# EFFECT OF WATER SPRINKLING IN SUMMER ON THE PRODUCTIVE ADAPTABILITY OF HALOTHANE SENSITIVE PIGS

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**Thesis submitted in partial fulfilment of the requirement for the degree of**

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# DECLARATION

I hereby declare that this thesis entitled **"EFFECT OF WATER SPRINKLING IN SUMMER ON THE PRODUCTIVE ADAPTABILITY OF HALOTHANE SENSITIVE 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 of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Mannuthy
15-01-'04

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# CERTIFICATE

Certified that the thesis entitled **"EFFECT OF WATER SPRINKLING IN SUMMER ON THE PRODUCTIVE ADAPTABILITY OF HALOTHANE SENSITIVE PIGS"** is a record of research work done independently by **Deepa Jacob**, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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# CERTIFICATE

We, the undersigned members of the Advisory Committee of **Deepa Jacob,** a candidate for the degree of Master of Veterinary Science in Livestock Production Management, agree that the thesis entitled **"EFFECT OF WATER SPRINKLING IN SUMMER ON THE PRODUCTIVE ADAPTABILITY OF HALOTHANE SENSITIVE PIGS"** may be submitted by Deepa Jacob, in partial fulfilment of the requirement for the degree.

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# *Introduction*

# 1. INTRODUCTION

Globally, pig production has been a success; and it is expected to continue over the years. The enhanced production of meat was brought about largely by an impressive improvement in production efficiency. Better production efficiency has also carried a better utilisation of natural resources (improved feed conversion) and better product quality (leaner carcasses). Livestock improvement by genetic gain has been an important research goal for many years. Higher gain, improved feed conversion and carcass quality (leanness) have been the major goals of selection (Fernandez, 1999).

But one-sided direction of pig improvement also gives negative results in the form of disturbance of homeostasis (Bulla *et al.,* 1991). In intensive pig production system, animals are subjected to a confined rearing environment and intense selection on growth and reproduction traits (Huang *et al., 1995*). Certain factors that affect the homeostatic balance of intensively housed animals are sub optimal climate, regrouping and moving. This has enhanced the pressure on the health and welfare of pigs, increased the stress of the animals, and augmented the environmental load. Hence, research regarding the interaction of genotype with the production environment (climate, housing, and nutrition) is required.

A classical example for interaction of genotype with the production environment is that of the halothane gene and the high ambient temperature. The halothane gene is a single recessive gene present in certain pig breeds. It causes an extreme susceptibility to stress (Rundgren *et al.,* 1990b). The stress factors include high ambient temperature, transport and handling. This gene has economically beneficial and also harmful effects on growth and carcass traits. The recessive halothane gene with incomplete penetrance causes smaller litter size, slower growth rate, shorter carcass length, larger longissimus muscle area, greater lean percentage, and a higher incidence of pale, soft, and exudative pork.

Therefore, introducing the gene to the swine industry, with caution, would be beneficial (Zhang *et al.,* 1992).

This economically important genetic defect of pigs is termed as Porcine Stress Syndrome (PSS). The specific reaction to inhalent anaesthetics is referred to as malignant hyperthermia (Vogeli *et al.,* 1994). In swine breeding work, stress susceptibility or the presence of halothane gene is recognized by malignant hyperthermia triggered by halothane anaesthesia (Russ *et al.,* 1992). Since the halothane gene was first identified, numerous studies have been conducted to compare growth, carcass, and meat quality characteristics of halothane genotypes (Leach *et al.,* 1996).

The pig production scenario in India is a bit different. Here, dairy cattle production still predominates the livestock economy. The other species, which also contribute substantially to the livestock sector, are neglected to a great extent. Pig production is not at all an exception to this. In addition, social taboos and unhygienic farming systems cause backwardness in the pig production sector. Hence swine products fetch only very low price. In order to increase swine production to meet the animal protein requirements of the twenty first century, we have to break the vicious cycle of low price and the unscientific system of pig rearing.

Pig rearing in India is carried out under diverse social, climatic and environmental conditions. If proper management and scientific systems are followed, pig farming can provide self-sufficiency and profitable return to the small and marginal farmers, especially in backward areas, and thus play an important role to uplift the socio-economic status of the weaker community. Pig breeding can also become a lucrative profession on proper management. As the maintenance of pigs at a household level is possible for medium type of families with their kitchen waste and other cheap edible materials, it can be made more economical and viable (Varghese and George, 2001).

Mutton, beef and chicken meat alone cannot meet the animal protein requirements of the growing population. In this connection, the quick growing pig can fill the gap to some extent (Haldar *et al.,* 1996). Pigs are rated as one of the best meat producing animals in the world because they have a number of biological advantages over other meat producing animals, such as high prolificacy, efficient mothering ability, rapid growth, economic feed conversion ratio, shorter gestation period, high dressing percentages etc. Thus pig farming is a promising source of meat production in India with their inherent characteristics of faster multiplicity, higher growth rate, efficient feed conversion ability etc. (Yadav *et al.,* 1991).

However, a major constraint in the development of the Indian swine industry is the nature of the Desi pigs. The common indigenous pigs with small body size and poor pork quality do not provide any tangible financial benefit to the common entrepreneurs. So, the farmer has no option other than introducing exotic breeds and their crossbreds for pig farming with their advantages (Singh *et al.,* 1997). Since indigenous pigs have more adaptability than exotic breeds to adverse tropical climate, rearing of crossbreds is a better option than maintaining pure exotic breeds. Only little systematic work appears to have been conducted to assess the productive adaptability of such crossbred pigs in the tropical Indian climate. Moreover, majority of the farmers are ignorant of the presence and effects of the stress susceptibility gene, the halothane gene in the swine population. So they are unaware of the specific management strategies to be adopted for the improvement of the production performance of the halothane sensitive pigs. In the light of actual and future challenges, it is important to ensure continuous improvement in efficiency and quality of production.

Production performance of pigs as influenced by halothane sensitivity is well reviewed and reported by workers from temperate climate, where climatic conditions are not so hazardous to livestock production. But reports on the influence of halothane sensitivity and congenial environmental conditions on production performance are scanty and scattered from tropical countries.

Hence the present study was undertaken with the following objectives:

1. To study the effect of water sprinkling in summer on the productive adaptability of halothane sensitive and resistant pigs.

2. To help in the selection of better adaptable pigs using indices like halothane sensitivity, growth performance and economics of rearing; and thus increase the efficiency of pig production.

# *Review of Literature*

# 2. REVIEW OF LITERATURE

In India, swine industry has significant importance with reference to improvement of socio-economic condition of the poor. Due to poor performance of indigenous pigs, exotic pigs are imported for total replacement and upgradation of indigenous pigs (Kalita *et al.*, 1999). Introduction of exotic inheritance to desi pigs is beneficial to boost pig production in India. Low level of performance is a major limiting factor to the development of intensive systems of swine production in the tropics; and this could be due to various stress factors including the tropical climate (Dominique *et al.*, 2000). Stress challenges have an impact on swine performance. (White *et al.*, 1998). Halothane sensitivity can be used as a field test for assessing stress susceptibility in the pig (Webb and Jordan, 1978; Schmidt and Kallweit, 1980).

## 2.1 HALOTHANE SENSITIVITY IN PIGS

The possible use of a pig's reaction to the anaesthetic halothane as a field test for Porcine Stress Syndrome in genetic improvement programmes was investigated by Webb and Jordan (1978). Positive reactors had significantly shorter and leaner carcasses, fewer pigs born alive, poorer meat quality and higher mortality than negative reactors.

Wolf and Kallweit (1991) reported that hh (halothane-susceptible) pigs showed the greatest reaction to stress, and HH (halothane resistant) pigs the least.

The porcine stress gene (hal) in recessive homozygotes (nn) leads to porcine stress syndrome (PSS), and is associated with pale, soft, exudative pork. (PSE). In heterozygosis, (Nn), it is linked to poor carcass quality (Bastos *et al.*, 2000).

### 2.1.1 Incidence

Eikelenboom *et al.* (1978) suggested that the halothane-test would be most effective for minimization of stress-susceptibility and abnormal meat quality when used as a selection criterion in commercial breeding and selection of Dutch Landrace pigs.

Bulla *et al.* (1991) reported that the malignant hyperthermia syndrome (MHS) was a genetic defect conditioned by an autosomal recessive gene of 82-98 percent of penetrance in different breeds of pigs.

In Large White Yorkshire (LWY) pigs, 3.8 percent of the animals tested for halothane sensitivity were found to be halothane positive (Wang *et al.*, 1995).

Li *et al.* (1996) found that the frequency of the halothane allele Hal n was highest in Landraces (0.198), lowest in Durocs (0.097), and intermediate in Large Whites (0.033).

Joseph (1997) reported that the incidence of halothane sensitivity in LWY and desi pigs was 44% and 39.4% respectively.

The frequency of the porcine stress syndrome (PSS) gene in Yorkshire pigs in Taiwan was 4.0% (Liu *et al.*, 1998)

### 2.1.2 Halothane Test

The young pigs were forced to inhale a mixture of oxygen and five per cent halothane through a face-mask. As soon as the first symptoms of progressive clonic and tonic muscular spasm were observed, treatment was immediately stopped and the animal designated as a reactor. In non-reacting animals the duration of the administration was five minutes, which was prolonged if there was any doubt about the animals reaction to halothane (Eikelenboom *et al.*, 1978).

Webb and Jordan (1978) selected pigs aged three to eleven weeks and weighing upto 26 kg. The pigs were gently restrained and allowed to breathe halothane in oxygen via a face-mask for upto three minutes. The oxygen flow rate of two to three litres per minute and the halothane concentration of four to eight per cent for the first minute and one to three per cent thereafter were regulated so that the eye reflex was lost within one minute. Reactions were assessed visually by the degree of rigidity of the hindlegs and were scored as 'positive' 'doubtful' or 'negative' where a positive reaction was defined as extreme rigidity. Rectal temperatures were recorded at the time of positive reaction.

The pigs inhaled a mixture of oxygen (3.5 litres per minute) and 4 per cent halothane. As soon as a typical halothane positive reaction appeared, in the form of extreme extension of the hind and forelegs, the treatment was immediately stopped. Rectal temperature was also measured. Those animals which did not show reactions within five minutes were classified as negative (Schmidt and Kallweit, 1980).

Sather *et al.* (1990) studied the effect of short-term halothane challenge on the rectal temperatures of piglets. The pigs were exposed to a 4.5 per cent concentration of halothane for upto five minutes, and the rectal temperatures were recorded every 10 seconds. Halothane sensitive pigs showed muscle rigidity and their rectal temperatures increased from 40.34 ± 0.09°C after one minute to 40.80 ± 0.10°C after three minutes. However the temperature response curves show too much variability to be useful for identifying the halothane genotypes in pigs.

In a study conducted by Bulla *et al.* (1991), the animals were forced to inhale four percent halothane and oxygen in a dose of five litres per minute for four minutes. The examination included breathing frequency, pulse rate, rectal temperature, defecation and urination frequency during halothane anaesthesia, time of onset of malignant hyperthermia symptoms during anaesthesia, time of falling asleep under the influence of anaesthesia etc. Individuals that reacted positively to halothane revealed symptoms of MHS by considerably elevated body temperature, increased frequency of respiration, pulse, and tonic muscular contraction of limb extensors within three minutes of halothane administration. The body temperature of halothane positive pigs was 1.5°C higher than that of animals without MHS symptoms.

Pigs were allowed to breathe halothane in oxygen for 3-5 minutes. In a standard three-minute test procedure the amounts of halothane (3-8%) and oxygen (2-3 litres/min) were regulated so that the eye-reflex disappeared within the first minute, and anaesthesia was just maintained for the remaining two minutes (0.5-2% halothane, 1-2 litres/min oxygen). Halothane positive pigs were classified as stress susceptible and halothane negative pigs were classified as stress resistant (Oliver *et al.*, 1993).

Warnants *et al.* (1993) anaesthetised the pigs with a mixture of 95% oxygen and 5% halothane. They were called HAL-positive, if muscle rigidity and extension of the hind legs occurred within five minutes.

### 2.1.3 Mortality

Webb and Jordan (1978) opined that positive reactors had greater mortality rates than negative reactors.

Halothane positive pigs showed higher rates of post-weaning mortality than negative reactors (Webb and Simpson, 1986).

McPhee *et al.* (1994) reported that the halothane allele had the capacity for improving economically important traits. But the value of this improvement might be compromised by an increase in mortality under conditions of high ambient temperature. It was also opined that death was an important economical aspect of malignant hyperthermia resulting from acute stress prior to slaughter.

Mortality rates were highest in summer in pigs homozygous for the halothane allele (McPhee and Trout, 1995).

## 2.2 ENVIRONMENT

Pig production worldwide is expected to continue to increase over the next years. However, there are environmental constraints. (Fernandez, 1999). Also, in the future, when implementing new technologies, emphasis will have to be placed not only on animal performance and economics but also on animal welfare consequences, on ethical aspects and on possible harmful consequences to the environment (Madec, 1999).

When exotic breeds of pigs are introduced to tropical and subtropical regions, they are faced with many problems relating to the hot climate, particularly conditions of heat stress and a vast array of physiological and biochemical reactions to it. Many of these changes in turn lead to impairment of growth and reproduction (Ramesh *et al.*, 2001). So a major topic to be considered in the future will be genetic-environment interactions.

### 2.2.1 Halothane Gene and the Environment

Schmidt and Kallweit (1980) reported that halothane positive animals showed a lower ability to adapt to environmental stress.

Mitchell and Heffron (1982) reported that the adverse effects of the halothane gene are increased by the stresses of handling, transport and high ambient temperature.

Kim *et al.* (1998) suggested that environmental factors might have a more important effect than genetic factors on the occurrence of PSE pork, and preslaughter management practices might be the most important factor contributing to pork quality.

### 2.2.2 Ambient Temperature

Since pigs are not able to sweat much, they are considered to be more sensitive to hot than cold conditions (Ingram, 1965).

Conditions of high ambient temperature might increase mortality rates in halothane positive pigs (McPhee *et al.*, 1994; McPhee and Trout, 1995).

Derno *et al.* (1995) observed that an important mechanism of acclimation to a cold environment in pigs was the increasing body insulation, which led to a reduction of energy losses for thermoregulatory responses. The pigs kept at 24°C had shorter bristles and lesser dorsal fat thickness than those kept at 12°C.

High ambient temperature lowered growth rates significantly (Katsumata *et al.*, 1996).

White *et al.* (1998) observed that boar respiratory rate was linearly related with increases in ambient temperature, black globe temperature and the temperature-humidity index. In contrast to the effects of high ambient temperatures, percent relative humidity did not significantly affect boar respiratory rate.

Dinesh (2000) reported that the mean daily maximum temperature and minimum temperature recorded at Vellanikkara during the period from October 1999 to May 2000 varied from 30.5°C to 35.5°C and from 22.5°C to 24.6°C respectively. The rainfall recorded during the study period varied from 508.5 mm in October to practically nil during the months of December, January and March.

**2.2.3 Season**

The climate at Mannuthy was classified by Somanathan (1980). Season I consisted of rainy season (May to November). This was further classified into cold and wet (June to August); and warm and wet (May and September to November). Season consisted of dry season (December to April). It was further classified into warm and dry (December to January); and hot and dry (February to April).

Sebastian (1992) observed that pigs born during the dry season were superior to pigs born during the wet season in growth rate, feed efficiency, average daily gain and carcass characteristics.

Baik *et al.* (1995) opined that the growth rate of pigs born in autumn and winter was significantly higher than that of those born in spring and summer.

On assessing the misting control strategy for growing-swine under summer conditions, Panagakis *et al.* (1996) found out that pigs were subjected to heat stress during summer months.

Shi *et al.* (1999) reported that, in Suzhong I pigs average respiration rates were highest in summer and lowest in winter while pulse rates were highest in autumn.

**2.2.4 Effect of Environment on Feed and Water Intake**

Under warm conditions, the voluntary feed intake and body fatness was decreased (Rinaldo and LeDividich, 1991).

*Pigs housed in the cool environment consumed more feed* (P<0.01), gained more weight (P<0.01), and utilized feed more efficiently (P<0.01) than those in the hot environment (Schenck *et al.*, 1992).

Shebaita *et al.* (1992) concluded that there were variations between bulls maintained at 16°C and 30°C. This was associated with a rise in water turnover rate and increase in total body water.

Quiniou *et al.* *(2000b) opined that voluntary feed intake (VFI) depends on* ambient temperature and body weight, with a negative effect of high ambient temperatures in heavier pigs.

### 2.2.5 Effect of Environment on Performance

Health, welfare and production performance of pigs are improved when they are kept under optimal climatic conditions in a specific-stress-free housing system (Ekkel *et al.*, 1996).

Joseph (1997) observed that environmental enrichments had high influence on the cost of production. He opined that economic pig production could be achieved by providing suitable combinations of environmental enrichments during appropriate times of growth.

A study conducted by Beattie *et al.* (2000) demonstrated a link between rearing environment and meat quality through improved production performance.

On analysing the adverse effects of tropical climate on the growth performance of growing pigs, Dominique *et al.* (2000) found out that, in the tropics, growth performance varied with the season.

The increase of ambient temperature above the thermoneutral zone is associated with a decrease of performance in weaned piglets, growing-finishing pigs and lactating sows, due to reduced feed intake (Quiniou *et al.*, 2000a).

### 2.2.6 Effect of Environment on Behaviour

Hicks *et al.* (1998) conducted a study on the behavioural measures for pigs exposed to acute stress. It was observed that high ambient temperature was associated with reduced aggression in pigs.

After studying the temperature regulatory behaviour, comfort behaviour and dunging preferences of growing pigs, Olsen *et al.* (2001) found out that heat made the pigs to defecate and urinate on solid-floored areas of the pen in an attempt to wallow in their own dung and urine. Since it caused poor hygiene in the pen, it was important to provide them with facilities that allow them to cool themselves on hot days.

## 2.3 WATER SPRINKLING

Heitman *et al.* (1962) studied the effects of modified summer environment on swine behaviour. It was observed that, on hot days pigs might cool themselves by going into a wallow or under water sprinklers.

After studying the misting control strategy for growing-swine under summer conditions, Panagakis *et al.* (1996) suggested that misting could substantially reduce stressful conditions.

Joseph (1997) suggested that if halothane positive animals were reared for breeding, environmental enrichments in the form of water sprinkling, wallowing and access to a shaded range would have better effect.

White *et al.* (1998) used respiratory rate of mature boars as criteria to estimate the effectiveness of water sprinklers in combination with fresh water concrete wallows for cooling boars in a warm climate region during the warmest six months of the year. Sprinkled boars had significantly lower respiratory rate during the warm season than non-sprinkled boars. The greatest differences occurred when mean monthly ambient temperature was greater than 30°C. Thus, the non-sprinkled boars were more heat stressed than sprinkled boars during the warm season. Boars in the study needed sprinklers and wallows when ambient temperature exceeded 23.4°C, black globe temperature exceeded 30.7°C or the temperature humidity index was greater than 71.3 units. Thus, the combination of water sprinklers and wallows used under shade in open-sided swine housing functioned effectively in a warm humid climate to enhance cooling of boars as evidenced by the reduced respiratory rate in sprinkled boars when compared with non-sprinkled boars. Combinations of shade, water sprinklers and wallows provided effective protection against high ambient temperature.

When conventional pig houses were provided with sprinklers, there was significant reduction in the air temperature to 33°C. The maximum beneficial effect of sprinklers was evident in reproduction parameters (Ramesh *et al.*, 2001).

## 2.4 BEHAVIOUR

### 2.4.1 Agonistic Behaviour

In a study conducted to assess the behaviour of weaned pigs, Rushen (1987) observed that mutual chronic aggression affected growth rate more than the intense fighting shortly after pigs have been mixed.

According to Rundgren *et al.* (1990a), the frequency of attacks and retreats did not differ between the halothane genotypes, but a tendency towards an interaction with sex was found. Gilts attacked more than castrates, and among the latter the number of attacks was higher for homozygous halothane resistant pigs than for the halothane sensitive ones, whereas among the gilts this order was reversed.

Within a group of animals, independent of group size, only a small (<3) number of pairs would be engaged in agonistic encounters at any one time (Nielsen *et al.*, 1995).

On analysing the behaviour of pigs exposed to acute stress, Hicks *et al.* (1998) found out that aggression was reduced when the ambient temperature was high.

Environmental enrichment reduced the time spent inactive and time spent involved in harmful social and aggressive behaviour while increasing the time spent in exploratory behaviour (Beattie *et al.*, 2000).

Ishiwata *et al.* (2002) suggested that the presence of a box in the pen reduces agonistic behaviour in pigs after regrouping.

### 2.4.2 Feeding Behaviour

Individual pigs could adapt to the physical and social constraints imposed by the system, by altering aspects of their feeding behaviour. Feeder access competition resulting from social synchrony and facilitation strongly influenced feeding behaviour of pigs (Young and Lawrence, 1994).

Nielsen *et al.* (1995) conducted a study on the effect of group size on feeding and social behaviours of pigs. They could not find any difference between group sizes in the daily feed intake, daily live weight gain feed conversion ratio or the number of attempts to displace other pigs from the feeder. It was suggested that aggression and growth might be independent characteristics. While studying the feeding behaviour, they observed that group housed animals preferred to feed at the same time, resulting in peaks in feeding activity.

According to Manju (1997) there was not much difference between the positive and negative groups. However positive groups showed better feeding temperament.

The feeding behaviour of pigs was mainly diurnal; and meal duration (+3 min) and meal size (+47 g) increased while temperature decreased from 22 to 12°C. But the daily number of meals (11) was not affected (Quiniou *et al.*, 1997).

Group housed pigs make less frequent feeder visits of longer duration, and eat at a faster rate than pigs housed individually. They also have lower growth rates, which may be due to elevated stress levels resulting from changes in the concentrations of hormones, such as cortisol and adrenaline associated with aggression and social stress (Bornett *et al.*, 2000). The results suggest that group cohesion is most likely to have been causal in the observed changes in feeding behaviour.

Dinesh (2000) observed that during feeding time all the animals tried to displace their penmates from the manger.

Morgan *et al.* (2000) suggested that: (1) pigs eat in meals separated by long intervals; (2) meals consist of clusters of eating bouts separated by shorter intervals, sometimes associated with drinking; (3) within each eating bout short intervals occur as pigs constantly move in and out of the feeder.

### 2.4.3 Eliminative Behaviour

Normally pigs attempt to urinate and defecate furthest away from their resting area (Whatson, 1978; Stolba and Wood-Gush, 1989).

Wechsler and Bachmann (1998) did a sequential analysis of eliminative behaviour of pigs. The typical sequence of behavioural elements was: enter dunging area, sniff, posture, defecate/urinate, sniff. For defecation and urination, the percentage of sniffs classified as 'close to wall' was significantly higher before than after eliminative behaviour whereas the percentage of sniffs classified as 'close to floor' was significantly lower before than after eliminative behaviour. It was concluded that sniffing behaviour was temporally associated with eliminative behaviour in pigs.

Dinesh (2000) reported that pigs marked a definite area either near the waterer or near the wallowing tank for defecation and urination.

In a study conducted by Olsen *et al.* (2001), the pigs placed the majority (more than 75%) of their dung in the outdoor runs- about 50% in the wallow. The pigs excreted away from the roughage and their lying area. It was suggested that roughage was an important factor to both the pigs' temperature regulation and to where the pigs place their dung. No effect of climatic conditions was observed in the eliminative behaviour of the pigs. More than 75% of all urinations and defecations were placed outdoors; and the majority of it was in the wallow. The pigs used a bent posture during defecations and urination, keeping their fore- and hind-legs closer together than when either standing or walking. Pigs prefer to keep their feed free from dung.

## 2.5 GROWTH PERFORMANCE

In a study conducted by Eikelenboom *et al.* (1978), significant differences were found between halothane reactors and non-reactors in the growth traits of the boars in the Dutch Landrace breed. But in the Yorkshire breed no significant differences were found in these traits between reacting and non-reacting animals.

Several studies have shown little difference in growth rates between the two genotypes (Simpson and Webb, 1989; Sather *et al.*, 1991; Pommier *et al.*, 1992).

Pigs housed in the cool environment consumed more feed ($P<0.01$), gained more weight ($P<0.01$), and utilized feed more efficiently ($P<0.01$) than those in the hot environment (Schenck *et al.*, 1992).

Zhang *et al.* (1992) analysed the effect of halothane gene on swine performance. They concluded that breeding groups with only one copy of the gene (Nn), grew rapidly and had relatively good carcass quality compared with groups with two copies.

McPhee *et al.* (1994) reported that the halothane allele reduced appetite, growth rate, feed conversion ratio and back fat. The study revealed that the halothane allele had the capacity for improving such economically important traits as food conversion efficiency and carcass leanness.

Growth rate was similar for all the 3 NN, Nn and nn genotypes, but food consumption tended to be lower in nn pigs than in those of the other genotypes (Gueblez *et al.*, 1995).

Katsumata *et al.* (1996) reported that growth rates were significantly lower at the high ambient temperature.

Manju (1997) opined that growth performance was not influenced by halothane genotype or transportation. She recorded the body weight of halothane negative non-transported pigs, halothane positive non-transported, halothane negative transported and halothane positive transported crossbred pigs in the seventh month as 58.25 kg.,55.5 kg., 59.4 kg. and 56 kg respectively.

Singh *et al.* (1997) studied 60 crossbred (LWY x Desi) piglets from birth to 16 weeks of age for their performance with regard to their growth and feed conversion efficiency. The live weight of pigs at 16 weeks was 17.25$\pm$ 0.05 kg.

Animals with two copies of the malignant hyperthermia mutation (*nn*) displayed improved live animal performance compared with NN (normal) and Nn (malignant hyperthermia carrier) animals (increased feed intake, average daily gain and feed efficiency) (Byrem *et al.*, 1999).

During the finishing period (15-21 weeks) mean daily food intakes and growth rates were higher and food conversion ratios were higher for pigs in enriched environments compared with their counterparts in barren environments. This led to heavier carcass weights (Beattie *et al.*, 2000)

In the tropics, growth performance varied with the season and during the warm season, feed intake was a major limiting factor to growth rate (Dominique *et al.*, 2000).

Hermesch *et al.* (2000) reported that growth rate was genetically independent from meat quality traits.

On studying the genetic correlations of growth, backfat thickness and exterior with stayability in Large White and Landrace sows, Lopez-Serrano *et al.* (2000) observed an antagonism between growth performance and longevity.

The increase of ambient temperature above the thermoneutral zone is associated with a decrease of performance in weaned piglets, growing-finishing pigs and lactating sows. This negative effect of warm exposure results mainly from a reduced voluntary feed intake. The decreased daily feed intake with increased temperature results from a meal size reduction whereas its frequency remains constant. Under warmer temperatures (above thermoneutral zone), feed intake capacity does not allow for compensation of the additional decrease in feed intake under warm conditions and performance is reduced (Quiniou *et al.*, 2000a).

### 2.5.1 Average Daily Gain and Feed Conversion Efficiency

Eikelenboom *et al.* (1980) reported that there was no effect of the halothane gene on feed efficiency in Dutch Landrace pigs.

While studying the effect of genetic and non-genetic factors on average daily gains in different age period in Landrace, Large White and their half-breds, Deo *et al.* (1981) observed that Large White pigs recorded a maximum average daily gain during 28 to 30 weeks of age (0.33 $\pm$0.025 kg.).

Kaczmarczyk and Koczanocoski (1981) reported from Poland that the average daily gain for Landrace pigs housed at 12 to 15, 15 to 18 and 18 to 21 degree centigrade during finishing averaged 516, 556 and 597 gram respectively.

Feed efficiency decreased as slaughter age increased and it was higher in Large White Yorkshire than crossbreds (Dash and Mishra, 1986).

Webb and Simpson (1986) reported that compared with negative reactors, halothane positive pigs showed significant advantages in food conversion ratio.

Podogaev (1989) assessed the performance and meat traits in pigs of different stress susceptibility. For the halothane resistant and susceptible pigs daily gain was 779 and 724 g, the consumption of FU/kg gain 3.6 and 3.9

Poltarsky (1989) assessed the performance and meat traits in pigs of different stress susceptibility. The differences in daily gain and backfat thickness between halothane positive and negative animals were non-significant.

The halothane sensitive pigs had higher daily weight gain and lower feed to gain ratio than halothane resistant animals (Rundgren *et al.*, 1990b).

Productivity of pigs in relation to stress resistance was studied by Babeev *et al.* (1991). Halothane-resistant pigs had higher average daily gains during finishing and better feed conversion efficiency than halothane-susceptible pigs.

Schenck *et al.* (1992) reported that pigs housed in the cool environment utilized feed more efficiently ($P<0.01$) than those in the hot environment.

A study conducted by McPhee *et al.* (1994) showed that the halothane allele had the capacity for improving such economically important traits as food conversion efficiency and carcass leanness.

Baik *et al.* (1995) opined that Yorkshires had the best feed conversion efficiency. Backfat thickness and feed conversion efficiency were significantly affected by parity of the dam.

Halothane carrier (Nn) pigs had a higher gain: feed ratio than halothane negative (NN) pigs, but average daily gain did not differ between the genotypes (Leach *et al.*, 1996).

A study conducted in South Africa by Fisher and Mellet (1997) proved that pigs with a halothane genotype nn showed the highest average daily gain and took fewer days to attain slaughter weight.

Joseph (1997) reported that halothane positive animals were better than halothane negative animals, in feed conversion efficiency and growth rate.

Kao *et al.* (1997) analysed the data on several Yorkshire pigs reared in Taiwan. The daily gains from 30 to 110 kg body weight were 952 g in boars and 740 g in females. The feed conversion ratio upto 110 kg was 2.49.

Manju (1997) opined that rate of gain or feed conversion efficiency was not influenced by halothane genotype or transportation.

Singh *et al.* (1997) reported that the cumulative feed conversion ratio of crossbred piglets was 3.62

After studying the rate of gain in body weights at different stages in Desi pigs, Lakhani (1999) reported the post-weaning average daily gain of Desi pigs to be 162 g.

On assessing the factors affecting pre-weaning and post-weaning average daily gain in Large White Yorkshire pigs, Singh *et al.* (1999) found out that the post-weaning average daily gain was 283.96 g.

Hermesch *et al.* (2000) observed that selection for improved feed efficiency and increased leanness increased the incidence of PSE meat. A higher average daily gain from three to 18 weeks was associated with an increased leanness, while a higher average daily gain in the later part of the growing period reduced leanness.

Deka *et al.* (2002) pointed out that genetic group had no significant influence on daily weight gain during any of the periods of growth.

## 2.6 BODY MEASUREMENTS

Gruev and Machev (1970) reported that sixth month body weight of pigs were significantly correlated with body length, height at withers and heart girth.

Dash and Mishra (1986) observed that there was significant difference in live weight, weight gain and body measurements between the weeks of growth, but not between breeds, in Large White Yorkshire pigs and its crossbreds. At the slaughter age of 24 weeks, the body length, height and girth of crossbreds were $94.23 \pm 1.90$ cm., $52.61 \pm 0.72$ cm., and $68.23 \pm 0.58$ cm. respectively.

## 2.7. RESPIRATION, PULSE RATE AND TEMPERATURE

In a study conducted by Geers *et al.* (1992) in homozygous halothane positive, homozygous halothane negative and heterozygous piglets, significant differences were observed in the levels, patterns and dynamics of subcutaneous temperature of the different genotypes. It was concluded that halothane gene carriers might also be identified by measuring body temperature profiles during exercise.

Sebastian (1992) concluded that the respiratory rate of swine was in the range of *19* to *28*.

Joseph (1997) reported higher pulse rate in pigs housed in open sties without facility for wallowing or water sprinkling than pigs housed in open sties with facility for wallowing and water sprinkling during the hot hours of the day. He opined that high values of rectal temperature, respiration rate and pulse rate indicated a certain level of thermal stress on animals without environmental enrichments.

Van-Milgen *et al.* (1998) reported that heat production increased linearly with the percentage of muscle. So, the added heat production of the higher-lean growth swine put increased pressures on the animals to maintain homeothermy under warm or hot environments.

White *et al.* (1998) used respiratory rate of mature boars as criteria to estimate the effectiveness of water sprinklers in combination with fresh water concrete wallows for cooling boars in a warm climate region during the warmest six months of the year. The combination of water sprinklers and wallows used under shade in open-sided swine housing functioned effectively in a warm humid climate to enhance cooling of boars as evidenced by the reduced respiratory rate in sprinkled boars when compared with non-sprinkled boars.

In Suzhong I pigs average respiratory rates were highest in summer and lowest in winter while pulse rates were highest in autumn (Shi *et al.*, 1999).

Brown-Brandl *et al.* (2001) suggested that respiratory rate and rectal temperature were two good indicators of thermal stress. Rectal temperature and respiratory rate increased non-linearly with increasing temperature.

Ramakrishnan (2001) observed that physiological variables like rectal temperature, pulse rate and respiratory rate of pigs did not vary between genetic groups.

## 2.8 CARCASS CHARACTERISTICS

Ayyaluswami *et al.* (1976) found out that the average backfat thickness was highly correlated with composition of the half carcass.

In a study conducted by Eikelenboom *et al.* (1978), Dutch Yorkshire and Dutch Landrace pigs were subjected to the halothane-test. In the Dutch Landrace breed significant differences were found between reactors and non-reactors in all carcass and meat quality characteristics of the gilts. Reactors possessed inferior meat quality, lower backfat thickness and carcass length while total meat percentage and meat to bone ratio were higher, when compared with non-reactors.

Schmidt and Kallweit (1980) reported that carcass composition was better in halothane positive pigs, while meat quality was better in halothane negative pigs.

Ramaswami *et.al.* (1985) suggested that in Large White Yorkshire pigs, dressing percentage, carcass weight and backfat thickness were directly proportional to slaughter weight.

Dash and Mishra (1986) observed that dressed weight at 24 weeks did not differ significantly between Large White Yorkshire pigs and its crossbreds.

Compared with negative reactors, halothane positive pigs showed significant advantages in eye muscle area, proportion of lean and visual conformation scores, but disadvantages in meat colour, incidence of pale, soft, exudative meat and carcass length (Webb and Simpson, 1986).

All the three halothane genotypes had similar backfat measurements (Jones *et al.*, 1988; Simpson and Webb, 1989)

For the halothane resistant and susceptible pigs, dressing percentage 68.6 and 66.4, and eye-muscle area 31.9 and 33.2 $cm^2$. Some other meat quality traits, such as the solids and protein percentages of lean, and some technological traits, were better in the susceptible than in the resistant pigs (Podogaev, 1989).

Poltarsky (1989) reported that the differences in daily gain and backfat thickness between halothane positive and negative animals were non-significant. Eye-muscle area was greater in positive than in negative animals, the difference being significant. A similar relationship applied to the percentage of lean in the carcass, where a significant difference was obtained between positive and negative barrows (46.3 vs. 45.1%).

Carcass lean content was higher, but meat colour paler for the nn(halothane positive) pigs compared with the NN (homozygous negative) and Nn(heterozygous) pigs. The organ weights were lower for the nn compared with the NN pigs (Rundgren *et al.,* 1990b). The nn pigs had higher dressing percentage than the other genotypes. The carcasses of the nn pigs were shorter.

Aalhus *et al.* (1991) found out that the relative growth of bone was similar for genotypes (P>0.05), but the relative growth of lean was lower and the relative growth of total fat and depot fat (subcutaneous and intermuscular) was higher for the nn genotype compared with Nn and NN. Although nn pigs had a higher lean content and higher lean: bone ratio than Nn or NN pigs at similar live weights, their relative advantage in composition decreased with increasing live weight.

Babeev *et al.* (1991) studied the productivity of pigs in relation to stress resistance. The ranking of resistant and susceptible pigs for carcass length and backfat thickness was not consistent for different breeds of pigs. But resistant pigs had a consistent superiority for loin-eye area over susceptible pigs.

Sather *et al.* (1991) assessed the effect of the halothane gene on pork production and meat quality of pigs reared under commercial conditions. They did not find any difference in dressing percentage between halothane carriers and halothane negative pigs.

No difference in linear carcass measurements was seen between the two genotypes (Sather *et al.*, 1991; Pommier *et al.*, 1992).

In hh (halothane susceptible) and HH (halothane resistant) barrows, loin-eye area averaged 39.69 and 34.67 $cm^2$ respectively; fat:lean ratio 0.39 and 0.49, and lean percentage 55.61 and 52.66, all differences being significant (Wolf and Kallweit, 1991).

Zhang *et al.* (1992) reported that halothane gene, when homozygous (nn), increases the water content in lean muscle and suppresses fat deposition in lean tissue while reducing the meat quality.

Oliver *et al.* (1993) suggested that halothane sensitivity affected all meat quality traits. Halothane positive animals showed less fat thickness and more lean percentage in the carcass.

Jones *et al.* (1994) analysed the production and ante-mortem factors influencing pork quality. Results from selection experiments for carcass lean content have showed little effect on meat quality. It was suggested that halothane–susceptible pigs accounted for only 25-30% of the incidence of PSE in commercial abattoirs in Canada.

The carcass quality of halothane-positive pigs was better than that of halothane-negative pigs (carcass lean 614 vs. 599 g/kg). The inverse relationship between carcass quality and meat quality was more pronounced in halothane-positive pigs than in halothane-negative pigs (DeSmet *et al.*, 1995).

Gueblez *et al.* (1995) suggested that the nn pigs had lower backfat thickness than NN pigs and higher loin eye area and lean percentage. There were no marked differences among genotypes for technological/cooking yield of meat.

The most pronounced effects of the halothane locus mainly concerned traits related to conformation, such as lean percentage or carcass length, and the pH measurement in eye muscle (Hanset *et al.*, 1995).

McPhee and Trout (1995) reported that the halothane allele *n* had little effect on carcass traits but for lean quality traits, the *n* allele acted additively to increase acidity, paleness, water lost through drip, centrifugation and cooking.

According to DeSmet *et al.* (1996), in a Belgian slaughter pig population, the halothane genotype was the predominant factor determining meat quality traits related to the PSE condition. For these traits, the Nn pigs were intermediate between NN and nn pigs, or close to NN pigs. Pork quality was dependent on various genetic and environmental factors, and their possible interactions. Meat quality was mainly associated with differences in the incidence of halothane susceptibility.

The halothane genotype did not have a significant effect on fatness and carcass composition, although the heterozygotes showed a significantly greater muscle depth than the nn homozygotes. There was no significant effect of halothane genotype on carcass and lean weight distribution. The halothane genotype had a significant effect on meat quality. The heterozygotes produced more pale soft exudative meat than the nn homozygotes (Garcia *et al.*, 1996).

Dressing percentage was higher in Nn pigs than in NN pigs, but there were no genotype differences for carcass length, backfat thickness or loin eye area (Leach *et al.*, 1996).

Candek (1997) studied the quality of pig meat and factors affecting its variability. He reported that the quality of pork was affected by a genetic effect, the sensitivity to halothane.

Fisher and Mellet (1997) studied the effect of halothane genotype on carcass and meat quality characteristics. It was observed that pigs with a halothane genotype nn had greater backfat thickness.

Manju (1997) observed that carcass characteristics like live weight of pigs at slaughter, carcass length, dressing percentage, meat bone ratio, loin eye area, backfat thickness and organ weights did not differ between the halothane genotypes.

Since consumer groups and industry demanded higher meat quality and more uniform products, meat quality traits were becoming more important relative to performance traits. Selection for both higher lean percentage and weight would decrease meat quality more than selection against backfat thickness (Sonesson *et al.*, 1998).

In a study conducted by Byrem *et al.* (1999), they found that animals with two copies of the malignant hyperthermia mutation (nn) yielded lower quality loin chops.

Carcass length was measured in centimetres with a cloth measuring tape from the anterior edge of the first rib to the anterior edge of the aitch bone. Backfat thickness was the mean of three measurements taken opposite to the first rib, last rib and last lumbar vertebra. Loin eye area was the mean of two measurements of traced impression areas of longissimus dorsi muscle taken with graph papers by making transverse incisions between $10^{th}$ and $11^{th}$ ribs in both the split halves (Mili *et al.*, 1999).

Beattie *et al.* (2000) assessed the influence of environmental enrichment on the behaviour, performance and meat quality of domestic pigs. According to them, pigs from enriched environments had greater levels of backfat and meat of better quality.

The swine stress gene (hal gene) in recessive homozygotes (nn) was associated with the occurrence of the porcine stress syndrome (PSS) and the occurrence of pale, soft, and exudative pork (PSE). In heterozygotes, (Nn), it was related to low quality of carcass, but higher carcass weight. The NN, Nn and nn animals did not differ in hot carcass weight, backfat thickness, muscle depth, lean meat percentage and longissimus dorsi muscle colour. The presence of hal gene in heterozygotes or recessive homozygotes was not associated with better carcass weight (Bastos *et al.*, 2001).

Effect of husbandry and housing of pigs on the organoleptic properties of bacon was studied by Maw *et al.* (2001). It was opined that important factors influencing meat quality were genotype, floor type and aerial environment.

# *Materials and Methods*

# 3. MATERIALS AND METHODS

The resources and facilities available at the Centre for Pig Production and Research, Department of Veterinary Surgery and Radiology, and Meat Technology Unit of the College of Veterinary and Animal Sciences, Mannuthy, Thrissur were mainly utilised for the study.

## 3.1 LOCATION

Mannuthy is geographically situated

at longitude 76°, 16″ E

at latitude 10°,32″ N and

at an altitude of 22.25 metres above MSL.

## 3.2 METEOROLOGICAL DATA

Meteorological data over a period of one year from July 2002 to June 2003 were collected from the Meteorological Station at Vellanikkara (Two kilometres from Mannuthy). Monthly averages of maximum and minimum temperatures, humidity, hours of bright sunshine, evaporation, wind velocity and monthly total rainfall were obtained. The experiment was conducted during the dry season at Mannuthy. (Somanathan, 1980).

## 3.3 EXPERIMENTAL ANIMALS

A group of male piglets in the age group of seven to eight weeks and similar in body weight in the Kerala Agricultural University Centre for Pig Production and Research, Mannuthy were subjected to the halothane test until sufficient number of halothane positive and negative animals were identified. Twelve halothane positive and twelve halothane negative piglets were selected at random, as uniformly as possible with respect to age and body weight, from among the tested piglets. They were considered as the experimental animals.

### 3.3.1 **Halothane Test** (Joseph, 1997)

The piglets were allowed to breathe halothane in oxygen at a concentration of 3.5 to 4 per cent through a face mask for two to five minutes. The animals were observed for hypersensitivity reactions such as the rigidity of limbs, widening of digits, hyperthermia, defecation and urination. The animals that showed hypersensitivity reactions were classified as halothane positive and those that did not show any hypersensitivity reactions were classified as halothane negative. The incidence of halothane sensitivity in the tested animals was worked out.

### 3.3.2 Allocation of experimental animals to treatment groups

The piglets were assigned to four treatment groups as given below:

T I
- G 1 Six halothane positive pigs with water sprinkling
- G 2 Six halothane negative pigs with water sprinkling

T II
- G 3 Six halothane positive pigs without water sprinkling
- G 4 Six halothane negative pigs without water sprinkling

## 3.4 MANAGEMENT

The pigs in all the treatment groups were maintained under the usual housing, feeding and management conditions prevailing in the farm. They were fed with standard concentrate ration having 18 per cent crude protein upto the age of five months and with 14 per cent crude protein during the rest of the study period. Daily twice feeding was followed. Monthly deworming and spraying of ectoparasiticides was practised. All the animals were kept castrated.

## 3.5 WATER SPRINKLING

The animals in the first treatment (T I) were sprinkled with water, from a garden sprinkler fitted on the wall between the sties of animals in group 1 and group 2. Sprinkling was done during the hot hours of the day, *i.e.* from 12 noon to 3.00 P.M., for the entire period of the experiment. The behavioural changes of the animals during sprinkling were observed.

## 3.6 BEHAVIOUR

The feeding, agonistic and eliminative behaviours of all the experimental animals were studied.

## 3.7 SLAUGHTER STUDIES

Three animals from each treatment group were selected randomly and slaughtered at the end of the experiment for evaluation of their carcass traits. The slaughter procedure was done by standard methods at Meat Technology Unit, College of Veterinary and Animal Sciences, Mannuthy.

## 3.8 OBSERVATIONS

Incidence of halothane sensitivity among the piglets subjected to the halothane test was worked out.

Rectal temperature, pulse rate and respiratory rate were recorded at weekly intervals throughout the experimental period.

Daily feed intake was recorded. The average daily gain and feed conversion efficiency were calculated.

The growth parameters like live weight, body height, length and girth of the pigs were recorded at fortnightly intervals throughout the experimental period. Body weight was recorded using a platform balance having a built-in cage. The height at the withers, body length *i.e.* the distance from the point of shoulder to the pin bones and chest girth just behind the elbow were measured in centimetres using a standard measuring tape.

When the animals were slaughtered at the end of the experiment, live body weight at slaughter, carcass weight, weight of head and individual organ weights were recorded; and dressing percentage calculated.

Carcass length was measured as the straight-line distance from the pubis symphysis to the anterior edge of the first rib taken on a suspended carcass.

The outline of the longissimus dorsi muscle between the tenth and eleventh rib was traced on a transparent paper, and the traced surface was plotted on a graph paper to calculate the loin eye area.

Backfat thickness was measured at the first rib, last rib and last lumbar vertebra, and the average was taken.

The observation on feeding behaviour in pigs was quantified by scores as described in Table 3.1(Joseph, 1997).

Table 3.1 Feeding Behaviour

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

Agonistic behaviour was quantified by recording the average number of agonistic encounters per one hour at feeding time.

Eliminative behaviour was quantified by recording the frequency of defecation and the quantity of faeces voided.

Assuming that feed represented 75 per cent of the total cost of production, the cost of production per kilogram live body weight, from weaning to slaughter, was calculated.

Data collected were statistically analysed (Snedecor and Cochran, 1985).

# Results

# 4. RESULTS

## 4.1. INCIDENCE OF HALOTHANE SENSITIVITY

Out of 40 crossbred (LWY x Desi) piglets screened, 23 animals were halothane positive and the rest (17) were halothane negative. The relative incidence of halothane sensitivity in crossbred piglets is depicted graphically in Fig. 4.1.

## 4.2. CLIMATIC VARIABLES

The climatic data over the period from July 2002 to June 2003 were collected from the meteorological station at Vellanikkara. Monthly averages of environmental variables such as maximum and minimum temperature, humidity, sunshine, rainfall (monthly total), and wind speed are presented in Table 4.1.

The mean daily maximum temperature observed varied between 28.9°C and 34.7°C; and minimum temperature varied between 22.1°C and 25°C.

The rainfall recorded during the period varied from nil in December and January to 571 mm in June.

## 4.3. RECTAL TEMPERATURE, RESPIRATORY RATE AND PULSE RATE

The mean rectal temperature, respiratory rate and pulse rate of the animals in different treatment groups are furnished in Tables 4.2,4.3 and 4.4 and depicted in Figures 4.2,4.3 and 4.4.

## 4.4. GROWTH

### 4.4.1 Feed Intake

The average daily feed intake of the animals in each fortnight is given in Table 4.5 and depicted in Fig.4.5.

### 4.4.2. Body Weight

The body weights of all the pigs were recorded at fortnightly intervals. The actual body weights of the pigs are given in Table 4.6 and depicted in Fig. 4.6. The adjusted body weight of the pigs are presented in Table 4.7 and depicted in Fig. 4.7.

### 4.4.3. Average Daily Gain and Feed Conversion Efficiency

The average daily gain (ADG) and feed conversion efficiency (FCE) are presented in Tables 4.8. and 4.9 and depicted in Figures 4.8 and 4.9.

## 4.5. BODY MEASUREMENTS

The length, girth and height of the pigs in all the treatment groups at fortnightly intervals are furnished in Tables 4.10, 4.11 and 4.12 and depicted in Figures 4.10, 4.11 and 4.12.

## 4.6. BEHAVIOUR

All the four groups were active and exhibited playful behaviour at the time of cleaning the pen. At the time of water sprinkling, the animals in the two sprinkled groups preferred to walk beneath the showers of sprinkled water and explore the pen. They were alert during the hot hours of the day also. At noon, the non-sprinkled groups exhibited signs of panting and drooling of saliva. This was more evident in the positive non-sprinkled pigs. This group of positive non-sprinkled pigs also made unsuccessful attempts to wallow in the water trough. They were very aggressive during the hot hours of the day.

The group averages of feeding, eliminative and agonistic behaviours of the pigs are presented in Tables 4.13, 4.14 and 4.15.

### 4.6.1. Feeding Behaviour

Halothane positive pigs had better feeding behaviour scores than halothane negative pigs. A more or less similar feeding behaviour was shown by the sprinkled group and non-sprinkled group. The positive pigs drank water more frequently; particularly the non-sprinkled ones.

Since the animals were housed in groups, they showed great excitement and eagerness towards feed. They ate at a fast rate. Irrespective of group, all the animals tried to displace their penmates from the manger. But when the animals were housed individually for two days, they ate at a slower rate.

### 4.6.2. Agonistic Behaviour

Halothane positive pigs exhibited more number of agonistic encounters. On comparing the behaviours between the sprinkled and non-sprinkled pigs, the later group was found to be more restless and engaging in agonistic encounters. The highest number of aggressive encounters was among the halothane positive non-sprinkled animals.

### 4.6.3. Eliminative Behaviour

All the four groups preferred to defecate and urinate in areas away from their feed trough. The wet areas of the pen were the most preferred sites. During the entire study period, the sprinkled groups defecated in all areas of the pen, without any discrimination. Halothane positive pigs voided more quantity of dung than the halothane negative pigs. Among the sprinkled and non-sprinkled pigs, the non-sprinkled animals voided more quantity of dung. Among the four groups, the halothane positive non-sprinkled pigs voided the largest quantity. The frequency of defecation also followed the same pattern.

The non-sprinkled groups tried to wallow in their urine.

## 4.7. CARCASS CHARACTERISTICS

The carcass characteristics of the pigs in all the treatment groups are presented in Table 4.16.

## 4.8. COST OF PRODUCTION

The cost of production per kilogram live body weight of pigs in all the treatment groups were worked out, and are furnished in Table 4.17 and depicted in Fig 4.13.

Table 4.1: Climatic variables during the period from July 2002 to June 2003

| Month | Max. Temp. (°C) | Min. Temp. (°C) | Humidity 1(%) | Humidity 2(%) | Rainfall (mm.) | Rainy days | Sunshine (hrs.) | Windspeed (km/hr) |
|---|---|---|---|---|---|---|---|---|
| July 2002 | 29.8 | 23.1 | 94.0 | 74.0 | 354 | 21 | 105.7 | 3.8 |
| August | 28.9 | 22.9 | 94.0 | 78.0 | 507 | 19 | 96.8 | 3.8 |
| September | 31.1 | 23.0 | 92.0 | 62.0 | 124 | 8 | 233.4 | 3.7 |
| October | 30.8 | 23.2 | 92.0 | 74.0 | 387 | 19 | 136.4 | 3.3 |
| November | 31.8 | 23.4 | 82.0 | 60.0 | 22 | 3 | 189.2 | 4.7 |
| December | 32.3 | 22.1 | 72.0 | 45.0 | 0 | 0 | 270.0 | 8.1 |
| January 2003 | 33.2 | 22.9 | 66.0 | 34.0 | 0 | 0 | 291.2 | 8.6 |
| February | 34.7 | 23.6 | 83.0 | 43.0 | 162 | 5 | 258.0 | 5.1 |
| March | 34.6 | 24.1 | 86.0 | 47.0 | 95 | 4 | 94.8 | 3.7 |
| April | 34.6 | 25.0 | 86.0 | 58.0 | 24 | 3 | 225.4 | 3.2 |
| May | 34.0 | 25.0 | 88.0 | 56.0 | 40 | 3 | 194.3 | 3.8 |
| June | 30.9 | 23.8 | 91.0 | 68.0 | 571 | 19 | 119.3 | 3.2 |

Humidity 1 = Mean morning atmospheric humidity
Humidity 2 = Mean evening atmospheric humidity

Table 4.2 Mean weekly rectal temperatures of animals, °F

| Weeks | Treatment Groups | | | |
|---|---|---|---|---|
| | **G1** | **G2** | **G3** | **G4** |
| **1** | 103.3 ± 0.1 | 102.9 ± 0.6 | 103.1 ± 0.7 | 103.1 ± 0.5 |
| **2** | 103.3 ± 0.2 | 102.5 ± 0.7 | 103.0 ± 0.8 | 103.2 ± 0.8 |
| **3** | 103.1 ± 0.3 | 103.1 ± 0.7 | 103.4 ± 0.5 | 103.5 ± 0.7 |
| **4** | 103.4 ± 0.05$^{a}$ | 102.1 ± 0.2$^{b}$ | 103.3 ± 0.5$^{a}$ | 102.5 ± 0.5$^{b}$ |
| **5** | 103.0 ± 0.07 | 102.3 ± 0.4 | 103.7 ± 0.2 | 102.7 ± 0.2 |
| **6** | 103.9 ± 0.2$^{a}$ | 102.7 ± 0.7$^{bc}$ | 102.9 ± 0.8$^{abc}$ | 103.4 ± 1.0$^{ab}$ |
| **7** | 103.5 ± 0.2$^{a}$ | 102.7 ± 0.7$^{bc}$ | 102.7 ± 0.3$^{bc}$ | 103.3 ± 0.9$^{ab}$ |
| **8** | 103.5 ± 0.2 | 103.1 ± 0.5 | 103.0 ± 0.9 | 103.0 ± 0.5 |
| **9** | 103.1 ± 0.3$^{a}$ | 102.1 ± 0.6$^{bc}$ | 101.8 ± 0.5$^{bc}$ | 102.5 ± 0.9$^{ab}$ |
| **10** | 104.3 ± 0.2$^{a}$ | 103.6 ± 0.3$^{a}$ | 103.4 ± 0.9$^{b}$ | 103.2 ± 0.7$^{b}$ |
| **11** | 103.7 ± 0.6$^{a}$ | 102.7 ± 0.5$^{b}$ | 103.8 ± 0.6$^{a}$ | 102.9 ± 0.5$^{b}$ |
| **12** | 103.5 ± 0.4$^{a}$ | 103.0 ± 0.4$^{b}$ | 103.5 ± 0.4$^{a}$ | 103.0 ± 0.3$^{b}$ |
| **13** | 102.9 ± 0.2 | 102.7 ± 0.5 | 103.6 ± 0.3 | 102.8 ± 0.4 |
| **14** | 103.3 ± 0.3$^{a}$ | 102.7 ± 0.7$^{b}$ | 103.5 ± 0.8$^{a}$ | 102.9 ± 0.3$^{b}$ |
| **15** | 103.2 ±0.4 | 103.1 ± 0.6 | 103.7 ± 0.4 | 103.1 ± 0.7 |
| **16** | 103.2 ± 0.2 | 102.5 ± 0.3 | 103.8 ± 0.4 | 102.9 ± 0.5 |
| **17** | 103.4 ± 0.2$^{a}$ | 102.6 ± 0.8$^{b}$ | 103.6 ± 0.6$^{a}$ | 102.8 ± 0.3$^{b}$ |
| **18** | 103.6 ± 0.2$^{a}$ | 103.1 ± 0.5$^{b}$ | 103.6 ± 0.5$^{a}$ | 103.2 ± 0.5$^{b}$ |

Figures having different superscripts in a row differ significantly ($P<0.05$)
G1 – Halothane positive pigs with water sprinkling
G2 – Halothane negative pigs with water sprinkling
G3 – Halothane positive pigs without water sprinkling
G4 – Halothane negative pigs without water sprinkling

Table 4.3 Mean weekly respiratory rate of animals, per minute

| Weeks | Treatment Groups | | | |
|---|---|---|---|---|
| | **G1** | **G2** | **G3** | **G4** |
| 1 | $36.2^{a}$ | $34.2^{b}$ | $37.2^{a}$ | $34.8^{b}$ |
| 2 | 35.5 | 34.8 | 35.7 | 34.8 |
| 3 | 35.2 | 35.6 | 36.7 | 35.7 |
| 4 | 36.8 | 35.8 | 36.8 | 37 |
| 5 | $35.2^{a}$ | $35^{a}$ | $38^{b}$ | $35.5^{b}$ |
| 6 | 36.2 | 35.2 | 37.2 | 36 |
| 7 | 37.2 | 36.3 | 36.8 | 36.2 |
| 8 | $37.3^{a}$ | $36.6^{b}$ | $38.2^{a}$ | $37^{b}$ |
| 9 | $39.1^{a}$ | $37.1^{bc}$ | $38.3^{abc}$ | $38.7^{ab}$ |
| 10 | 41.8 | 40.1 | 38.2 | 40.2 |
| 11 | 42 | 40.3 | 40.7 | 40.3 |
| 12 | 41.3 | 41 | 42.2 | 41.3 |
| 13 | 41 | 41.5 | 41.3 | 42 |
| 14 | 40.8 | 41.5 | 41.7 | 40.5 |
| 15 | 41.8 | 41.5 | 43.3 | 41.8 |
| 16 | 42.8 | 41.5 | 42.8 | 43 |
| 17 | 42 | 42.3 | 42.8 | 42.3 |
| 18 | $44.2^{a}$ | $41.8^{b}$ | $43.8^{a}$ | $43.2^{b}$ |

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

Table 4.4 Mean weekly pulse rate of animals, per minute

| Weeks | Treatment Groups | | | |
|---|---|---|---|---|
| | G1 | G2 | G3 | G4 |
| 1 | 82.0 | 80.5 | 86.7 | 82.3 |
| 2 | 82.5 | 79.2 | 83.7 | 79.2 |
| 3 | 86.2 | 78.7 | 75.2 | 73.2 |
| 4 | 78.0 | 79.5 | 74.7 | 77.0 |
| 5 | 74.6 | 68.2 | 72.8 | 75.2 |
| 6 | 80.5 | 73.0 | 75.3 | 69.7 |
| 7 | $80.5^{a}$ | $69^{b}$ | $77.8^{a}$ | $69.3^{b}$ |
| 8 | $77.2^{a}$ | $69.8^{bc}$ | $68.7^{bc}$ | $75.0^{ab}$ |
| 9 | 69.2 | 70.7 | 71.3 | 73.5 |
| 10 | 67.5 | 71.7 | 67.8 | 71.8 |
| 11 | 71.7 | 72.0 | 73.5 | 71.2 |
| 12 | 69.5 | 66.3 | 71.2 | 72.8 |
| 13 | 68.0 | 67.5 | 72.7 | 70.0 |
| 14 | 68.8 | 65.2 | 71.3 | 69.5 |
| 15 | 68.7 | 65.5 | 68.3 | 67.3 |
| 16 | 69.0 | 63.8 | 68.5 | 67.2 |
| 17 | 66.5 | 64.2 | 67.7 | 64.5 |
| 18 | $65.5^{ab}$ | $60.3^{b}$ | $65.7^{a}$ | 73.0 |

Figures having different superscripts in a row differ significantly ($P<0.01$)

Table 4.5 Mean daily feed intake of animals, kg

| Fortnights | Treatment Groups | | | |
|---|---|---|---|---|
| | **G1** | **G2** | **G3** | **G4** |
| **1** | 0.383 | 0.483 | 0.480 | 0.553 |
| **2** | 0.643 | 0.733 | 0.720 | 0.780 |
| **3** | 0.763 | 0.837 | 0.793 | 0.980 |
| **4** | 0.933 | 1.033 | 1.033 | 1.163 |
| **5** | 1.097 | 1.497 | 1.237 | 1.180 |
| **6** | 1.517 | 1.650 | 1.663 | 1.830 |
| **7** | 1.893 | 2.050 | 2.047 | 2.072 |
| **8** | 2.003 | 2.220 | 2.153 | 2.227 |
| **9** | 2.150 | 2.293 | 2.207 | 2.323 |
| **Mean ± S.D.** | 1.265 ± 0.609 | 1.422 ± 0.641 | 1.370 ± 0.626 | 1.456 ± 0.625 |

Table 4.6 Mean and standard deviation of absolute body weights of animals, kg

| Fortnights | Treatment Groups | | | | |
|---|---|---|---|---|---|
| | **G1** | **G2** | **G3** | **G4** | |
| **Initial** | 8.917 ± 1.463 | 8.333 ± 1.506 | 9.250 ± 1.294 | 9.000 ± 1.378 | NS |
| **1** | 11.083 ± 2.035 | 10.500 ± 1.342 | 11.917 ± 1.828 | 11.500 ± 1.643 | NS |
| **2** | 14.250 ± 2.894 | 13.000 ± 2.236 | 14.917 ± 2.853 | 14.167 ± 2.443 | NS |
| **3** | 16.833 ± 3.971 | 15.500 ± 3.017 | 17.330 ± 3.615 | 17.333 ± 3.386 | NS |
| **4** | 21.500 ± 4.506 | 20.167 ± 4.491 | 23.000 ± 5.367 | 22.667 ± 3.983 | NS |
| **5** | 24.167 ± 5.456 | 24.000 ± 4.099 | 26.000 ± 5.404 | 25.000 ± 4.604 | NS |
| **6** | 33.167 ± 6.306 | 31.667 ± 6.250 | 34.417 ± 7.351 | 33.833 ± 5.601 | NS |
| **7** | 39.333 ± 6.501 | 37.333 ± 6.976 | 41.683 ± 8.605 | 39.500 ± 6.213 | NS |
| **8** | 45.167 ± 6.735 | 43.667 ± 8.214 | 48.500 ± 9.418 | 45.833 ± 6.875 | NS |
| **9** | 49.667 ± 7.174 | 48.167 ± 8.976 | 52.167 ± 9.847 | 50.167 ± 6.940 | NS |

NS = Non Significant at 5 per cent level

Table 4.7 Adjusted mean body weights of animals, kg

| Fortnights | Treatment groups | | | | |
|---|---|---|---|---|---|
| | **G1** | **G2** | **G3** | **G4** | |
| **1** | 11.040 | 11.059 | 11.530 | 11.371 | NS |
| **2** | 14.188 | 13.807 | 14.358 | 13.980 | NS |
| **3** | 16.756 | 16.503 | 16.639 | 17.102 | NS |
| **4** | 21.394 | 21.550 | 22.043 | 22.348 | NS |
| **5** | 24.051 | 25.507 | 24.956 | 24.652 | NS |
| **6** | 33.018 | 33.599 | 33.079 | 33.387 | NS |
| **7** | 39.169 | 39.476 | 39.600 | 39.006 | NS |
| **8** | 44.989 | 45.970 | 46.905 | 45.302 | NS |
| **9** | 49.483 | 50.552 | 50.516 | 49.616 | NS |

NS = Non significant at 5 per cent level

Table 4.8 Average daily gain of animals, kg

| Fortnights | Treatment groups | | | |
|---|---|---|---|---|
| | **G1** | **G2** | **G3** | **G4** |
| **1** | 0.1548 | 0.1548 | 0.1905 | 0.1785 |
| **2** | 0.2261 | 0.1785 | 0.2143 | 0.1905 |
| **3** | 0.1845 | 0.1726 | 0.1726 | 0.2261 |
| **4** | 0.3333 | 0.3333 | 0.4048 | 0.3810 |
| **5** | 0.1905 | 0.2741 | 0.2143 | 0.1666 |
| **6** | 0.6428 | 0.5476 | 0.6011 | 0.6310 |
| **7** | 0.4405 | 0.4048 | 0.4761 | 0.4046 |
| **8** | 0.4166 | 0.4523 | 0.5296 | 0.4523 |
| **9** | 0.3215 | 0.3215 | 0.2738 | 0.3095 |
| **Mean ± S.D.** | $0.3234^{NS} \pm 0.1488$ | $0.3155^{NS} \pm 0.1280$ | $0.3419^{NS} \pm 0.1539$ | $0.3267^{NS} \pm 0.1468$ |

NS = Non-significant at 5 per cent level

Table 4.9 Feed conversion efficiency of pigs

| Fortnights | Treatment groups | | | |
|---|---|---|---|---|
| | **G1** | **G2** | **G3** | **G4** |
| **1** | 2.48 | 3.12 | 2.52 | 3.10 |
| **2** | 2.84 | 4.11 | 3.36 | 4.09 |
| **3** | 4.14 | 4.85 | 4.59 | 4.33 |
| **4** | 2.80 | 3.10 | 2.55 | 3.05 |
| **5** | 5.76 | 5.47 | 5.77 | 7.08 |
| **6** | 2.36 | 3.01 | 2.77 | 2.90 |
| **7** | 4.3 | 5.06 | 4.3 | 5.12 |
| **8** | 4.8 | 4.91 | 4.07 | 4.92 |
| **9** | 6.69 | 7.13 | 8.06 | 7.51 |
| **Mean ± S.D.** | 4.02 ± 1.44 | 4.53 ± 1.27 | 4.22 ± 1.69 | 4.68 ± 1.59 |

Table 4.10 Mean fortnightly body length of animals, cm

| Fortnights | Treatment Groups | | | |
|---|---|---|---|---|
| | **G1** | **G2** | **G3** | **G4** |
| **Initial** | 45.833 ± 3.7 | 46 ± 3.6 | 48.167 ± 3.3 | 47.167 ± 2.2 |
| **1** | 50.667 ± 3.2 | 49.833 ± 2.4 | 51.5 ± 2.7 | 49.833 ± 1.9 |
| **2** | 54.167 ± 4.6 | 54.5 ± 3.7 | 55.167 ± 4.4 | 55.667 ± 3.0 |
| **3** | 57.333 ± 5.2 | 57 ± 3.5 | 58.833 ± 5.0 | 59.0 ± 4.1 |
| **4** | 62.333 ± 4.7 | 60.333 ± 3.7 | 62.167 ± 4.5 | 62.167 ± 3.1 |
| **5** | 65.000 ± 3.6 | 63.667 ± 4.2 | 65.667 ± 4.8 | 65.167 ± 3.1 |
| **6** | 67.500 ± 4.0 | 66.0 ± 4.5 | 69.167 ± 4.9 | 67.0 ± 2.7 |
| **7** | 70.333 ± 3.6 | 68.333 ± 4.1 | 72.0 ± 4.8 | 70.833 ± 3.7 |
| **8** | 72.667 ± 3.7 | 70.167 ± 4.2 | 74.833 ± 5.2 | 72.167 ± 3.6 |
| **9** | $74.833 \pm 3.1^{a}$ | $71.833 \pm 4.0^{b}$ | $76.5 \pm 5.08^{a}$ | $74.0 \pm 3.3^{b}$ |

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

Table 4.11 Mean fortnightly body girths of animals, cm

| Fortnights | Treatment Groups | | | | |
|---|---|---|---|---|---|
| | **G1** | **G2** | **G3** | **G4** | |
| **Initial** | 45.833 ± 3.5 | 43.333 ± 3.3 | 45 ± 2.8 | 44.667 ± 3.7 | NS |
| **1** | 47.667 ± 3.0 | 46.333 ± 3.5 | 48.667 ± 2.5 | 47.333 ± 3.4 | NS |
| **2** | 51.833 ± 4.7 | 50.667 ± 3.9 | 52.0 ± 3.7 | 51.5 ± 4.1 | NS |
| **3** | 56.167 ± 5.2 | 54.167 ± 3.8 | 55.5 ± 3.3 | 55.167 ± 4.1 | NS |
| **4** | 59.167 ± 4.9 | 58.667 ± 4.3 | 60.833 ± 4.3 | 59.667 ± 3.9 | NS |
| **5** | 63.667 ± 4.5 | 62.833 ± 5.4 | 63.333 ± 4.7 | 62.833 ± 3.9 | NS |
| **6** | 74.167 ± 5.4 | 73.833 ± 4.5 | 75.333 ± 3.4 | 75.667 ± 5.5 | NS |
| **7** | 78.5 ± 5.7 | 78.5 ± 5.5 | 82.0 ± 4.7 | 81.0 ± 4.6 | NS |
| **8** | 86.167 ± 6.9 | 83.8 ± 5.0 | 86.5 ± 5.6 | 87.667 ± 5.7 | NS |
| **9** | 89.667 ± 6.5 | 86.667 ± 6.5 | 89.667 ± 6.2 | 90.0 ± 5.4 | NS |

NS – Non significant at 5 per cent level

Table 4.12 Mean fortnightly body height of animals, cm

| Fortnights | Treatment Groups | | | | |
|---|---|---|---|---|---|
| | **G1** | **G2** | **G3** | **G4** | |
| **Initial** | 33.833 ± 0.7 | 34 ± 1.4 | 34.167 ± 1.3 | 35.167 ± 1.7 | NS |
| **1** | 36.833 ± 2.5 | 36.167 ± 2.2 | 37.5 ± 1.3 | 36.167 ± 2.0 | NS |
| **2** | 39.167 ± 2.4 | 39.167 ± 1.7 | 39.5 ± 1.7 | 37.833 ± 2.5 | NS |
| **3** | 45.5 ± 3.7 | 41.833 ± 2.4 | 42.333 ± 3.5 | 40.833 ± 3.6 | NS |
| **4** | 45.5 ± 3.7 | 43.833 ± 4.4 | 45 ± 3.8 | 42.667 ± 3.9 | NS |
| **5** | 48 ± 3.5 | 46.667 ± 4.1 | 47.167 ± 4.1 | 45 ± 4.7 | NS |
| **6** | 49.333 ± 3.9 | 48.833 ± 3.4 | 49.333 ± 3.5 | 47.833 ± 3.4 | NS |
| **7** | 50 ± 4 | 50.667 ± 2.4 | 50.5 ± 3.2 | 49.167 ± 2.9 | NS |
| **8** | 51.667 ± 3.9 | 52.167 ± 2.4 | 52.833 ± 3.4 | 50.5 ± 3.0 | NS |
| **9** | 53.167 ± 3.8 | 53.667 ± 2.7 | 54.167 ± 3.3 | 53.33 ± 3.6 | NS |

NS – Non significant at 5 per cent level

Table 4.13 Feeding behavioural scores of pigs

| Months | Treatment groups | | | |
|---|---|---|---|---|
| | **G1** | **G2** | **G3** | **G4** |
| **1** | 2.83 | 2.50 | 2.33 | 2.67 |
| **2** | 2.33 | 2.50 | 2.50 | 2.00 |
| **3** | 2.33 | 2.17 | 2.67 | 1.83 |
| **4** | 2.00 | 1.67 | 2.67 | 2.17 |
| **5** | 2.50 | 1.83 | 2.50 | 1.83 |
| **Mean ± S.D.** | 2.4 ± 0.3[a] | 2.13 ± 0.37[a] | 2.53 ± 0.14[a] | 2.1 ± 0.34[a] |

Figures having the same superscripts in a row do not differ significantly

Table 4.14 Eliminative behaviour of pigs

| | **G1** | **G2** | **G3** | **G4** |
|---|---|---|---|---|
| •Quantity of faeces voided (g. per 24 hr) | 2186.67[a] | 1993.33[a] | 2246.67[a] | 1956.67[a] |
| •Frequency of defecation (per 24 hour) | 11.67[b] | 11.5[b] | 11.83[b] | 11[b] |

•Group averages
Figures having the same superscripts in a row do not differ significantly

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Table 4.15 Agonistic behavioural scores of pigs

| Months | Treatment groups | | | |
|---|---|---|---|---|
| | **G1** | **G2** | **G3** | **G4** |
| **1** | 5.67 | 3.00 | 6.83 | 3.33 |
| **2** | 4.50 | 3.67 | 8.83 | 2.50 |
| **3** | 5.83 | 3.67 | 6.83 | 5.33 |
| **4** | 7.50 | 5.00 | 5.83 | 3.50 |
| **5** | 3.67 | 3.50 | 6.50 | 1.83 |
| **Mean ± S.D.** | 5.43 ± 1.45[a] | 3.76 ± 0.74[a] | 6.96 ± 1.12[a] | 3.3 ± 1.31[a] |

Figures having the same superscripts in a row do not differ significantly

Table 4.16 Carcass characteristics of the pigs at seven months of age

| Carcass characteristics | Treatment groups | | | | |
|---|---|---|---|---|---|
| | G1 | G2 | G3 | G4 | |
| Live weight at slaughter (kg) | 52.00 | 51.33 | 55.00 | 51.33 | NS |
| Carcass weight (kg) | 38.07 | 37.73 | 41.00 | 36.73 | NS |
| Half carcass weight (kg) | 19.03 | 18.87 | 20.50 | 18.37 | NS |
| Dressing percentage with head | 80.83 | 81.02 | 82.30 | 78.89 | NS |
| Dressing percentage without head | 73.19 | 73.50 | 74.49 | 71.55 | NS |
| Carcass length (cm) | 57.83 | 57.67 | 63.17 | 57.00 | NS |
| Back fat thickness (cm) | 2.82 | 2.48 | 3.36 | 2.75 | NS |
| Loin eye area (cm) | 18.71 | 18.6 | 25.63 | 15.08 | NS |
| Weight of head (kg) | 3.97 | 3.84 | 4.29 | 3.77 | NS |
| Weight of feet (kg) | 0.85 | 0.85 | 0.98 | 0.86 | NS |
| Weight of gut (kg) | 8.00 | 7.17 | 7.83 | 8.67 | NS |
| Weight of heart (kg) | 0.15 | 0.15 | 0.181 | 0.14 | NS |
| Weight of lungs (kg) | 0.73 | 0.72 | 0.82 | 0.78 | NS |
| Weight of diaphragm (kg) | 0.12 | 0.11 | 0.17 | 0.12 | NS |
| Weight of liver (kg) | 0.7 | 0.80 | 0.74 | 0.77 | NS |
| Weight of spleen (kg) | 0.11 | 0.10 | 0.09 | 0.10 | NS |
| Weight of kidney (kg) | 0.17 | 0.17 | 0.17 | 0.15 | NS |
| De-boned meat (kg) | 31.64 | 31.73 | 34.44 | 30.6 | NS |
| Meat-bone ratio | 6.12 | 6.41 | 6.28 | 6.49 | NS |

NS = Non-significant at 5 per cent level

Table 4.17 Cost of Production per kilogram live body weight of pigs in different treatment groups

| | Treatment groups | | | |
|---|---|---|---|---|
| | **G1** | **G2** | **G3** | **G4** |
| No. of animals | 6 | 6 | 6 | 6 |
| Total initial body weight (kg) | 53.5 | 50 | 55.5 | 54 |
| Total final body weight (kg) | 298 | 289 | 313 | 301 |
| Total body weight gain (kg) | 244.5 | 239 | 257.5 | 247 |
| Total feed intake (kg) | 956.2 | 1074.92 | 1036 | 1101.1 |
| Total feed cost (Rs.) | 7465.86 | 8395.13 | 8095.61 | 8599.6 |
| Cost of feed per kg (Rs.) | 7.81 | 7.81 | 781 | 7.81 |
| Feed conversion ratio | 4.02 | 4.53 | 4.22 | 4.68 |
| Cost of production on feed basis (FCR x Cost of feed/kg) (Rs.) | 31.4 | 35.38 | 32.96 | 36.55 |
| Cost of production per kg live body weight (Rs.)* | 41.87 | 47.17 | 43.95 | 48.73 |

* Under the assumption that cost of feed accounts for about 75 per cent of total cost of production in pigs (Joseph, 1997).

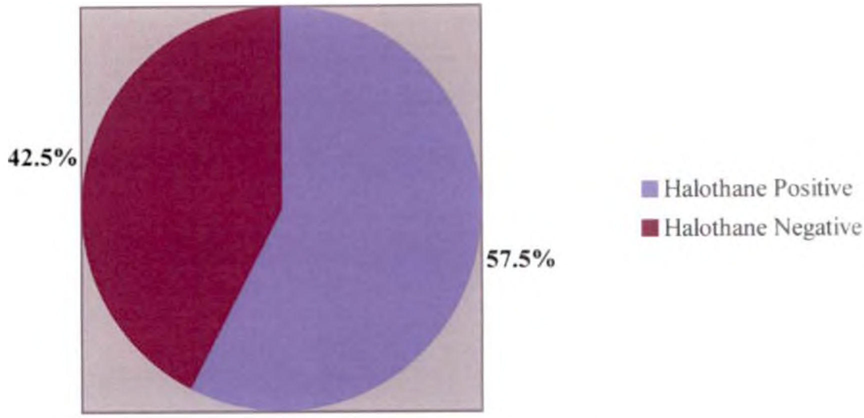
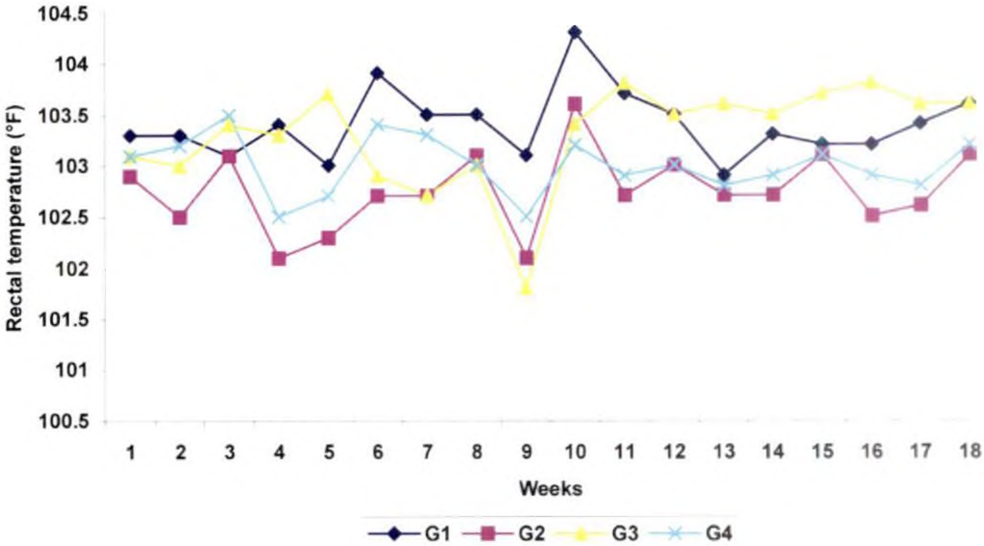



**Fig 4.1: Incidence of halothane sensitivity**




G 1 Halothane positive pigs with water sprinkling
G 2 Halothane negative pigs with water sprinkling
G 3 Halothane positive pigs without water sprinkling
G 4 Halothane negative pigs without water sprinkling

**Fig 4.2: Weekly rectal temperature of pigs**

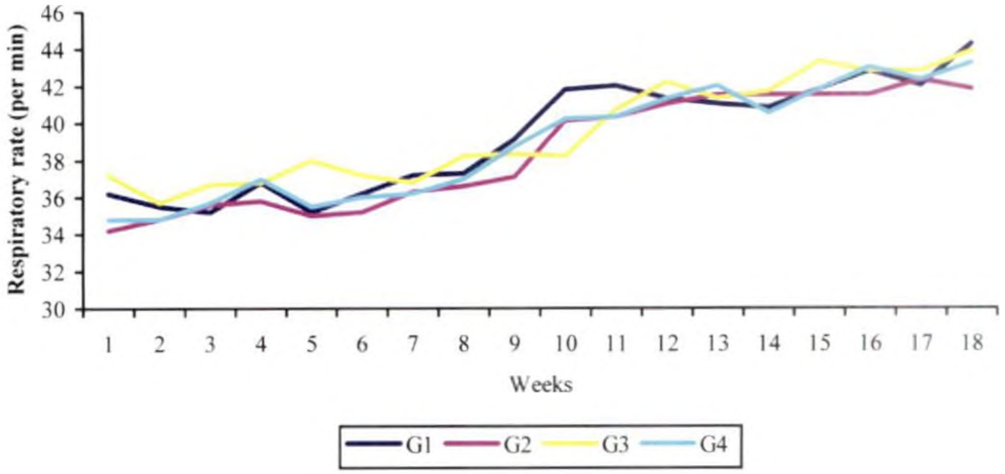



**Fig 4.3: Weekly respiratory rate of pigs**

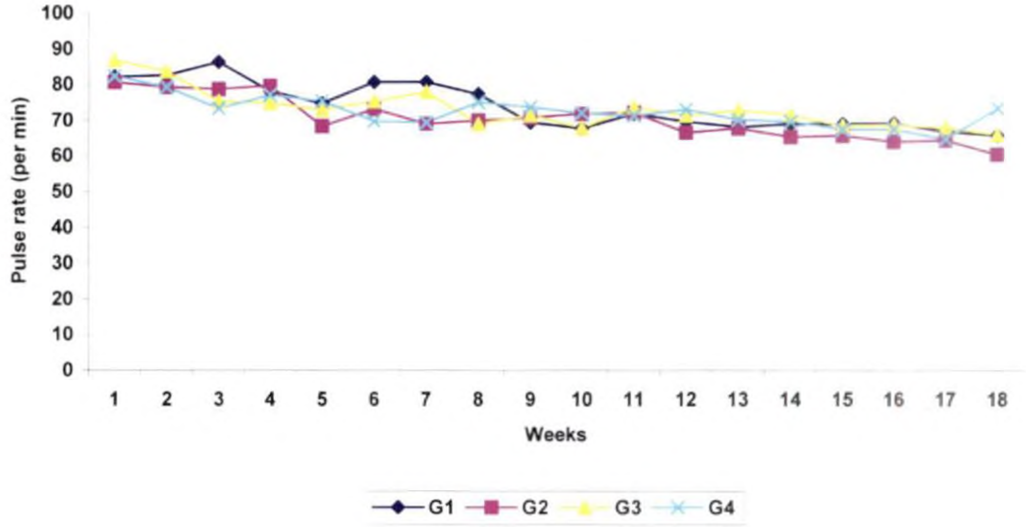



**Fig 4.4: Weekly pulse rate of pigs**

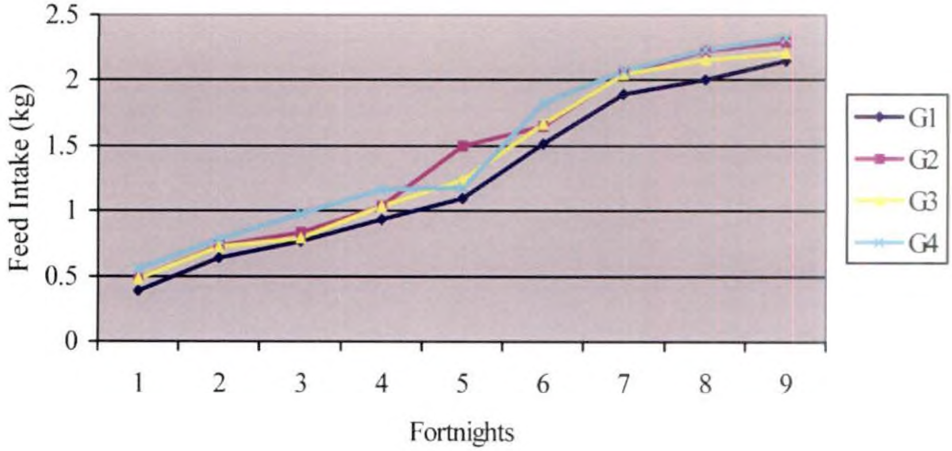



**Fig 4.5: Mean daily feed intake**

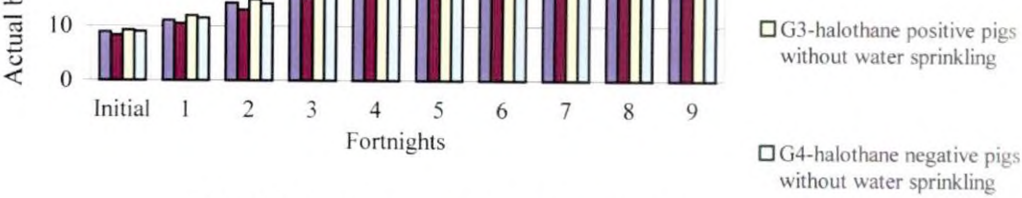



**Fig 4.6: Actual body weights (kg) of pigs**

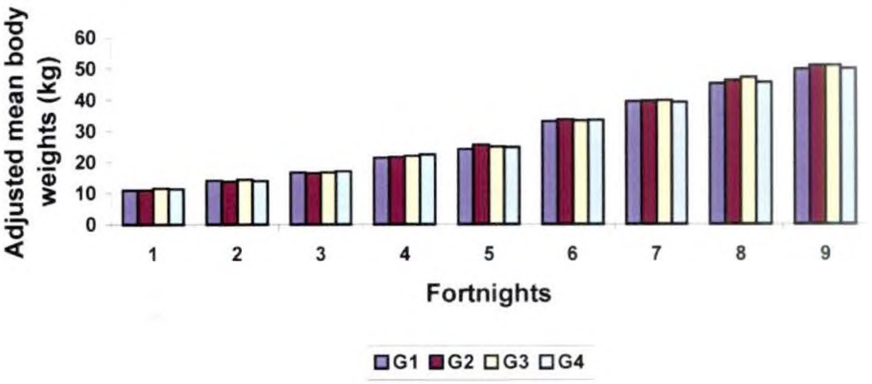



Fig.4.7 Adjusted body weight (kg)

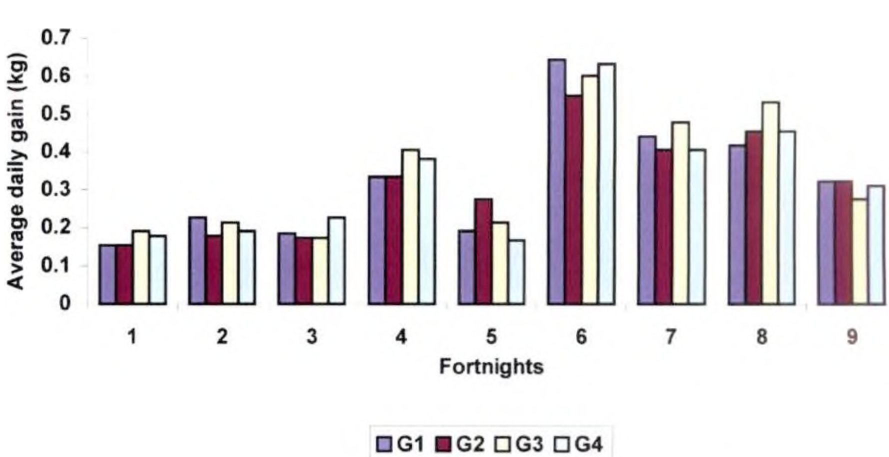



Fig.4.8 Average daily gain of animals, kg

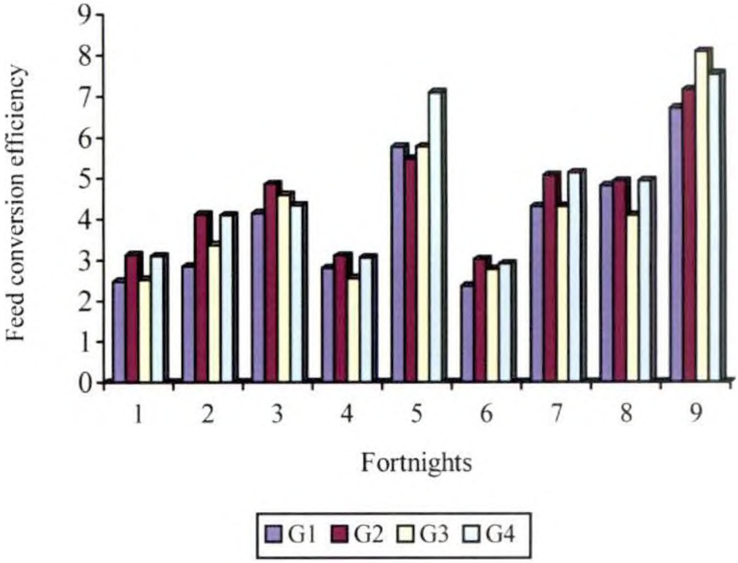



**Fig 4.9 Feed conversion efficiency**

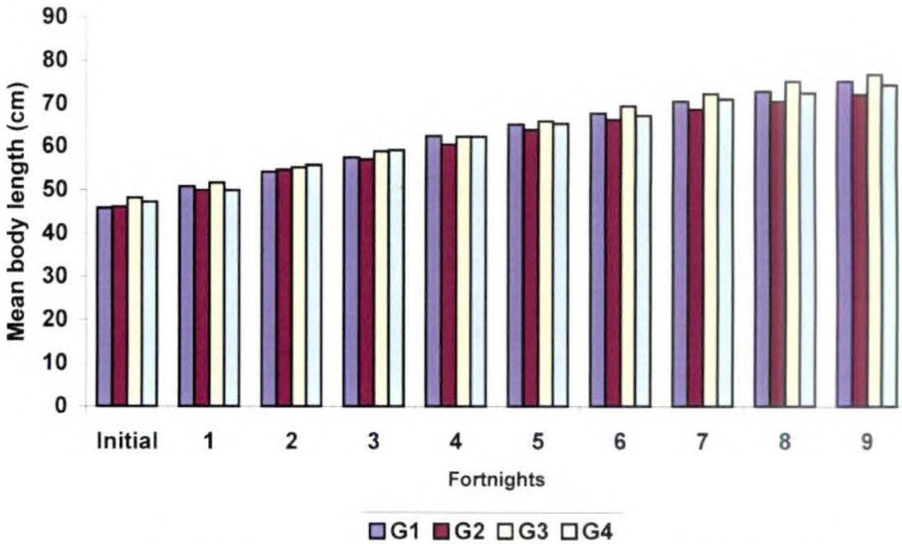



**Fig.4.10 Mean fortnightly body length of animals, cm**

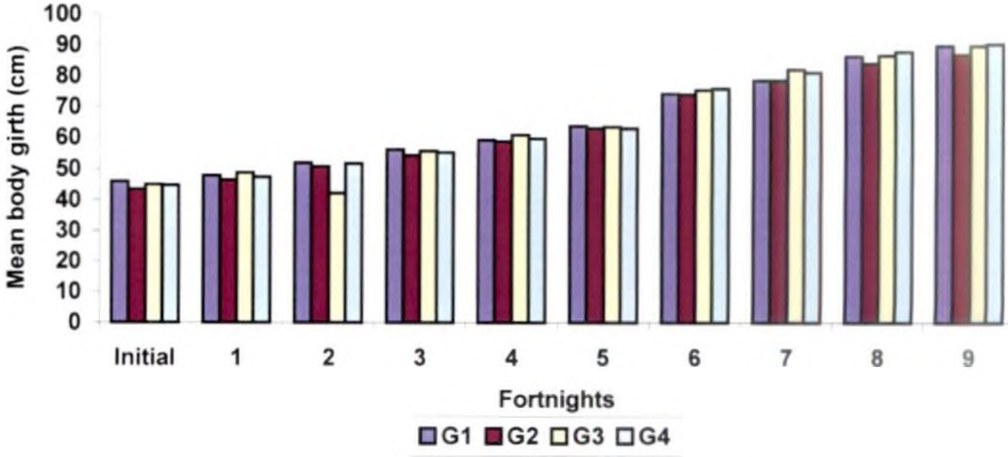



Fig.4.11 Mean fortnightly body girth of animals, cm

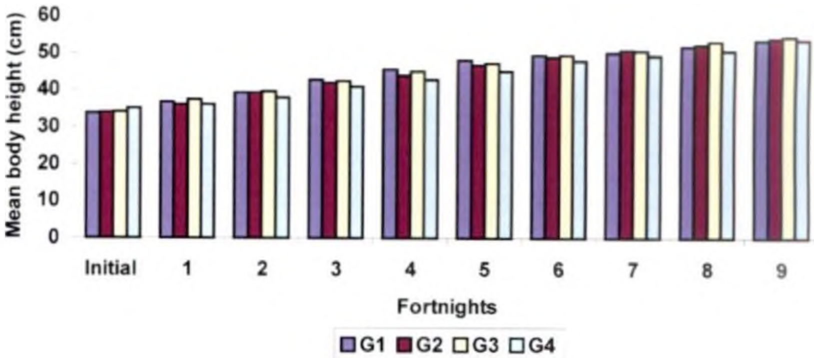



Fig.4.12 Mean fortnightly body height of animals, cm

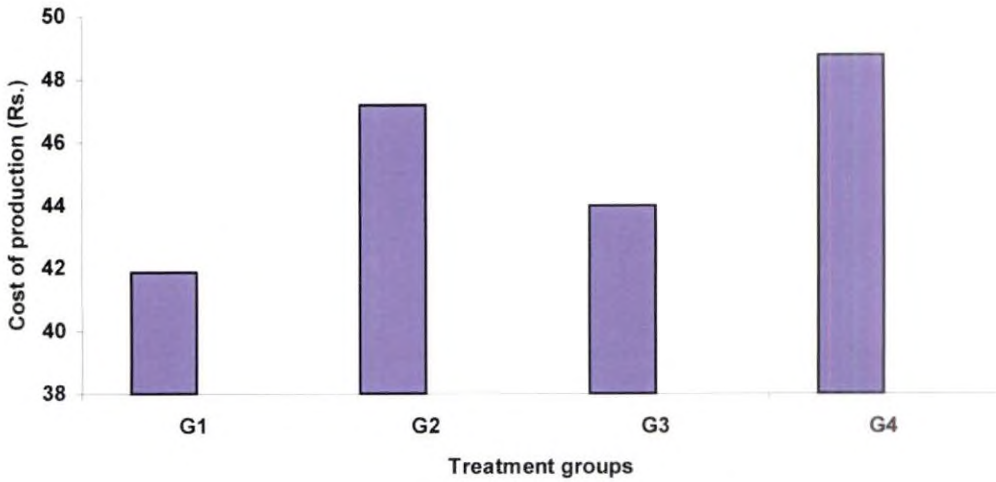



Fig.4.13 Cost of production per kilogram live body weight, Rs.

# *Discussion*

# 5. DISCUSSION

## 5.1. HALOTHANE SENSITIVITY

The relative incidence of halothane sensitivity observed in the present study is 57.5%. This value is higher than that observed by Wang *et al.* (1995), Li *et al.* (1996) and Joseph (1997) with respect to Large White Yorkshire pigs. This brings to light the fact that the incidence of halothane sensitivity in crossbreds is higher than that of LWY pigs. This might be due to the fact that the hal gene has a wide range of degree of penetrance in different breeds of pigs as opined by Bulla *et al.* (1991). The findings also indicate that there are a significant number of halothane positive pigs in the Centre for Pig Production and Research, Mannuthy. It increases the relevance of such a study for the implementation of simple management strategies for a major enhancement in production performance.

The hal gene in pigs is being used as an indicator of stress susceptibility and also improved production performance. In view of this genetic-environmental interaction, a high incidence of halothane sensitivity observed in this study may help to formulate appropriate management strategies for improved productive adaptability.

## 5.2. CLIMATIC VARIABLES

The data on climatic variables presented in Table 4.1 is a clear indication of the seasonal differences in Mannuthy from July 2002 to June 2003. The rainy season was from June to November and the dry season was from December to May. These climatic variables observed is similar to that reported by Somanathan (1980).

The mean daily maximum temperature observed varied between 28.9°C and 34.7°C; and minimum temperature varied between 22.1°C and 25°C.

The rainfall recorded during the period varied from nil in December and January to 571mm in June. Similar observations were reported by Dinesh (2000).

## 5.3. RECTAL TEMPERATURE, RESPIRATORY RATE AND PULSE RATE

It is clear from Table 4.2, 4.3 and 4.4 that high values were observed for rectal temperatures and respiratory rates in all the four treatment groups during the entire study period, which was in summer. This observation is in support to the related findings of Shi *et al.* (1999). During the fourth, 11$^{th}$, 12$^{th}$, 14$^{th}$, 17$^{th}$ and 18$^{th}$ weeks, the rectal temperatures of the halothane positive groups and halothane negative groups were significantly different ($P<0.05$). During the tenth week, there was significant difference between the sprinkled groups and non-sprinkled groups ($P<0.05$). The differences between the four groups during the 6$^{th}$, 7$^{th}$ and 9$^{th}$ weeks, were statistically significant ($P<0.05$).

The observed respiratory rate is higher than that reported by Sebastian (1992). Such a trend of high values indicates a certain level of thermal stress on the animals. This is in agreement with the observation of Joseph (1997) and Brown-Brandl *et al.* (2001)

During the 1$^{st}$, 8$^{th}$ and 18$^{th}$ weeks, the respiratory rates of the halothane positive groups and negative groups were significantly different ($P<0.05$). In the 5$^{th}$ week, there was significant difference between the sprinkled and non-sprinkled groups ($P<0.05$). In the 9$^{th}$ week, the difference between the four treatments was statistically significant ($P<0.05$).

Pulse rate of the animals showed normal values. In the 7$^{th}$ week, the pulse rate of halothane positive groups and halothane negative groups were significantly different ($P<0.01$). During the eighth and 18$^{th}$ weeks, the differences between the four treatments were statistically significant ($P<0.01$).

## 5.4. GROWTH

### 5.4.1. Feed Intake

The average daily feed intake of the four treatment groups of pigs increased progressively with the advance in age. From Table 4.5 it can be seen that the average daily feed intake of halothane positive sprinkled pigs, positive non-sprinkled pigs, negative sprinkled pigs and negative non-sprinkled pigs were 1.265 ± 0.609, 1.370 ± 0.626, 1.422 ± 0.641 and 1.456 ± 0.625 respectively.

Halothane positive pigs had a lower daily feed intake than the negative groups. This result is in agreement with the findings of McPhee *et al.* (1994) and Gueblez *et al.* (1995). This finding is suggestive of the influence of genotype on feed intake. In contrast to the reports of Beattie *et al.* (2000), the mean daily feed intake of the sprinkled pigs in the present study was lower than that of the non-sprinkled ones. A possible reason is that the sprinkled pigs were more engaged in exploratory behaviour.

### 5.4.2. Body weight

Body weight is considered the most important parameter for measuring growth.

The weaning weights of halothane positive sprinkled pigs, positive non-sprinkled pigs, negative sprinkled pigs and negative non-sprinkled pigs were 8.917 ± 1.463, 9.25 ± 1.294, 8.333 ± 1.506 and 9 ± 1.378 respectively. These initial weights of the animals in the different treatment groups did not differ significantly. The animals showed a progressively increasing weight with advancing age. The fortnightly body weights of the treatment groups were different at different stages of growth. But these differences were statistically non-significant.

By the end of the experimental period, the body weights of the halothane positive sprinkled pigs, positive non-sprinkled pigs, negative sprinkled pigs and negative non-sprinkled pigs were 49.667 ± 7.174, 52.167 ± 9.847, 48.167 ± 8.976, and 50.167 ± 6.94 respectively. Halothane positive groups and non-sprinkled groups showed slightly better growth, but the differences were not statistically significant. All the weights were lower than that observed by Manju (1997). This might have been due to the thermal stress on the animals during the summer months. This supports the view of Katsumata *et al.* (1996) who reported that growth rates were lower at high ambient temperature.

The result is supported by several studies, which showed very little difference in growth between the two genotypes (Eikelenboom *et al.*,1978; Simpson and Webb, 1989; Sather *et al.*, 1991; Pommier *et al.*,1992 and Manju, 1997).

### 5.4.3. Average daily gain and feed conversion efficiency

The average daily body weight gain of halothane positive sprinkled pigs, positive non-sprinkled, negative sprinkled and negative non-sprinkled pigs were 0.3234 ± 0.1488, 0.3419 ± 0.1539, 0.3155 ± 0.1288 and 0.3267 ± 0.1468 kg. respectively. Halothane positive groups showed slightly better growth. These differences between the four treatment groups were non-significant. This observation is akin to that of Poltarsky (1989), Manju (1997) and Deka *et al.* (2002).

Feed conversion efficiency of halothane positive sprinkled pigs, positive non-sprinkled, negative sprinkled and negative non-sprinkled pigs were 4.02 ± 1.44, 4.22 ±1.69, 4.53 ± 1.27 and 4.68 ± 1.59 respectively. The halothane positive sprinkled pigs had advantage over the other three treatment groups in feed conversion efficiency. This result is similar to the reports of Webb and Simpson (1986), Rundgren *et al.* (1990b), Schenck *et al.* (1992), McPhee *et al.* (1994) and Joseph (1997). But it does not agree with the findings of Babeev *et al.* (1991).

## 5.5. BODY MEASUREMENTS

The average body length, body girth and body height of the pigs in all the four treatment groups are given in Tables 4.10, 4.11 and 4.12 respectively.

During the ninth fortnight, the body lengths of halothane positive and halothane negative groups were significantly different ($P<0.05$).

The differences in the body girths and body heights of the four treatment groups were statistically non-significant.

On the whole, linear increases in all body measurements were seen with increase in body weight. This shows that the body weight and body measurements are correlated with each other, as reported by Gruev and Machev (1970).

## 5.6. BEHAVIOUR

It can be seen from Table 4.13 that halothane positive pigs showed better feeding behaviour scores. But the differences between the treatment groups were non-significant. This result is in agreement with that of Manju (1997).

The feeding behaviour exhibited by these group-fed animals are similar to that observed by Nielsen *et al.* (1995), Bornett *et al.* (2000) and Dinesh (2000). The general symptoms exhibited by the halothane positive non-sprinkled pigs are indicative of thermal stress on this group of animals.

The differences between the treatment groups regarding the agonistic behaviour scores were found to be statistically non-significant. This finding is in support to that of Rundgren *et al.* (1990a). Halothane positive non-sprinkled pigs exhibited the highest number of aggressive encounters. These aggressive encounters may be used as welfare indicators in confined pigs.

The eliminative behaviours shown by the animals were similar to that reported by Dinesh (2000) and Olsen *et al.* (2001). The frequency of defecation and the quantity of faeces voided are presented in Table 4.14. On statistical analysis, the differences between the treatments were found to be non-significant. Even then, the non-sprinkled halothane positive pigs voided the largest quantity.

In contrast to the reports of Whatson (1978) and Stolba and Wood-Gush (1989), which say that pigs urinate and defecate in areas away from their resting areas, the sprinkled pigs defecated in all areas of the pen, without discrimination. This might be due to the fact that all areas of these pens were wet from the sprinkled water.

The preference of the sprinkled groups to stand beneath the showers of sprinkled water supports the opinion of Heitman *et al.* (1962). The exploratory behaviour exhibited by these groups is an indication of the welfare level of these pigs.

The aggressive behaviour of the non-sprinkled groups and the attempts to wallow in the feed trough and their own urine throws some light on the stress level of these pigs.

## 5.7. CARCASS CHARACTERISTICS

Carcass traits of the four treatment groups of pigs are presented in Table 4.16.

The statistical analysis of the data indicated that live weight at slaughter, half-carcass weight, dressing percentage, carcass length, back-fat thickness, loin eye area, meat-bone ratio, weight of head and other organs did not show any significant difference ($P>0.05$) between the treatment groups. These results are in agreement with that of Jones *et al.* (1988), Simpson and Webb (1989), Sather *et al.* (1991), Pommier *et al.* (1992), McPhee and Trout (1995) and Manju (1997).

## 5.8. COST OF PRODUCTION

Cost of production is considered to be the basic measure of economic efficiency in swine farming. The production cost per kilogram of live body weight depends on the total feed intake, feed cost, feed conversion efficiency and total body weight gain. It can be seen from Table 4.17 that the cost of production per kilogram live body weight in halothane positive sprinkled pigs, positive non-sprinkled, negative sprinkled and negative non-sprinkled pigs were Rs.41.87, Rs.43.95, Rs.47.17 and Rs.48.73 respectively. The rearing of halothane positive pigs with sprinkling proved most profitable. It points to the favourable effect of environmental enrichment in the form of water sprinkling. Similar observations were made by Joseph (1997).

# Summary

# SUMMARY

An investigation was carried out in the Centre for Pig Production and Research, Mannuthy to assess the effect of water sprinkling in summer on the productive adaptability of halothane sensitive pigs.

Crossbred weaned piglets were randomly selected and screened for halothane sensitivity using the halothane challenge test. The incidence of halothane sensitivity in the tested animals was worked out.

Twelve halothane positive and twelve halothane negative piglets were selected at random, as uniformly as possible with respect to age and body weight, from among the tested piglets, and put into four groups (two halothane positive groups and two halothane negative groups), each comprising of six piglets.

Two groups (one halothane positive group and one halothane negative group) were sprinkled with water, from a garden sprinkler fitted on the wall between the sties of animals in the two groups. Sprinkling was done during the hot hours of the day, *i.e.* from 12 noon to 3.00 P.M., for the entire period of the experiment. The behavioural changes of the animals during sprinkling were observed.

The pigs in all the treatment groups were maintained under the usual housing, feeding and management conditions prevailing in the farm. They were kept castrated.

The physiological parameters, daily feed intake, growth performance, feed efficiency, behavioural characteristics and carcass characteristics of all the experimental animals were studied. The economics of production was calculated. The climatic profile of the area was also collected.

The relative incidence of halothane sensitivity in crossbred piglets of CPPR, Mannuthy was found to be 57.5%. For the physiological parameters, high values were recorded for rectal temperature and respiratory rate in all the four treatment groups during the entire study period, which was in summer. But the difference between the treatment groups was non-significant. Pulse rate of the animals showed normal values.

The average daily feed intake of the four treatment groups of pigs increased progressively with the advance in age. The average daily feed intake of halothane positive sprinkled pigs, positive non-sprinkled pigs, negative sprinkled pigs and negative non-sprinkled pigs were 1.265 ± 0.609, 1.370 ± 0.626, 1.422 ± 0.641, 1.456 ± 0.625 respectively. Halothane positive pigs had a lower daily feed intake than the negative groups. Feed intake of the sprinkled pigs in the present study was lower than that of the non-sprinkled ones.

The weaning weights of halothane positive sprinkled pigs, positive non-sprinkled pigs, negative sprinkled pigs and negative non-sprinkled pigs were 8.917 ± 1.463,9.25 ± 1.294, 8.333 ± 1.506 and 9 ± 1.378 respectively. The animals showed a progressively increasing weight with advancing age.

By the end of the experimental period, the body weights of the halothane positive sprinkled pigs, positive non-sprinkled pigs, negative sprinkled pigs and negative non-sprinkled pigs were 49.667 ± 7.174, 52.167 ± 9.847, 48.167 ± 8.976, and 50.167 ± 6.94 respectively. Halothane positive groups and non-sprinkled groups showed slightly better growth, but the differences were not statistically signfiicant.

Even though halothane positive groups showed slightly better growth, the treatment had no significant effect on the daily body weight gain.

Feed conversion efficiency of halothane positive sprinkled pigs, positive non-sprinkled, negative sprinkled and negative non-sprinkled pigs were 4.02 ± 1.44, 4.22 ±1.69, 4.53 ± 1.27 and 4.68 ± 1.59 respectively. The halothane positive sprinkled pigs had advantage over the other three treatment groups in feed conversion efficiency.

For body measurements, significant differences were obtained during some fortnights, but they were inconsistent.

The general behavioural symptoms exhibited by the halothane positive non-sprinkled pigs were indicative of thermal stress on this group of animals. Halothane positive pigs showed better feeding behaviour scores. Halothane positive non-sprinkled pigs exhibited the highest number of aggressive encounters. The frequency of defecation and quantum of dung voided followed the same pattern. Statistically non-significant differences were obtained for all the feeding, agonistic and eliminative behavioural characteristics.

Statistical analysis of data regarding the carcass traits indicated that live weight at slaughter, half-carcass weight, dressing percentage, carcass length, back-fat thickness, loin eye area, meat-bone ratio, weight of head and other organs did not show any significant difference ($P>0.05$) between the treatment groups.

The cost of production per kilogram live body weight in halothane positive sprinkled pigs, positive non-sprinkled, negative sprinkled and negative non-sprinkled pigs were Rs.41.87, Rs.43.95, Rs.47.17 and Rs.48.73 respectively. The rearing of halothane positive pigs with sprinkling proved relatively more profitable. It pointed to the favourable effect of environmental enrichment in the form of water sprinkling.

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# EFFECT OF WATER SPRINKLING IN SUMMER ON THE PRODUCTIVE ADAPTABILITY OF HALOTHANE SENSITIVE PIGS

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# ABSTRACT

A study was conducted to assess the effect of water sprinkling in summer on the productive adaptability of halothane sensitive pigs. Twenty-four weaned castrated crossbred male piglets were randomly selected after screening for halothane sensitivity. Twelve piglets, six halothane positive and six halothane negative pigs were sprinkled with water during hot hours of the day. The other twelve were treated as controls.

The relative incidence of halothane sensitivity observed was 57.5%. The halothane positive sprinkled pigs had advantage over the other three treatment groups in feed conversion efficiency, resulting in least cost of production for this group. The cost of production per kilogram live body weight in halothane positive sprinkled pigs, positive non-sprinkled, negative sprinkled and negative non-sprinkled pigs were Rs.41.87, Rs.43.95, Rs.47.17 and Rs.48.73 respectively. Thus, the rearing of halothane positive pigs with water sprinkling proved relatively more profitable.

Halothane positive pigs had a lower daily feed intake than the negative groups.

Sprinkling with water had no statistically significant effect on the physiological parameters, body weights, average daily gain, body measurements, behavioural characteristics and carcass traits of the animals.

Even though the differences between the treatments in the behavioural characteristics were non-significant, the number of aggressive encounters, the frequency of defecation and the quantity of dung voided were highest for the halothane positive non-sprinkled pigs.

The overall results obtained during the course of the study are the unit cost of production was less for halothane positive animals with environmental enrichment by sprinkling.