trend in mortality with qualitative removal of enrichments is more evident in LWY lending support to similar findings of John(1996) but at variance with that of Earnst and Abramowsky(1993).

The above findings in connection with the informations on relationship between environmental variables and reproduction traits furnished in Table 4.2.2 are highly valid indicators of usefullness of environmental enrichments in evolving strategies for developing suitable animal environmental models or combinations for effective exploitation of genetic merit of exotic pigs reared in tropics.

5.10. Carcass Traits

Table 4.10 reveals a significantly higher dressing Percentage in T1 and T3 in LWY and T1 in Desi indicating that the dressing percentage may be regulated by manipulating provisions of environmental enrichments in LWY. This observation is in accordance with that of Krider and Carrol(1971). Wallowing seems to have no beneficial effect on dressing percentage especially in LWY supporting the findings of Arganosa et al. (1988).A significant breed differenc existed between LWY and Desi in all the traits except backfat thickness and meat-bone ratio, which may be atributed to the difference in body weight at slaughter. A trend for higher meat-bone ratio in T2,T3 and T4 of LWY when compared to T1 brings to light the beneficial effect of environmental enrichments on this trait. An apparently low back fat thickness observed in T4 in both breeds is indicative of the low tendancy for back fat deposition in animals reared in environment with enrichments as reported by Krider and Carrol (1971) but in contrast to the related findings of Matte(1993). Loin eye area, weight of gut, carcass weight and carcass length showed clear trends in association with environmental enrichments revealing the flexibility of carcass composition as reported by McMeekan (1940,1941). Majority of the traits except dressing percentage were in favour of environmental enrichments.

Swine industry in developing countries have more concern on quantitative aspects than on qualitative aspects especially with respect to carcass charecterestics. In general the trend is against excess fat deposition and hence the findings in this study open avenue for beneficial intervention in the above traits by using suitable combinations of environmental enrichments.

**5.11 Behaviour and Cost of Production**

It can be seen from Table 4.11 that the feeding behaviour score which may be considered as the manifestation of appetite at the time of feeding , had higher values in T2 and T4 in both breeds indicating the increased demand of nutrients for maintanance of body temperature arising from wallowing and water sprinkling. It also reflects the increased growth and breeding demand in these groups. The post-partum score reflects the nutritional demand arising from lactational stress depending upon the litter size and weight, which inturn was influenced by pre-partum environmental enrichments.

The "play" behaviour score which may be considered as a measure of animal comfort, harmoney with environment and alleviation of stress showed an incremental progression by qualitative additions of environmental enrichments lending support to the views of Clive Philips and David Piggins (1992).

A regressing trend for agonistic behaviour score in animals reared in enriched environments indicate that animals reared under such environments are under comparitively less social stress and keep social harmoney and stability which are essential pre-requistics for better production and reproduction performance in group housing systems.

The female sex behaviour score which may be considered as a measure of extent of manifestation of oestrus and sexual receptivity, revealed a progressive trend with environmental enrichments especially in LWY supporting the related findings of Pfeifer and Lengerken(1991).

The maternal behaviour score which may be used as a measure of mothering ability in sows also showed beneficial trend in favour of environmental enrichments supporting the findings of Simonsen(1995) but in contrast to that of Oldigs et al.(1995).

The cost of production per unit (Kilogram) meat was relatively low in T3 of LWY and T4 of Desi indicating the beneficial effect of enrichments on this trait.

Comparitively higher cost of production in T2 and T4 of LWY may be atributed to the loss of body weight by habitual wallowing and movements in the ranges supporting the findings of Arganosa et al.(1988).

The costs of production per unit weaned piglet were low in T2 and T4 pointing out the favourable effect of enrichments especially wallowing on this trait specifically in LWY. The withdrawal of enrichment during rearing period may be the reason for relatively higher cost of production in T2,T3 and T4 when compared to T1 in the case of Desi. These observations are in line with that of Oldigs et al.(1995), Simonsen(1995) but in contrast to that of Costa et al.(1995).

The above findings open avenue for economic piglet production by providing suitable combinations of environmental enrichments during appropriate times of growth and breeding.

Pig rearing has got a fragile economic background in all the countries. The cost of production per unit meat and weaned piglets are considered to be basic measures of economic efficiency in swine farming. Since feed constitute about 70-75% of total cost of production,any attempt to reduce the feed cost or to enhance feed utilisation efficiency(FUE) are benefitted in pig husbandry. The above findings throw light on a reasonably high influence of environmental enrichments on the production cost in different forms and degrees . An appropriate combination of breed and enrichments results in greater economic efficiency.

**5.12. Performance of Halothane Positive and Halothane Negative Pigs.**

The litter weight at weaning was significantly higher($P<0.05$) in H- LWY pigs when compared to H+ LWY. Similar findings were reported by Angelov and Stoikov(1990) and Gart et al.(1992).But Rundgren et al.(1990) reported contrasting observations.

Daily weight gain in H+ of Desi was significantly higher($P<0.05$) than that of H- Desi, which is in line with the observations of Rundgren(1988) but disagree with that of Koliandr(1988) and Reik(1989).

The drymatter digestibility and feed conversion efficiency were markedly high in H+ pigs especially in Desi. This finding is in accordance with early reports of

Reinecke and Kalm(1988) and Leach et al.(1996) but at variance with that of McPhee et al.(1994) and Matthes and Schwerin(1995).

Halothane sensitivity revealed beneficial effects(non significant) on birth weight(in both LWY and Desi), average weaning weight(in LWY), pre-weaning mortality(in LWY) and dressing percentage(in Desi). These observations were in agreement with that of Beckova and Holkova(1988) and Gart et al(1992) but in contrast to that of Kojima et al(1996)and Angelov and Stoikov(1990).

The total and live litter size at birth (in both breeds), litter weight at birth(in LWY), litter size at weaning(in both breeds), pre-weaning mortality(in Desi), age at farrowing(in both breeds), dressing percentage( in LWY) were beneficially influenced by halothane resistance. These observations are similar to that of Puonti and Schulman(1988), Angelov and Stoikov(1990) and Gart et al.(1992).

Halothane sensitivity may not be fully disquallified as it bears certain beneficial effects on FCE, DM digestibility and daily weight gain. But litter performance seems to be better for halothane resistant pigs.

The Composite Sow Index which may be considered as an indicator of productive adaptability , scored was higher in halothane negative pigs in both breeds.This finding is in agreement with related observations of Puonti and Schulman(1989), Angelov and Stoikov(1990) and Gart(1992) but at variance with Beckova and Holkova(1988) and Rundgren et al.(1990). This prove that halothane sensitivity may adversely affect majority of the reproduction traits and hence it will be advantageous if breeding stock are selected against halothane sensitivity with respect to productive adaptability.

**5.13. Comparitive Performance of Halothane Positive and Negative LWY and Desi Pigs in different Treatment Groups.**

It can be seen from Table 4.13. that the age at farrowing of LWY in T2 for H- animals was significantly ($P<0.01$) lower than that of H+ animals in the same treatment group.

A high FCE was noticed in H+ animals in all treatment groups except in T3 of LWY where H- animals showed a high efficiency. This may be atributed to the fact that, absence of wallowing in T3 might have induced certain degree of stress when it was in combination with exposure to range and hence the synergetic effect might have produced beneficial effect in H- animals resulting in high FCE.

Although other traits such as total litter size at birth and weaning, litter weight at weaning and daily weight gain did not show any significant variation between H+ and H- animals in different treatment groups, an apparently clear halothane sensitivity x breed x environmental enrichment inter-action existed in almost all cases.

The above observations are in agreement with similar or related findings of Wechsler et al.(1991), Angelov and Stoikov(1990), Gart(1992), Tse et al. (1993)and Einarson et al.(1996) but at variance with that of Arganosa et al.(1988).

The stress susceptible animals when provided with environmental enrichments tended to have relatively better performance when compared to H- especially in the case of total litter size at birth(T2 in LWY and T3 in Desi), litter size at weaning(T2 in LWY and T4 in Desi), litter weight at weaning(T2 in LWY), daily weight gain(T1,T2 and T4 in Desi) and age at farrowing(T4 in LWY and T3 in Desi). This brings to light that the unfavourable effect of halothane sensitivity in reproduction can be considerably reduced by providing suitable combinations of environmental enrichments at appropriate periods of reproduction.

The above findings open avenue for developing strategies for efficient exploitation of genetic potential of animals utilising appropriate combinations of breed, halothane genotype and environmental enrichments. This may help for developing appropriate animal _ environment models/ combinations of environmental enrichments suitable for different agro-climatic conditions.

The present Swine Production Systems of humid tropics have given only little emphasis on the relative merits and demerits of different environmental enrichments, genetic make up of animals reared and extend of interaction between these two elements. The observations made in the present study highlights the importance of genetic make up, environmental enrichments and genotype environment interaction in the success of swine farming enterprices. These findings may help to develop suitable animal environment combinations for maximum economic benefits protecting the animal welfare and well being.

5.14. Biochemical Traits

The creatine kinase(CK) level in H+ animals of Desi was significantly higher ($P<0.05$) than that of H+ in LWY. All other biochemical parameters showed no significant variation between breeds and halothane sensitivity groups. These observations are in line with that of Janczic et al.(1988).

Although there was no significant variation in other biochemical traits between H+ and H- animals of both breeds , an apparently clear trend for higher values of LDH(in LWY) and alkaline phosphatase(ALP, in LWY and Desi) in H+ animals lend support to early reports of Nikilchenko et al.(1986) Szilagyl et al.(1989) and Schaefer et al.(1990). Hence these parameters may be used as phenotypic indicators of stress susceptibility in respective breeds.

A trend for higher serum glucose level in H+ animals in both LWY and Desi supports the early findings of Otten and Eichinger(1996). A relatively lower serum protein levels in H+ animals of both breeds when compared to H- animals is at variance to related reports from temperate regions (Schafer et al.1990). This indicates that that biochemical responses of an animal, to certain extent depended on environment.

An apparently clear breed x halothane sensitivity interaction existed in many traits indicating that the biochemical responses of different breeds of animals and also those of same breed under different environmental conditions vary and hence may be inconsistent. But responses in specific genotype - environmental combinations may be consistent and provide valuable tool for genetic screening at early stages.

**5.14.Management Systems for Pigs under various situations.**

The systems of management for pigs under various situations recommended based on the observations and results of the foregoing study (Table 4.15) may be used as a guide for designing managemental strategies under various situations. The designs formulated based on these guidelines may be considered as relatively better in respective situations when compared to present conventional systems of management followed in tropics especially in humid tropics.

The observations and the results in the present study indicate that environmental variables, halothane sensitivity and environmental enrichments have got clear influence on the production and reproduction performance of pigs especially that of exotic(LWY) pigs. A clear breed difference was noticed between Desi and LWY with respect to various production and reproduction traits. Environmental enrichments in the form of wallowing, water sprinkling and access to a shaded range were found to have beneficial effect on traits such as body weight, daily weight gain, FCE, conception rate, live litter size at birth,birth weight,litter weight at weaning and average weaning weight.Provision for access to a shaded range seems to be beneficial for fattening pigs with respect to FCE and growth rate. Wallowing and water sprinkling have got negative effect on these traits. But for reproduction traits, all the above enrichments had beneficial effect. When halothane sensitive animals were better in FCE and growth rate, halothane negative animals came out with good reproduction results. But positive animals with environmental enrichments performed better than negative.An apparently clear interaction between breeds,genotypes and environmental enrichments were noticed in certain production and reproduction traits.Based on these findings the following managemental recommendations are made.

1.Halothane positive animals may be selected for fattening purpose and negative for breeding purpose.If positive animals are reared for breeding, environmental enrichments in the form of wallowing,water sprinkling and access to a shaded range will have better effect.

2.Fattener pigs may be provided with an access to a shaded range rather than providing wallowing and water sprinkling facilities.

3.Environmental enrichments(wallowing/water sprinkling/access to shaded range) may be provided during growing and pre-partum stages of breeding stock for getting better mothering ability and litter performance.Suitable enrichments during later half of lactation may have beneficial effect on litter traits.

# SUMMARY

A study was conducted in University Pig Breeding Farm, Mannuthy(UPBF) to assess the effect of halothane sensitivity and certain environmental enrichments on the performance of Large White Yorkshire(LWY) and Desi pigs.

The variations in production performance and its relation to environmental vaiables were studied based on the Farm records and climatological data for five years(1992-96).

The incidence of halothane sensitivity in both LWY and Desi pigs was assessed by halothane screening of samples of weaned piglets of both breeds and production performance of both positive and negative animals were studied.

Thirty-two halothane screened female weanling pigs from exotic(LWY) and Desi groups maintained in UPBF were selected in quadruplets within the breed on the basis of litter size and live weight. They were reared as per the managemental practices followed in the farm. One animal from each breed quadruplet was allotted at random to one of the four groups. The four groups were again randomly assigned to four treatments of housing with different combinations of

environmental enrichments such as wallowing and water sprinkling and access to a range.

The production,reproduction and carcass performance were studied in all the tratment groups of both breeds.

Significant correlations were found between certain environmental variables and important production and reproduction traits in both breeds.

The incidence of halothane sensitivity was found to be higher (0.440) in LWY when compared to that of Desi(0.394).

A clear breed difference was noticed between Desi and LWY with respect to traits such as feed intake, feed conversion efficiency, daily weight gain, body measurements, conception rate, live litter size at birth, birth weight, litter weight at weaning and average weaning weight.

When halothane sensitive animals were better in FCE and growth rate, halothane resistant animals came out with good reproduction results. But positive animals with environmental enrichments performed better than negative in certain traits.

The biochemical traits associated with Halothane sensitivity were inconsistent. But clear trends with breeds and genetic groups existed between H+ and H- groups.

An apparently clear interaction between breed, genotype and environmental enrichments was noticed in certain production and reproduction traits.

Based on the observations and results suitable combinations of various environmental enrichments for different breeds, genotype and purposes were designed which may be used as tools for developing management systems under different situations.

Based on the overall findings in the study the following managemental recommendations were made.

1. Halothane positive animals may be selected for fattening purpose and negative for breeding purpose. If positive animals are reared for breeding, environmental enrichments in the form of wallowing, water sprinkling and access to a shaded range will have better effect.

2. Fattener pigs may be provided with an access to a shaded range rather than providing wallowing and water sprinkling facilities,

3.Environmental enrichments(wallowing/water spinkling/access to shaded range) may be provided during growing and pre-partum stages of breeding stock for getting better mothering ability and litter performance. Suitable enrichments during later half of lactation may have beneficial effect on litter traits.

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# EFFECT OF ENRICHMENT OF ENVIRONMENT AND HALOTHANE SENSITIVITY ON PERFORMANCE OF LARGE WHITE YORKSHIRE AND DESI PIGS

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**ABSTRACT OF A THESIS**

Submitted in partial fulfilment of the requirement for the degree

# Doctor of Philosophy

Faculty of Veterinary and Animal Sciences

Kerala Agricultural University

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COLLEGE OF VETERINARY AND ANIMAL SCIENCES

Mannuthy-Thrissur.

**1997**

# ABSTRACT

The effect of environmental variables, halothane sensitivity and environmental enrichments in the form of wallowing, water sprinkling and access to a shaded range on various production and reproduction traits of exotic(LWY) and Desi pigs was assessed by conducting a study in Kerala Agricultural University Pig Breeding Farm , Mannuthy (UPBF). Significant correlations were found between environmental variables and important production and reproduction traits in both breeds . The incidence of halothane sensitivity was found to be higher in LWY when compared to that of Desi.A clear breed difference was noticed between Desi and LWY with respect to traits such as body weight,daily weight gain,body measurements, feed intake, feed conversion efficiency(FCE), weaning weight,cost of production for unit meat and weaned piglet.Environmental enrichments were found to be beneficial for most of the traits such as body weight, daily weight gain,FCE,conception rate,live litter size at birth,birth weight,litter weight at weaning and average weaning weight.When halothane sensitive animals were better in FCE and growth rate, halothane resistant animals came out with good reproduction results.But positive animals with environmental enrichments performed better than negative in

certain traits.The biochemical traits associated with halothane sensitivity were inconsistent.But clear trends with breed and genetic groups existed between halothane positive and negative animals.An apparently clear interaction between breeds, genotype and environmental enrichments were niticed in certain production and reproduction traits.Provision for access to a shaded range was found to be beneficial for fattening pigs with respect to FCE and growth rate.Wallowing and water sprinkling have got negative effect on these traits.But for reproduction traits all the above enrichments had beneficial effect.Based on the observations and the results suitable combinations of various environmental enrichments for different breeds,genotypes and purpose were designed which may be used as tools for developing managemental systems under different situations.