EFFECT OF HOUSING SYSTEMS ON THE REPRODUCTIVE PERFORMANCE OF SOWS AND GILTS

By

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THESIS

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Department of Livestock Production Management

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DECLARATION

I hereby declare that the thesis entitled "**EFFECT OF HOUSING SYSTEMS ON THE REPRODUCTIVE PERFORMANCE OF SOWS AND GILTS**" 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.

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CERTIFICATE

Certified that the thesis entitled "**EFFECT OF HOUSING SYSTEMS ON THE REPRODUCTIVE PERFORMANCE OF SOWS AND GILTS**" is a record of research work done independently by **Sri. V. Ramesh**, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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RAMESH, V.

Dedicated to my

beloved parents

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Introduction

INTRODUCTION

The success and efficiency of pig farming largely depend upon the reproductive performance of pigs. The information available does indicate that housing, management and environment can affect reproductive efficiency (Hughes and Cole, 1975; Hughes and Varley, 1980). Chronic exposure to high ambient temperature of 33.5°C to 35.5°C was found to delay puberty and increase behavioural anoestrus. The average air temperature, relative humidity and day length were significantly correlated with the conception rate with coefficients of -0.87, 0.66 and -0.97 respectively (Knotek *et al.*, 1984).

The housing system which provided less space and increased confinement delayed puberty and decreased conception rate, litter size and farrowing index. Improvement in the reproductive performance of gilts and sows was observed when they were maintained under range system (Christenson, 1981) or in sties were provided with wallowing tank and sprinklers (Wettmann and Bazer, 1985).

The pig owing to its lack of sweat glands and presence of layer of subcutaneous fat are very much vulnerable to heat stress. The indigenous pigs, by virtue of having evolved locally may have more adaptability to tropical conditions than the exotic pigs. However, because of the increased growth rate and body weights that the exotic pigs have, most of the organised pig farmers are rearing exotic stock. But 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 inturn lead to impairment of growth and reproduction.

At a rough estimate, out of 11.78 million pigs in India about 20 per cent are of exotic stock. In Kerala the figure would be about 30 to 40 per cent of 1.87 million pigs (Economic Review, 1993; FAO, 1995). Exotic pigs in the state are being maintained under various systems of housing. The systems that ameliorate the climatic stress on the exotic stock are likely to enhance the profitability of the pig enterprise.

Different housing systems have been utilized to reduced the climatic stress on pigs. A comprehensive study involving different housing systems simultaneously can bring out the merits and demerits of each system. Reports on the influences of different housing systems in India on pig reproduction are scanty and few. The present study aims to have a comprehensive knowledge on the effect of different climatic parameters on reproductive performance of sows and gilts. The study also aims to find out the relative efficiency of different housing systems with respect to reproductive performance of sows and gilts.

In the light of the foregoing the present study was undertaken with the objective of comparing the microclimate under different housing systems and their effect on the reproductive performance of female pigs.

Review of Literature

2. REVIEW OF LITERATURE

2.1 Age and weight of gilts at puberty

2.1.1 Housing systems

In general the gilts reared under confinement were found to reach the age at puberty later. Jensen *et al.* (1970) observed a 4 days increase in age at puberty of tethered gilts compared with nontethered gilts. The effect of confinement on increasing the age at puberty were reported by Meacham and Masincupp (1970), Blackwood (1972), Christenson (1981) and Germanova *et al.* (1996).

Mavrogênis and Robinson (1976) reported a very high difference of 14 days in age at puberty between individually penned gilts and group housed gilts. Christenson (1981) observed a difference of 5 days only between individual and group housed gilts. Whereas Nakamura *et al.* (1993) observed a still higher difference of 24.5 days between individual stalls and group stalls.

A lower proportion of gilts were found to reach puberty in confinement than non-confinement (Rampacek *et al.*, 1981).

2.1.2 Floor space and type of floor

Reducing the space allowance by increasing group size increased the age at puberty (Clark *et al.*, 1985).

Gilts reared under different types of floor were not had any difference in age at puberty. Jensen *et al.* (1970) observed no difference in puberal traits between gilts on dirt lots and littermates housed in a slotted floor building. The same results were observed by Phuah and Soo (1980), and Stansbury *et al.* (1987).

2.1.3 Housing enrichments

Housing enrichments in the form of wallowing, sprinkling and free access to range area, aided the gilts reach puberty earlier than control. Warnick *et al.* (1965) observed a 10 days increase in age at puberty of non-sprayed gilts compared with gilts sprayed with cold water. Tompkins *et al.* (1967) observed a difference of 4 days between sprayed and non-sprayed gilts, whereas Spitschak and Franke (1995) observed a still higher difference of 20 days between sprayed and non-sprayed gilts. Joseph (1997) observed a 21 days increase in the age at puberty of confined gilts compared with gilts reared under range system.

2.2 Percentage of oestrus occurrence

2.2.1 Housing systems

Gilts reared under confinement found to have reduced expression of regular oestrus cycle. Jensen *et al.* (1970)

found that occurrence of "quiet estrus" appeared to be more frequent in the tethered gilts in comparison with the non-tethered gilts. The effect of confinement reduced the expression of regular oestrous cycles (Hoagland *et al.*, 1980; Christenson, 1981 and Pearce *et al.*, 1993).

Gilts kept in individual pens had higher incidence of irregular oestrus cycles than gilts kept in group pens. (England and Spurr, 1969). Sommer (1980) reported that the females housed individually showed more contact seeking activity and stronger reaction to the observer during oestrus than group housed females, although a typical oestrus behaviour such as mounting was possible only in group.

A lower percentage of gilts showing regular oestrus cycle and higher percentage of silent estrus were reported in confinement reared gilts. Reel (1966) observed a lower percentage of gilts with regular oestrus cycles in gilts maintained completely in pens than the gilts exposed to strange areas. England and Spurr (1969) observed a higher incidence of behavioural anoestrus in confinement and non-confinement reared gilts (28 vs 16%).

Christenson and Young (1978) found that gilts in total confinement buildings had only 40-80 per cent of regular oestrus cycles (cyclic gilts) at breeding age. Christenson (1981) found that confinement and nonconfinement reared gilts had a 71.3 and 85.2 per cent respectively of heat occurrence. Christenson (1981) observed that higher incidence of behavioural anoestrus in confinement than non-confinement reared gilts (14.6 and 6.6%) respectively.

2.2.2 Floor space

Higher stocking density found to reduce the expression of estrous behaviour. Christenson and Ford (1970) observed that high stocking density and/or large group sizes have reduced estrous expression. In contrast Christenson and Hruska (1984) found that very low stocking density of three gilts/pen had a lower percentage of oestrus cycles than either 9, 17 or 27 gilts/pen.

2.3 Conception rate

2.3.1 Housing systems

Pigs reared in confinement had lower conception rate than non-confined pigs. Kabanov *et al.* (1974) found an increase of 6.1 per cent in conception rate among exercised sows than the non-exercised sows. Yarmark and Shatalin (1977) found the age at first conception as 251 days and conception rate as 100 per cent in forcefully exercised gilts. Plyaschenko *et al.* (1984) observed a higher difference of 10 per cent between confinement and non-confinement group. A difference of 6 per cent in forcefully exercised gilts. Plyaschenko *et al.* (1984) observed a higher difference of 10 per cent between confinement and non-confinement group. A difference of 6 per cent conception rate between non-exercised and exercised gilts was observed by Pokhodnya (1985). Pigs reared in pen fitted with individual boxes and access to a paddock had higher conception rate. Tamov and Benkov (1990) found that sows housed in groups of 12/pen with access to paddock, in groups of 12 per pen fitted with individual boxes and with access to a paddock. The conception rate to first mating was 43, 53 and 51 per cent and conception rate to 3 matings 62, 72, 76 per cent respectively. Sveistys and Juska (1991) observed a 7 per cent increased in conception rate in exercised gilts over non-exercised gilts.

Pigs reared in group housing had higher in conception rate than individual housing. Knap (1969) found a higher conception rate of 87.2 per cent for sows housed in groups of 5-6 than for sows individually housed 84.2 per cent. Schlegel and Sklenar (1972) observed a conception rate of 73.5 per cent and 62.2 per cent in group housed sows and gilts respectively in comparison with the 69.4 and 58.8 per cent in individually housed sows and gilts respectively. On the contrary Klatt and Schlisske (1974) found a 90 per cent conception rare in individually housed gilts, when the conception rate for group housed gilts was only 81.9 per cent.

Teodornovic *et al.* (1984) observed a higher difference of 18.5 per cent between individual stalls and group stalls.

2.3.2 Floor space

In group housing pigs reared in smaller group size had lower conception rate than the higher group size. Adler and Meding (1974) found that gilts and sows had a conception rate of 83.6 per cent and 82.3 per cent respectively in the smaller group and 97.2 per cent and 85.4 per cent respectively in the larger group. Abilay and Acda (1984) found that individually penned gilts at a floor space of 1.5 m^2/pig required only 1 service/conception. Whereas gilts in group pen having 2.4 m^2/pig had 1.4 services/conception.

2.3.3 Housing enrichments

Housing enrichments interms of wallowing, sprinkling and access to a shaded range area was found to have higher conception rate. Edwards *et al.* (1968) found that gilts maintained in the confinement had lower conception rates than those kept in outside pasture lots. Shearer (1974) observed that gilts housed in open fronted houses where the air temperature exceeded 25°C for 5 per cent of the time and in unshaded quarters where the air temperature exceeded 25°C for about 26 per cent of the time, the conception rate was 67 and 87 per cent respectively.

Gilts sprayed with cold water prior to insemination found to increase conception rate in comparison with non sprayed gilts (75.0 vs 65%) (Hendel, 1986). Spitschak and Franke (1995) who reported a conception rate of 93 to 100 per cent in extensively managed sows.

2.4 Gestation period

2.4.1 Housing systems

Krutyporokh (1974) found that confined sows farrowed during 110 days to 119 days post breeding, whereas the sows kept in range farrowed during 112 days to 117 days post breeding. Young *et al.* (1977) observed no significant difference in gestation period for the crossbred sows reared in indoor and outdoor. Hale *et al.* (1981) found that in gilts the mean length of gestation was 114.6 to 115.0 days and in sows 114.2 to 114.3 days for outdoor and indoor group respectively. Costa *et al.* (1995) observed gestation period of 115 days and 115.4 days for sows reared in outdoor and indoor respectively.

2.4.2 Floor space and type of floor

Abilay and Acda (1984) found that for individually penned gilts at a floor space of 1.5 m^2/pig, the gestation period was 112.0 days whereas for gilts in group pen having a floor space of 2.4 m^2/pig had a gestation period of 112.4 days. Rocha (1994) observed that sows managed on dirt lots with eucalyptus trees, the gestation period was 113.0 days, and sows in confinement with concrete floor had gestation period of 113.5 days.

2.5 Weight loss during lactation

Jensen *et al.* (1978) reported that there was no significant difference in weight loss during lactation between the sows reared in one unit system and two unit system.

The type of floor in the farrowing house also influenced the weight loss during lactation as the sows lost more weight on plastic-coated expanded metal flooring (PL) than concrete floors (Stansbury *et al.*, 1987)

Pigs reared in group housing had less weight loss during lactation than the individually housed sows (Rowlinson and Bryant, 1982 and Hulten *et al.*, 1995).

Costa *et al.* (1995) observed no significant difference in weight loss during lactation between two groups of pigs managed outdoor (or) indoor.

2.6 Litter performance

2.6.1 Housing systems

Schlegel and Sklenar (1972) observed that the sows and gilts in groups produced 0.1 and 0.4 piglets/litter more than those kept singly. When the gilts were reared in group Klatt and Schlisske (1974) observed a higher birth weight of 1.24 vs 1.16, a lower litter size of 9.78 vs 11.11 and lower litter weight of 12.15 vs 12.84 at birth for their litters than the individually housed gilts. Abilay and Acda (1984) found a birth weight of 1.1 kg vs 1.2 kg and litter weight of 10.7 vs 11.3 and litter size of 10.4 vs 11.2 between group housed and individually housed gilts respectively. The only advantage in group housed gilts noted was a lower mortality percentage (9.0% vs 18%). But Panaiotov and Benkov (1986); Gertken *et al.* (1993) and, Nakamura *et al.* (1993) observed a better litter performance of group housed sows and gilts. On the contrary, Hoy and Lutter (1995) found that group housing had a beneficial effect on the course of farrowing, but litter size fell by an average 1.2 piglets per litter and mean birth weight was reduced by 70 g than individual pens.

Danilenko and Fedotov (1974) observed that sows, housed in groups with or without access to a paddock or tethered indoors, the number of liveborn piglets averaged 9.9, 9.8 and 11.1 respectively, number of still born piglets 0.6, 0.4 and 0.1 respectively, litter weight at birth 13.0, 13.0 and 15.7 kg respectively, litter size at weaning 9.0, 9.1 and 9.6 respectively and piglet weaning weight of 17.4, 17.7 and 18.5 kg respectively indicating an advantages position for tethered system. Hale *et al.* (1981) found that exercised and non exercised dams farrowed 10.0 and 10.2 pigs respectively and had an average birth weight 1.6 and 1.5 kg respectively, weaned 8.1 and 7.9 pigs respectively and weaned pigs weighed 8.5 and 8.2 kg respectively. Pokhodnya (1985) found that sow groups (1) housed permanently indoors without exercise (2) allowed ad lib access to a paddock during pregnancy, (3) allowed access to a paddock for 2-6 h daily, and (4) allowed ad lib access to a paddock during pregnancy and 2-6 h daily during lactation. For the 4 groups respectively, litter size averaged 9.3, 9.4, 9.9 and 9.7 at birth and 7.8, 8.4, 9.2 and 9.1 at weaning, piglet survival to weaning 84.1, 86.1, 94.7 and 93.3 per cent and piglet weight at weaning at 28 days 5.88, 5.77, 5.89 and 5.86 kg. Troxler and Weber (1996) also found that tethered sows had larger litter size at birth and weaning than the sows in loose housing.

Kabanov *et al.* (1974) on the other hand observed that conception rate, litter size and piglet weight at weaning were exceeded by 6.1 per cent, 0.4 and 0.6 kg respectively in exercised sows than non exercised sows. The effect of loose housing on increasing the litter performance were also reported (Plyashchenko *et al.* 1984; Dyck *et al.*, 1988 and Weber, 1995).

Farrowing rate was found to be improved in exercised sows (90.7% vs 82.7%) than the sows kept in conventional houses (Kunavongkrit *et al.*, 1989).

Sidor (1991) observed that sows were housed in cages with an escape area for the piglets or in open without bedding. For the 2 groups respectively, the number of liveborn piglets per litter averaged 9.57 and 9.76, litter size at 21 days 8.57 and 7.62, litter weight at 21 days 45.1 and 39.6 kg and at weaning (35 days) 8.76 and 8.31 kg respectively.

2.6.2 Floor space and type of floor

Litter performance of sows and gilts having a larger floor space allowance had a lower litter size of 8.8 vs 9.2 and a lower piglets birth weight of 1.39 vs 1.4 kg Netherlands *et al.* (1984). Similar observation was made by Kuhlers *et al.* (1985). According to Darly *et al.* (1985) floor space allowance of less than $0.5m^2$/animal was found to reduce the litter size at the rate of 1.0 pig/litter and reduce the pig born alive at the rate of 0.7 pigs/litter.

Phuah and Soo (1980) compared the litters under concrete floors and metal mesh floors. The number of liveborn piglets per litter averaged 9.24 and 8.84 respectively, litter size at weaning (35 days) 6.18 and 7.18 respectively, preweaning mortality 30.65 per cent and 18.20 per cent respectively, piglets weaning weight of 5.21 and 5.62 kg respectively, and litter weight at weaning 32.24 and 40.80 kg. Christeson (1981) and Kornegay and Lindemann (1984) reported that litter performance was improved when litters were raised on plastic coated expanded metal flooring (PL) instead of concrete or solid flooring. Stansbury *et al.* (1987) observed 15 ± 3.4 kg heavier piglets at weaning on plastic coated expanded metal flooring than on the concrete flooring. He also observed a gradual decline in weaning weight from 63 ± 2.8 kg at 18°C to 61 ± 2.5 kg at 25°C and 52 ± 2.5 kg at 30°C. Paska and Elias (1989) found that litter less (or) straw litter flooring produced litter size at birth of 9.31 and 9.44 and litter size at 35 days 7.20 and 8.34 respectively.

McGlone and Morrow (1990) found that more piglets were crushed and fewer piglets were weaned when pens had a level floor rather than sloped floor. Lou and Hurnik (1994) observed an ellipsoid farrowing crate with oval horizontal frame and bowed vertical bars had lower still birth when compared to conventional rectangular crate.

2.6.3 Housing enrichments

Under range system an increased litter performance was observed by Mecham and Masincupp (1970). Costa *et al.* (1995) observed that sows managed in a range had larger litters at weaning (9.22 vs 8.47), heavier piglets at 21 days (6.48 vs 5.87 kg) and at weaning (10.6 vs 9.78 kg) than confined sows. Spitschak and Franke (1995) found that extensively managed sows of east German origin had litter size at birth of 11.4 and at weaning 9.7.

Earnst and Abramowsky (1993) observed that litter size at birth and number of liveborn piglets weaned were lower for sows under extensive management in a free range system when compared to sows managed indoors.

Whatley *et al.* (1957) observed that an increase in litter size may result from cooling sows with sprinklers during the summer. The effect of sprinkling on increasing litter performance were reported by Warnick *et al.* (1965); Tompkins *et al.* (1967) and Kornegay and Thomas (1983). Hendel (1986) found that gilts sprayed with cold water prior to insemination, had a significantly higher conception rate than nonsprayed controls (75.0 vs 65.0%). There were no significant difference in litter size between sprayed and non sprayed sows. Joseph (1997) observed that an increase in litter size and weight at birth and weaning may result from cooling sows with sprinklers and access to a shaded range area.

Krylov and Shakhnovich (1977) observed that piglets housed individually with under floor heating and piglets housed without under floor heating the weight at birth averaged 1.31, 1.42 kg respectively and at one month 7.4 and 7.12 kg respectively. Rocha *et al.* (1994) found that confined sows tended to have smaller litters at birth (8.9 vs 9.7) and at weaning (7.8 vs 8.4) and lower weaning weight (8 vs 7.3 kg) than sows on dirt lots.

Social environment was found to have improved effect on litter performance. Wechsler *et al.* (1991) have found that providing a natural and non stressful surroundings two sows i.e., the litters remaining with the dams until the birth of next litters and provision for nest activity and rooting areas, the sow produced 2.47 litter per year.

2.7 Period of post weaning oestrus

The interval from weaning to estrus is influenced by a number of variable factors. The period of post weaning oestrus ranges from 3 to 10 days. Housing systems also influence the period of post weaning oestrus.

2.7.1 Housing systems

England and Spurr (1969) found that the average interval from weaning to mating at first estrus was 5.3 and 5.7 days for individually and group penned sows. The same pattern of results were observed by Fahmy and Dufour (1970) and Teodorovic *et al.* (1984) with difference of 8 days between individual stalls and group stalls. But Gertken *et al.* (1993) observed only one day difference in period of post weaning oestrus between individual stalls and group stalls.

In contrast Sommer (1980) and Hemsworth *et al.* (1982) observed a shorter weaning to oestrus interval for sows housed in groups than in individual pens (7.9 and 23.0 days respectively). Nakamura *et al.* (1993) observed a higher difference of 30 days between group stalls and individual stalls.

Schlegel and Sklenar (1972) found that 87.6 per cent of group housed sows and 86.4 per cent of group housed gilts came into oestrus whereas 81.1 per cent of individually housed sows and 82.2 per cent of individually housed gilts exhibited oestrus. The difference was highly significant for sows. Pokhodnya (1985) reported 70 per cent, 84.6 per cent, 94.3 per cent and 95.0 per cent heat occurrence respectively after first farrowing for the sows housed permanently indoors without exercise, allowed ad lib access to a paddock during pregnancy, allowed access to a paddock for 2-6 hrs daily, and allowed ad lib access to a paddock during pregnancy and for 2-6 hrs daily during lactation. The percentage of heat occurrence for second farrowing were 80.9, 88.8, 96.8 and 97.0 respectively.

Ferket and Hacker (1985) observed that there was no significant difference in interval from weaning to first oestrous between sows housed indoor and housed outdoor. Rocha *et al.* (1994) found that sows managed on dirt lots with (or) without eucalyptus trees or in confinement had no significant difference in the interval from weaning to subsequent oestrus. On the contrary Costa *et al.* (1995) found that sows managed outdoors had a longer interval from weaning to first oestrus (7.67 vs 5.40 days) than confined sows.

Bryant *et al.* (1983) reported that the sows in group with boar present showed lactational oestrus within 15 days after farrowing. Whereas sows without boar present exhibited oestrus only 5 days after weaning. Stolba *et al.* (1990) found that increased complexity of housing system for lactating sows reduced the contact between the sow and the piglets and resulted in the incidence of lactational oestrus.

Primiparous sows had longer interval than the multiparous sows. Kunavongkrit *et al.* (1989) found that primiparous sows had smaller litters and a longer interval from weaning to oestrus than multiparous sows. On the contrary, Nakamura *et al.* (1993) observed that the average interval from weaning to mating was significantly shorter in gilts compared to sows.

Material and Methods

MATERIALS AND METHODS

Fifty four Large White Yorkshire gilts and fifty four Large White Yorkshire sows belonging to University pig breeding farm, Kerala Agricultural University, Mannuthy were utilised for the study. The pigs were maintained on rations with the following composition.

Composition of Ration's Fed

Rations	Ration I	Ration II
CP per cent	CP 18 per cent	CP 14 per cent
Age groups fed	<6 months and during lactation	>6 months
Ingredients (parts/1000)		
Yellow maize	400	300
Groundnut cake	150	80
Rice polish	170	280
Wheat bran	170	280
Dried unsalted fish	100	50
Common salts	5	5
Mineral mixture	5	5
Vitamin A B_2 D_3 (Rovimix)	100	100

Experimental design

The sows and gilts were randomly assigned to three experimental groups T_1, T_2 and T_3 each consisting of three groups of six sows and three groups of six gilts.

The eighteen groups of six sows and gilts thus formed were placed under three housing systems as detailed below.

T_1 -	Conventional house with wallowing and without sprinklers	six gilts	six sows
		six gilts	six sows
		six gilts	six sows
T_2 -	Conventional house with wallowing and sprinklers	six gilts	six sows
		six gilts	six sows
		six gilts	six sows
T_3 -	Range system (with night-time confinement in conventional houses)	six gilts	six sows
		six gilts	six sows
		six gilts	six sows

Housing system

Sows and gilts in the first experimental group (T_1) were housed in concrete floored loose housing system. The pen had a covered area of 1.9 m^2/animal and an open exercise yard of 2.9 m^2/animal including wallowing facility of 0.37 m^2/animal. The roof was of cement-asbestos sheets at an average height of 2.56 m at eaves and 4.24 m at ridge.

Sows and gilts in the second experimental group (T_2) were housed in the identical loose housing sties as that of group

(T_1), with a provision of sprinklers. Microsprinkler in each pen was operated continuously for 15 minutes in every 20 minutes interval during the hot period of the day from 12.00 p.m. to 3.30 p.m.

Sows and gilts in the first (T_1) and second (T_2) experimental groups, remained in their respective sties during day and night. All the animals were fed in accordance with the standard feeding schedule in the farm.

Sows and gilts in the third (T_3) experimental group were put under range system from 8.00 a.m. to 4.30 p.m. with a floor space of 24 m^2/animal. The sows and gilts were fed twice daily at 9.00 a.m. and at 2.30 p.m. in the range at the standard feeding schedule. Clean drinking water was made available to the animals at all times and wallowing facilities available in the range were utilised. After 5.00 p.m. the sows and gilts were moved into the conventional house.

Changes in microclimate

Microclimatic variables viz., temperature and relative humidity in different housing were recorded. The maximum and minimum temperature and relative humidity in the sties of T_1 and T_2 groups were recorded daily at 7.00 a.m. and 2.30 p.m. with the help of maximum and minimum thermometer and wet-dry bulb thermometer were installed in the sties. The range environmental temperature and relative humidity were measured using the instruments installed outside the shed. Asimulated natural surrounding were provided under the range system with the natural shade trees and wallows available in the range.

Age and weight of gilts at puberty

The first onset of oestrus in the gilts were recorded based on the behavioural manifestation and the nature of external symptoms of heat and further confirmed with the use of a boar. The age and weight of gilts at the time of puberty were recorded.

The intensity of oestrus symptoms were scored as given below:

Sl. No.	Description	Score
1.	Oestrus grunting, keeping away from other animals, retlessness, excitement swollen and moist vulva	1
2.	Slight discharge from vulva, swollen vulva, immobility response	2
3.	Typical mating stance and sniffing and fondling of boar and its genitalia, and allowing mating	3

The percentage of animals showing oestrus in different housing systems was recorded.

Breeding performance

The gilts were bred during the first oestrus and the sows during the first postweaning oestrus itself. Age and weight of gilts at the time of breeding were recorded. The gilts and sows were observed for positive signs of conception, viz. non-return to oestrus and physical signs of pregnancy within a period of 8 weeks. From this the percentage of successful breeding of gilts and sows in different housing systems was recorded.

Farrowing

All pregnant gilts and sows, one week prior to expected date of farrowing were transferred to farrowing pens. Prior to admittance, they were dewormed, washed, scrubed and sprayed against ectoparasites using a solution of Butox (0.02%).

Litter performance

All the pigs and their respective litters were housed separately till weaning (56 days). The litter performance, litter size and weight at birth and weaning were recorded.

Weight loss during lactation

The weight of the dam at weaning depends upon the weight of the dam at the time of farrowing. Weight of gilts and sows, one week after farrowing and at weaning were recorded. From this weight loss during lactation in gilts and sows were estimated.

Period of post weaning oestrus

The period of post weaning oestrus in gilts were recorded. In the sows two periods of post weaning oestrus were observed. The first post weaning oestrous periods were observed in the sows which were weaned while starting of the experiment. The second observation was made in the same sows after the end of subsequent weaning.

The following observations were made

1. The changes in indoor climatic variables like ambient temperature and relative humidity under different systems of housing in comparison to the outside.

2. Age of occurrence of first heat in gilts.

3. Percentage of animals showing oestrus.

4. Percentage of successful breeding.

5. Weight of gilts and sows at the time of breeding, one week after farrowing and at weaning.

6. Litter performance

   a. At birth

      (i) Litter size

      (ii) Litter weight

   b. At weaning

      (i) Litter size

      (ii) Litter weight

7. Preweaning mortality

8. Days required for onset of post weaning heat

The data collected during the course of the study were statistically analysed as per the methods described by Snedecor and Cochran (1985) and results interpreted.

Plate 1. Conventional house (Treatment 1)

Plate 2&3 Conventional house with sprinkler (Treatment 2)

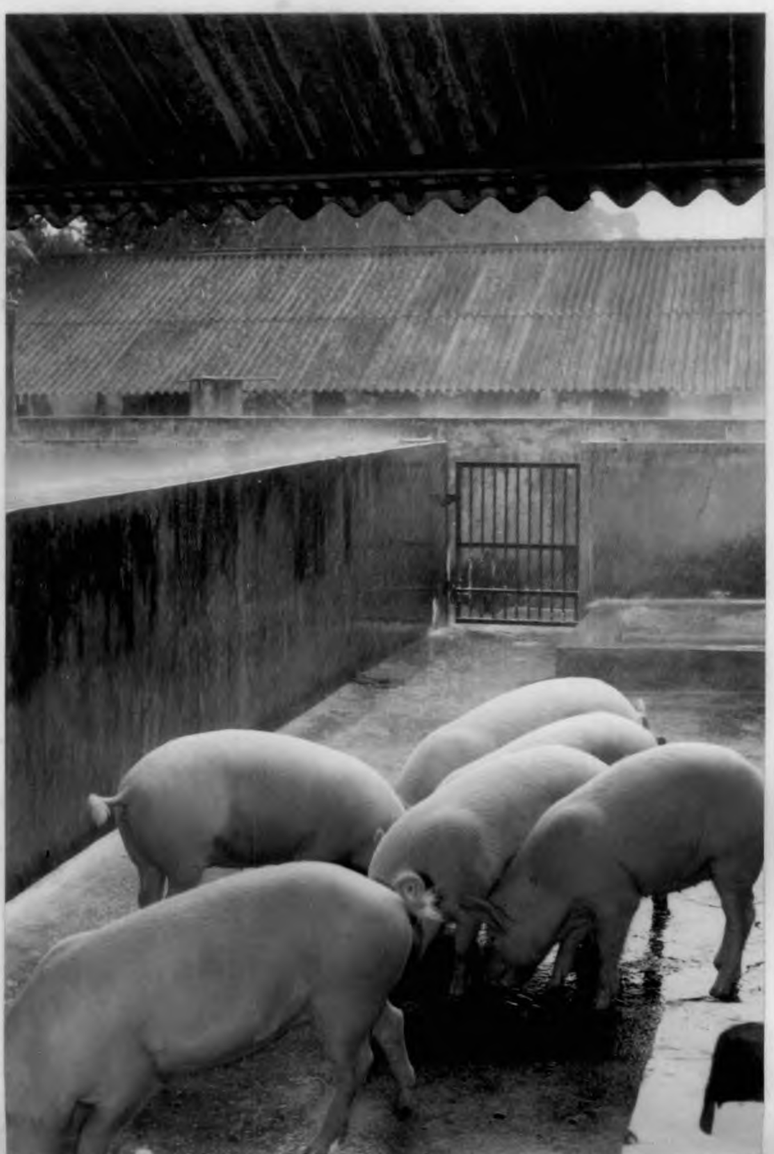

Plate 4. Range system (Treatment 3)

Plate 5. Mud wallowing in range

Plate 6. Oestrus behaviour mounting

Plate 7. Standing heat reflex

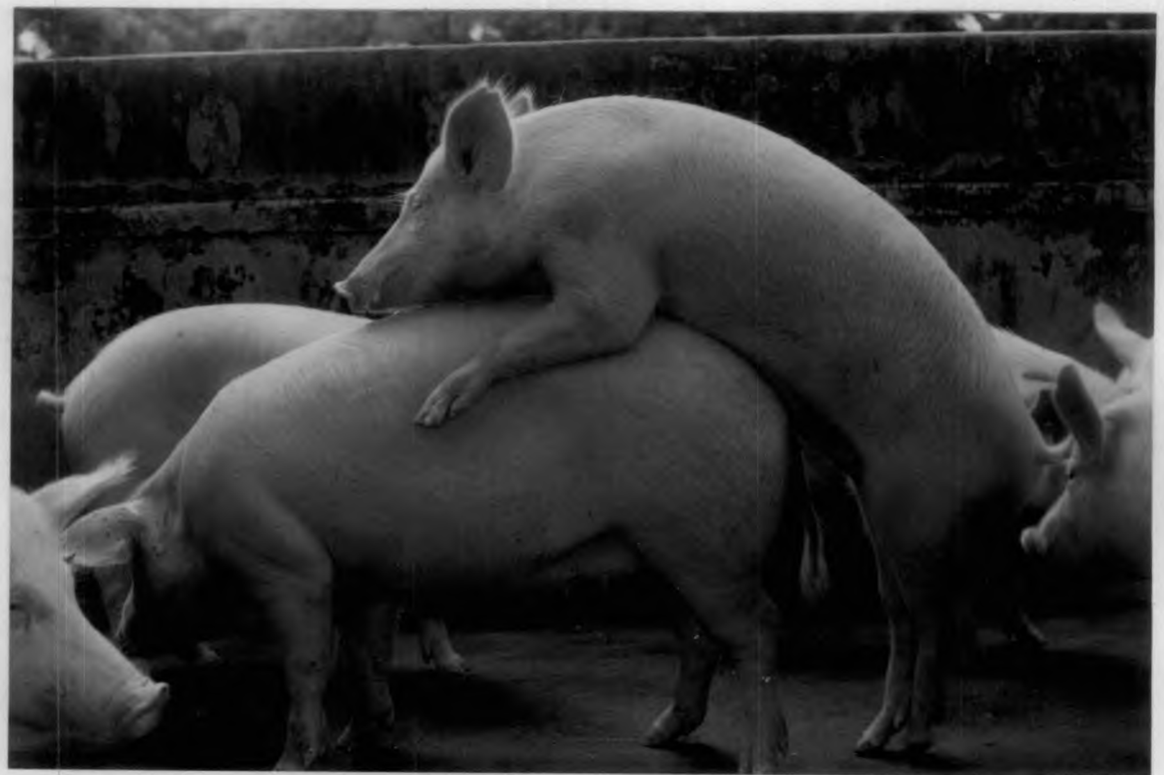

Plate 8. Riding test

Plate 9. Coupling

Results

RESULTS

The effect of housing systems on the microclimatic conditions and on the reproductive performance of gilts and sows housed in them were studied. Three types of housing systems, namely, conventional house with wallowing tank (Control T_1), conventional house, sprinklers (T_2) and range system (T_3) were put to test for a period of six months starting from December 1997.

4.1 Microclimatic changes

Microclimatic parameters like maximum temperature and relative humidity were found to be significantly ($P<0.05$) higher in T_1 housing system than the T_2 and T_3. In range system (T_3) the microclimatic parameters were equivalent to atmospheric levels. Under (T_2) the provision of sprinklers had improved the microclimate over the T_1 and sometimes it was better than the natural condition prevailed under T_3 system. The averages of the climatic variables for six months period in the systems studied are presented in Table 4.1. The highest maximum temperature was experienced during the month of April in the T_1 group (37.28 ± 0.22). In T_2 and T_3 also the highest average maximum temperatures were recorded in April but were significantly lower than that of temperature recorded in T_1 in the same month. The lowest maximum and lowest minimum temperature of 31.04 ± 0.16°C and 22.66 ± 0.18°C respectively were recorded during December in T_2 group. This was significantly lower than the readings obtained from the T_1 and T_3 groups. During the study period the season was dry without any rain. Consequently there were no significant variation in relative humidity between the treatments. Even in the treatment group T_2 the presence of sprinklers did not significantly increase the humidity inside the pens (Table 4.1).

4.2 Age of occurrence of first oestrus in gilts

The age of occurrence of first oestrus (days) in gilts in treatment groups T_1, T_2 and T_3 are shown in Table 4.2 and Fig.4.1. The gilts under the treatment groups T_2 and T_3 had reached puberty and were mated earlier than the gilts under treatment T_1.

4.3 Body weight at different stages of reproduction

The weight of gilts and sows at the time of breeding, one week after farrowing and at weaning are presented in Tables 4.3 and 4.4 and depicted in Figures 4.1 and 4.2.

4.4 Percentage of oestrus occurrence and breeding success of gilts and sows

The percentage of gilts and sows exhibited oestrus and successfully bred are presented in Tables 4.5 and 4.6 and in Figures 4.3 and 4.4. There was no significant difference between treatment groups.

4.5 Intensity of oestrus in gilts and sows

The intensity of oestrus behaviour measured on a 3 point score is presented in Tables 4.7 and 4.8 and depicted in Figures 4.5 and 4.6. The scores were significantly ($P<0.01$) higher in T_2 and T_3 treatments compared to T_1.

4.6 Gestation length of gilts and sows

The gestation length of gilts and sows in different treatment groups are furnished in Tables 4.9 and 4.10. There was no significant ($P<0.05$) difference between treatment groups.

4.7 Weight loss during lactation in gilts and sows

The weight loss during lactation in gilts and sows are given in Tables 4.11 and 4.12. There was no significant difference between treatment groups.

4.8 Litter performance of gilts and sows

The litter performance of gilts and sows at birth and weaning such as litter size, litter weight and preweaning mortality are presented in Tables 4.13 and 4.14 and graphically presented in Figures 4.7 to 4.10.

4.9 Period of post weaning oestrus of gilts and sows

The number of days required for the onset of post-weaning oestrus in gilts and sows are furnished in Tables 4.15 and 4.16. There was no significant difference between treatment groups.

Table 4.1 Mean and SE of microclimatic changes

Month	Treatment groups	Maximum temperature °C	Minimum temperature °C	Relative humidity % (morning)	Relative humidity % (afternoon)
December	T_1	32.42±0.16 [a]	24.45±0.14 [a]	81.61±1.11 [a]	59.22±1.45 [a]
	T_2	31.04±0.16 [c]	22.66±0.18 [c]	82.87±1.17 [a]	61.22±1.34 [a]
	T_3	31.70±0.17 [b]	23.77±0.16 [b]	82.96±1.15 [a]	60.83±1.35 [a]
January	T_1	33.51±0.26 [a]	24.06±0.22 [a]	78.19±1.44 [a]	47.54±0.82 [a]
	T_2	32.12±0.25 [b]	23.27±0.22 [a]	78.25±1.29 [a]	50.25±0.90 [a]
	T_3	33.05±0.25 [a]	23.59±0.25 [a]	78.41±1.50 [a]	48.87±0.93 [a]
February	T_1	34.97±0.17 [a]	24.07±0.22 [a]	78.71±1.52 [a]	49.46±1.43 [a]
	T_2	33.78±0.15 [c]	22.81±0.24 [b]	79.46±1.49 [a]	50.53±1.37 [a]
	T_3	34.43±0.18 [b]	23.61±0.24 [a]	83.03±1.92 [a]	51.28±1.64 [a]
March	T_1	36.90±0.20 [a]	24.54±0.17 [a]	83.96±1.29 [a]	44.61±1.80 [a]
	T_2	35.59±0.27 [b]	22.66±0.14 [c]	85.45±1.23 [a]	46.22±1.72 [a]
	T_3	36.19±0.22 [b]	23.58±0.18 [b]	86.09±1.37 [a]	47.19±1.86 [a]
April	T_1	37.28±0.22 [a]	26.24±0.24 [a]	83.63±0.98 [a]	46.23±1.63 [a]
	T_2	36.40±0.22 [b]	25.13±0.25 [b]	84.30±1.00 [a]	47.40±1.60 [a]
	T_3	36.57±0.25 [b]	25.62±0.25 [ab]	86.20±1.00 [a]	49.76±1.77 [a]
May	T_1	34.68±0.27 [a]	25.64±0.25 [a]	88.22±0.93 [a]	60.83±1.48 [a]
	T_2	33.71±0.26 [b]	24.52±0.25 [b]	89.45±0.84 [a]	62.93±1.42 [a]
	T_3	34.19±0.28 [ab]	25.19±0.23 [ab]	89.64±0.85 [a]	63.09±1.57 [a]

Figures having different superscript in a column differ significantly ($P<0.01$)

Table 4.2 Mean and SE of age of occurrence of first oestrus in gilts

Treatment groups	Age in days
T_1 Wallowing	$305.47^{a} \pm 9.51$
T_2 Wallowing and sprinkling	$270.36^{b} \pm 8.75$
T_3 Range system	$276.22^{b} \pm 5.65$

Figures having different superscript in a column differ significant ($P<0.01$)

Fig. 4.1 AGE AND WEIGHT OF GILTS AT THE TIME OF BREEDING ONE WEEK AFTER FARROWING AND AT WEANING

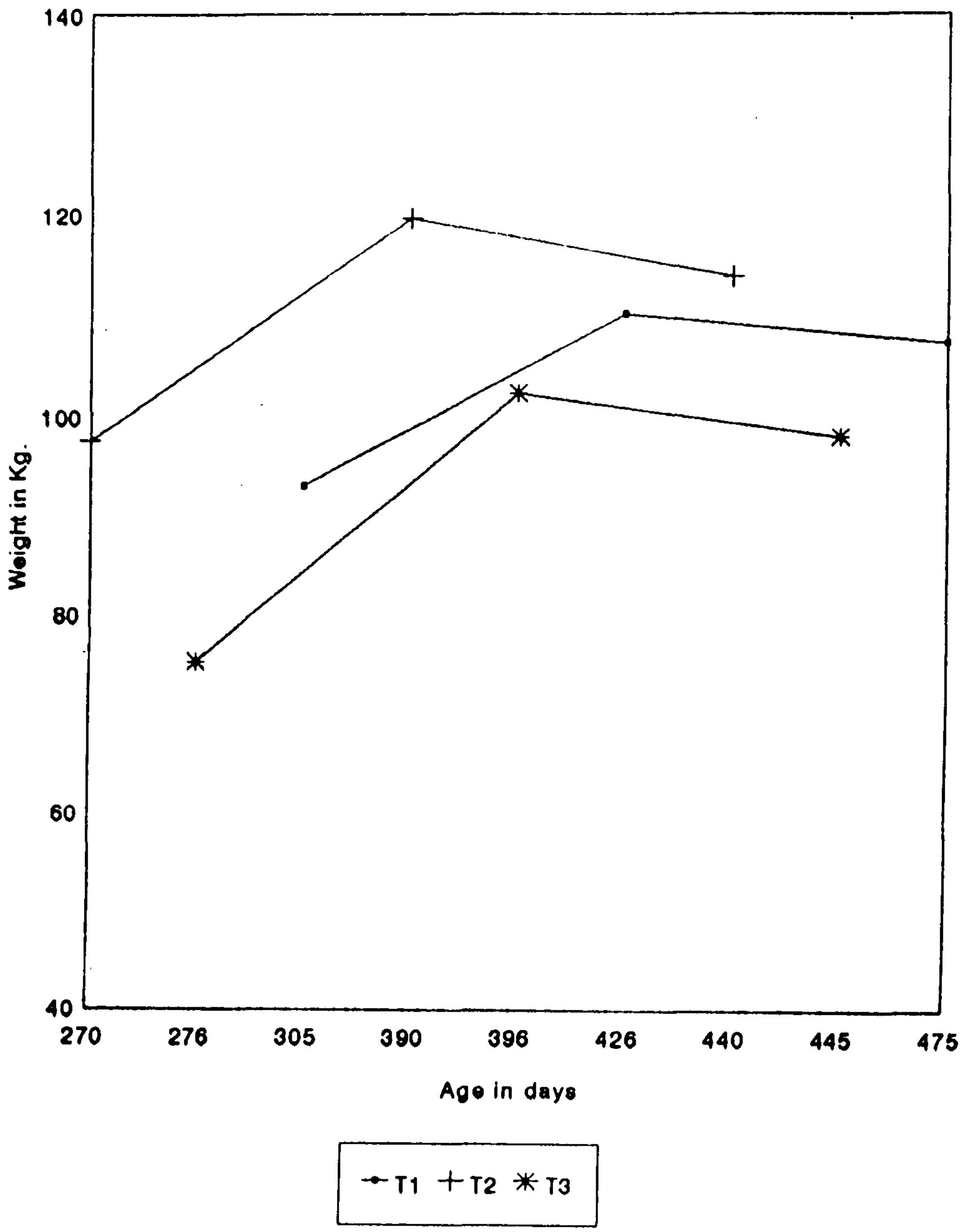

Table 4.3 Mean and SE of weight of gilts at the time breeding, one weak after farrowing and at weaning

Treatment groups	T_1	T_2	T_3
Weight of gilts at the time of breeding (kg)	93.11 ± 3.73^a	97.63 ± 3.09^a	75.39 ± 3.19^b
Weight of gilts one week after farrowing (kg)	110.14 ± 5.37^a	119.56 ± 4.45^a	102.32 ± 2.60^a
Weight of gilts at the time of weaning (kg)	107.25 ± 7.46^a	113.80 ± 4.26^a	97.92 ± 2.37^a

Figures having different superscript in a row differ significant ($P<0.05$)

Table 4.4 Mean and SE of weight of sows at the time breeding, one weak after farrowing and at weaning

Treatment groups	T_1	T_2	T_3
Weight of sows at the time of breeding (kg)	114.44 ± 4.56^{a}	95.55 ± 2.38^{b}	111.58 ± 7.48^{a}
Weight of sows one week after farrowing (kg)	141.14 ± 6.67^{a}	116.58 ± 4.5^{b}	138.97 ± 8.32^{a}
Weight of sows at the time of weaning (kg)	137.36 ± 6.41^{a}	110.27 ± 4.43^{b}	129.54 ± 8.22^{a}

Figures having different superscript in a row differ significant ($P<0.05$)

Fig. 4.2 WEIGHT OF SOWS AT THE TIME OF BREEDING ONE WEEK AFTER FARROWING AND AT WEANING

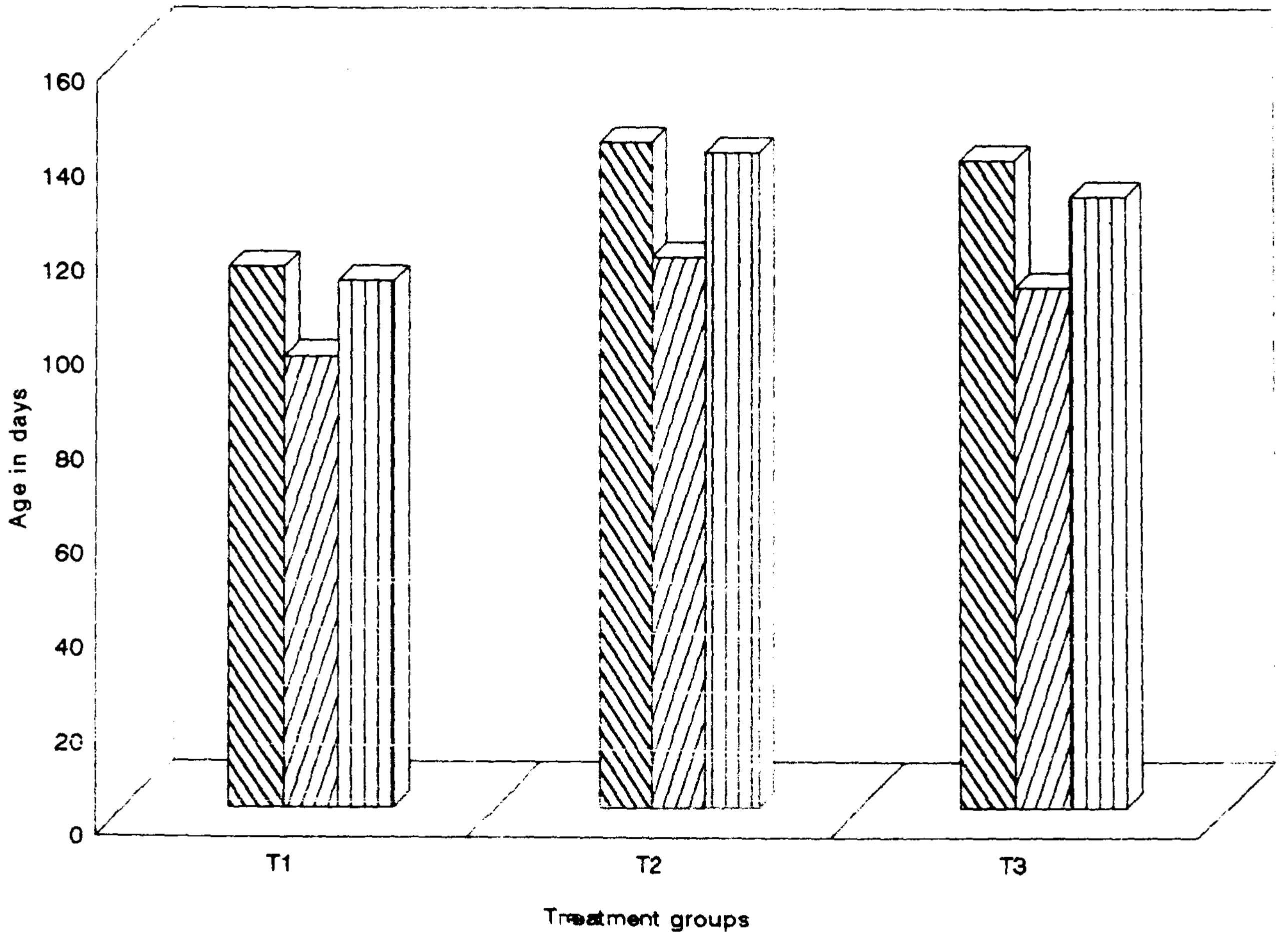

Table 4.5 Percentage of oestrus occurrence and breeding success of gilts

Treatment groups	T_1	T_2	T_3
Percentage of gilts showing oestrus	94.44^{a}	100.00^{a}	100.00^{a}
Percentage of successful breeding	88.24^{a}	94.44^{a}	100.00^{a}

Figures having the same superscript in a row do not vary significantly

Fig. 4.3 PERCENTAGE OF OESTRUS OCCURRENCE AND BREEDING SUCCESS OF GILTS

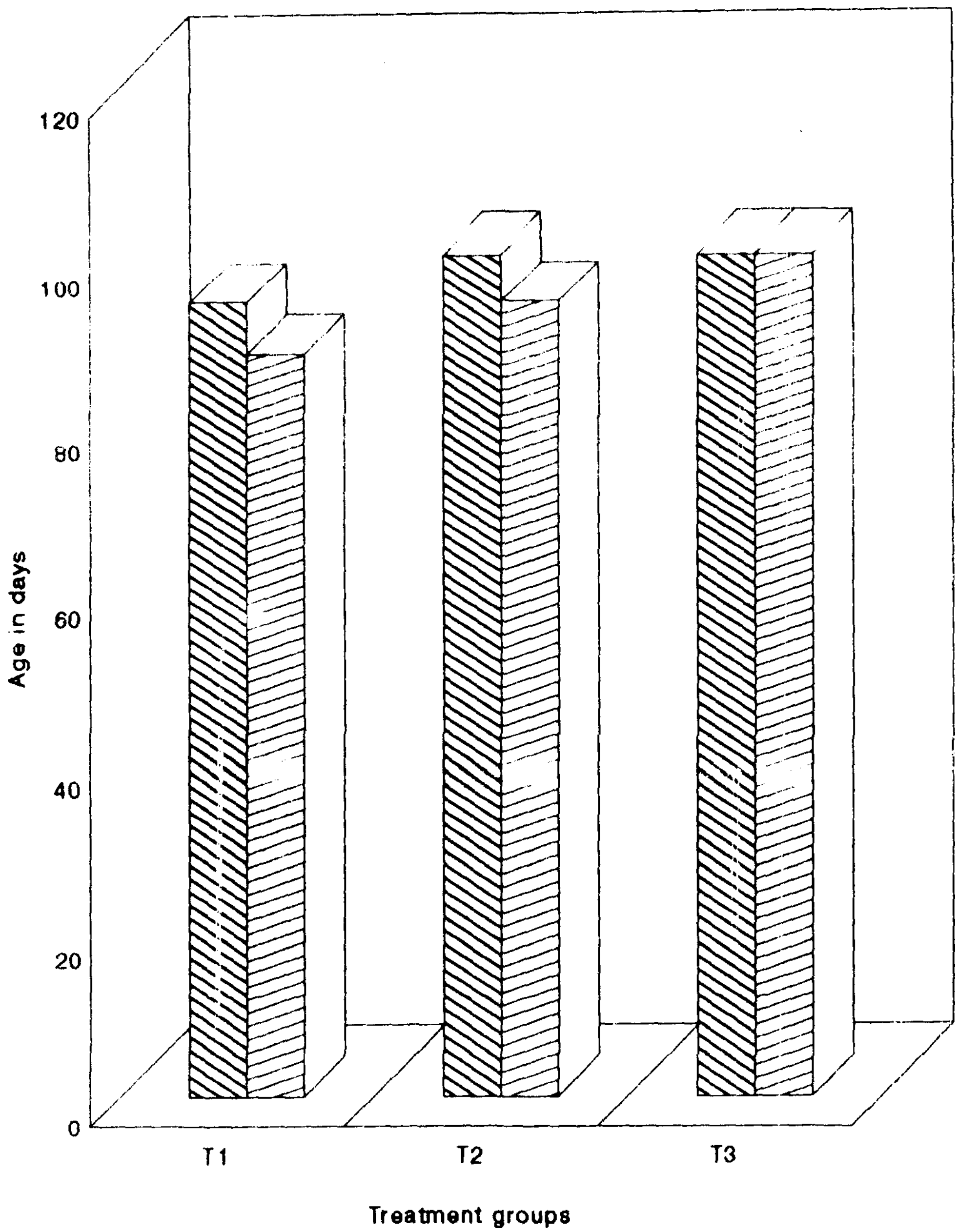

Table 4.6 Percentage of oestrus occurrence and breeding success of sows

Treatment groups	T_1	T_2	T_3
Percentage of sows showing oestrus	94.44^a	100.00^a	100.00^a
Percentage of successful breeding	88.88^a	100.00^a	100.00^a

Figures having the same superscript in a row do not vary significantly

Fig. 4.4 PERCENTAGE OF OESTRUS OCCURRENCE AND BREEDING SUCCESS OF SOWS

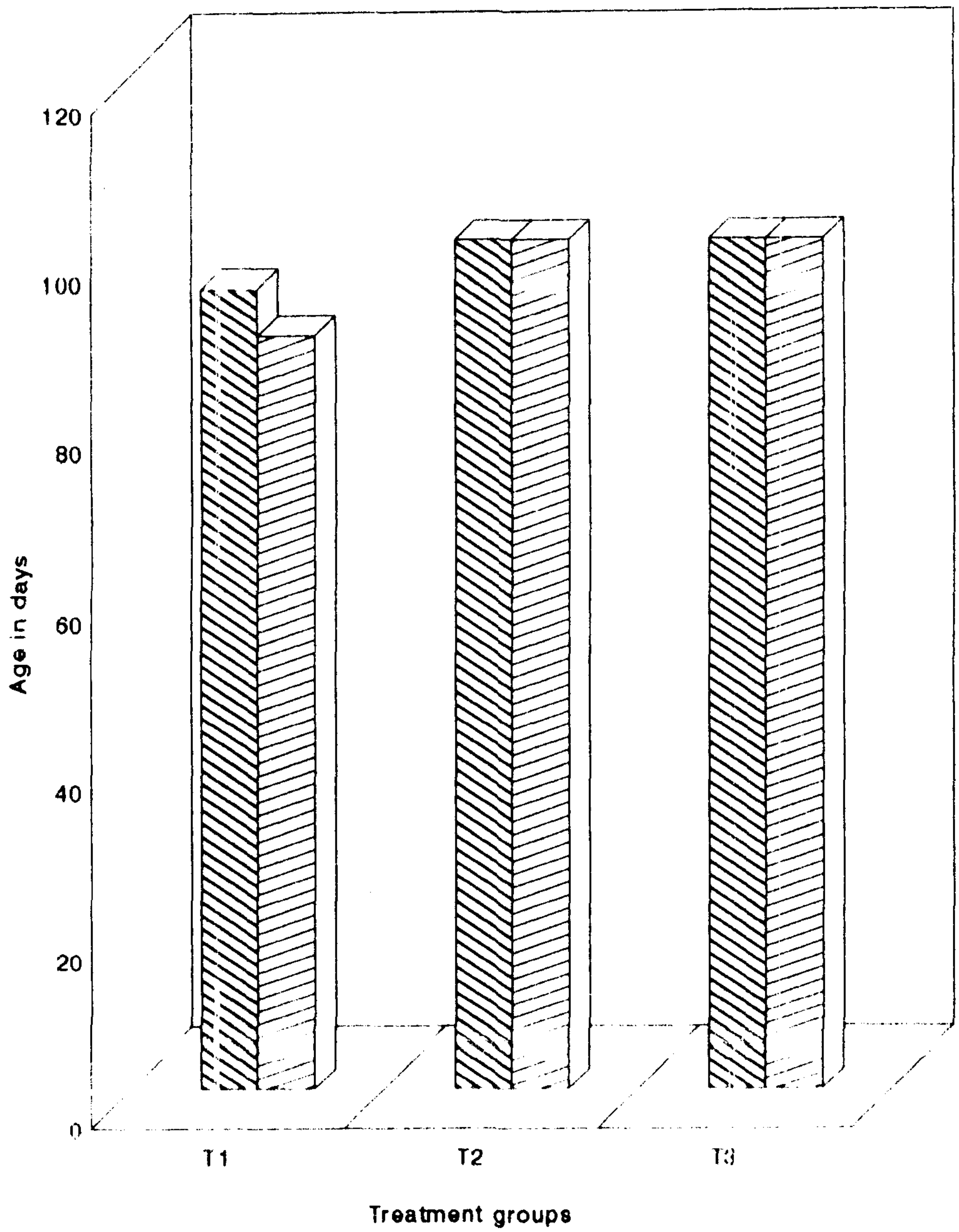

Table 4.7 Mean and SE of intensity score of oestrus in gilts

Treatment groups	Maximum score 3
T_1 Wallowing	$1.80^{a} \pm 0.14$
T_2 Wallowing and sprinkling	$2.60^{b} \pm 0.24$
T_3 Range system	$2.81^{b} \pm 0.10$

Figures having different superscript in a column differ significantly (P<0.01)

Fig. 4.5 INTENSITY OF OESTRUS IN GILTS

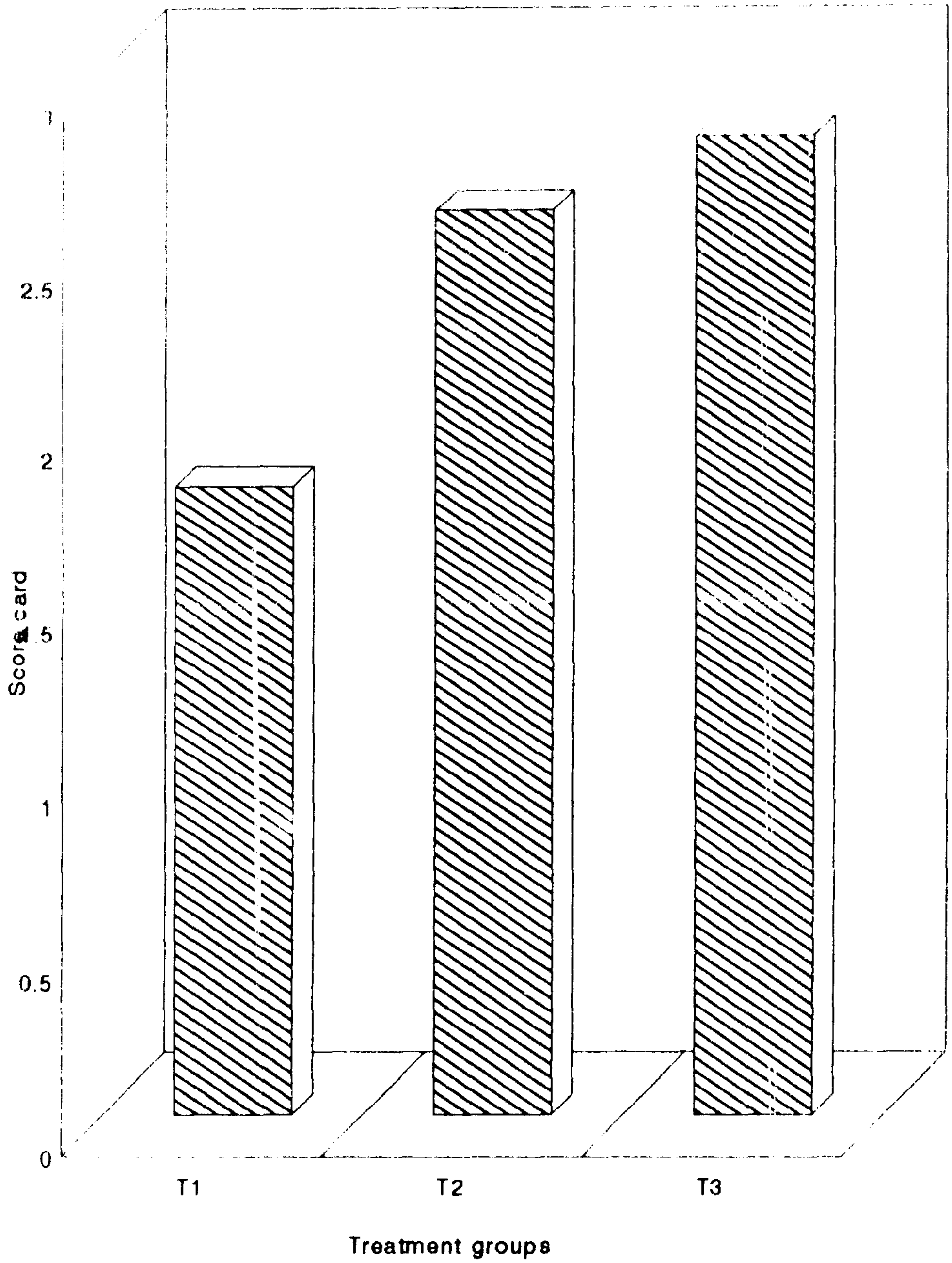

Table 4.8 Mean and SE of intensity score of oestrus in sows

Treatment groups	Maximum score 3
T_1 Wallowing	$2.00^a \pm 0.13$
T_2 Wallowing and sprinkling	$2.66^b \pm 0.16$
T_3 Range system	$2.84^b \pm 0.10$

Figures having different superscript in a column differ significantly (P<0.01)

Fig. 4.6 INTENSITY OF OESTRUS IN SOWS

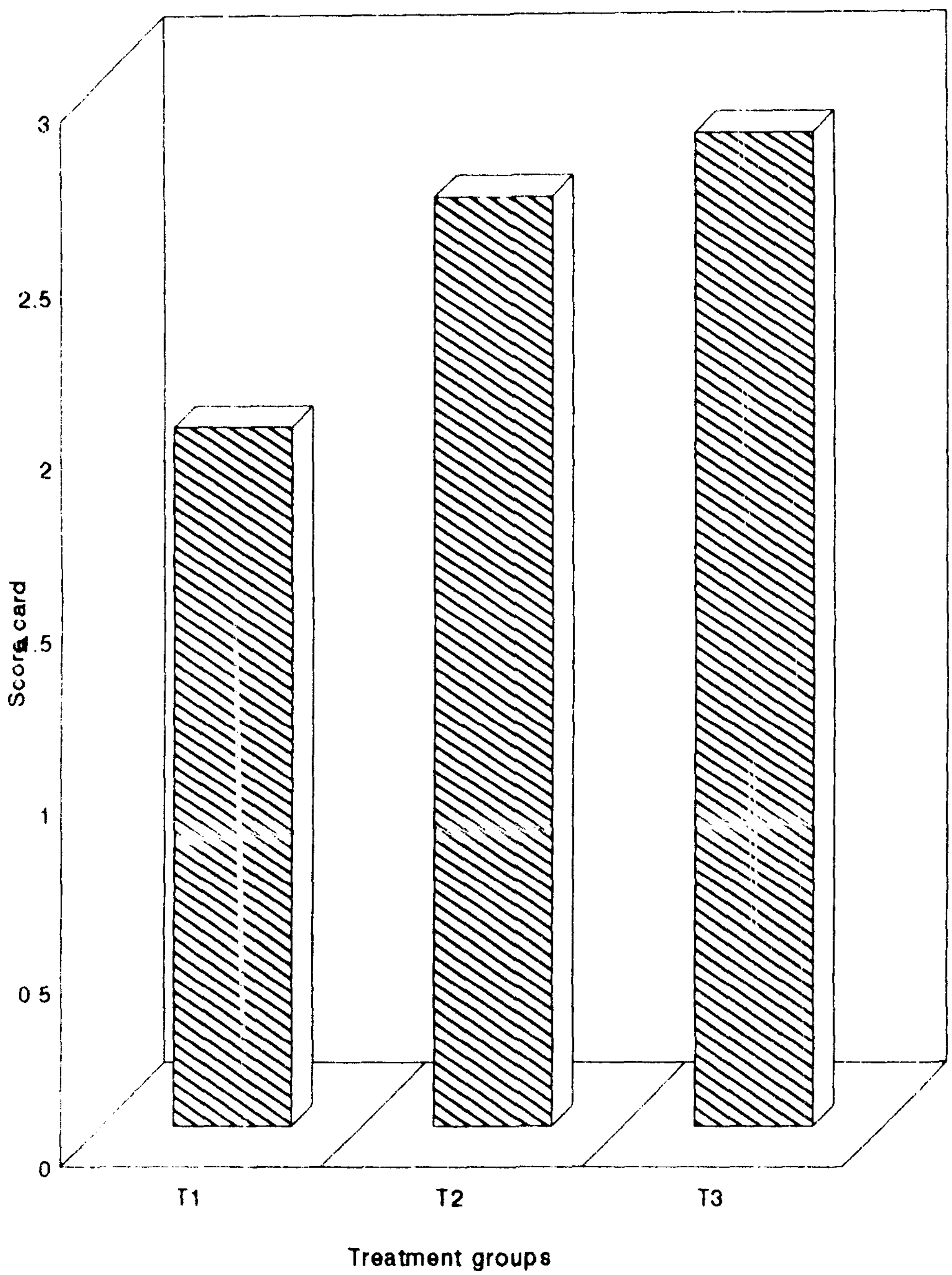

Table 4.9 Mean and SE of gestation length of gilts

Treatment groups	Gestation period in days
T_1 Wallowing	$113.53^{a} \pm 0.16$
T_2 Wallowing and sprinkling	$113.40^{a} \pm 0.24$
T_3 Range system	$113.18^{a} \pm 0.16$

Figures having the same superscript in a column do not vary significantly

Table 4.10 Mean and SE of gestation length of sows

Treatment groups	Gestation period in days
T_1 Wallowing	$113.27^{a} \pm 0.14$
T_2 Wallowing and sprinkling	$113.22^{a} \pm 0.15$
T_3 Range system	$113.15^{a} \pm 0.19$

Figures having the same superscript in a column do not vary significantly

Table 4.11 Mean and SE of weight loss during lactation in gilts

Treatment groups	Weight in kg
T_1 Wallowing	4.46 ± 0.14^{a}
T_2 Wallowing and sprinkling	5.76 ± 1.00^{a}
T_3 Range system	4.40 ± 0.98^{a}

Figures having the same superscript in a column do not vary significantly

Table 4.12 Mean and SE of weight loss during lactation in sows

Treatment groups	Weight in kg
T_1 Wallowing	$4.51^{a} \pm 0.75$
T_2 Wallowing and sprinkling	$6.31^{a} \pm 1.51$
T_3 Range system	$6.36^{a} \pm 1.11$

Figures having the same superscript in a column do not vary significantly

Table 4.13 Mean and SE of litter performance of gilts

Treatment groups	T_1	T_2	T_3
Litter size at birth (live) (Nos)	5.85 ± 0.40^{a}	8.80 ± 0.97^{b}	9.06 ± 0.26^{b}
Litter weight at birth (live) (kg)	8.39 ± 0.56^{a}	13.60 ± 1.50^{b}	13.89 ± 0.43^{b}
Average piglet weight (kg) at birth	1.44 ± 0.03^{a}	1.54 ± 0.04^{b}	1.53 ± 0.01^{b}
Litter size at weaning (Nos)	4.00 ± 0.69^{a}	6.40 ± 0.92^{b}	6.87 ± 0.22^{b}
Litter weight at weaning (kg)	33.26 ± 5.54^{a}	55.73 ± 9.35^{b}	62.72 ± 1.99^{b}
Average piglet weight (kg) at weaning	8.61 ± 0.56^{a}	8.62 ± 0.20^{a}	9.15 ± 0.18^{a}
Percentage of preweaning mortality	70.85 ± 10.17^{a}	32.59 ± 7.52^{b}	24.03 ± 1.56^{b}

Figures having the different superscript in the same row differ significantly ($P<0.01$)

Fig. 4.7 LITTER SIZE AT BIRTH AND AT WEANING OF GILTS

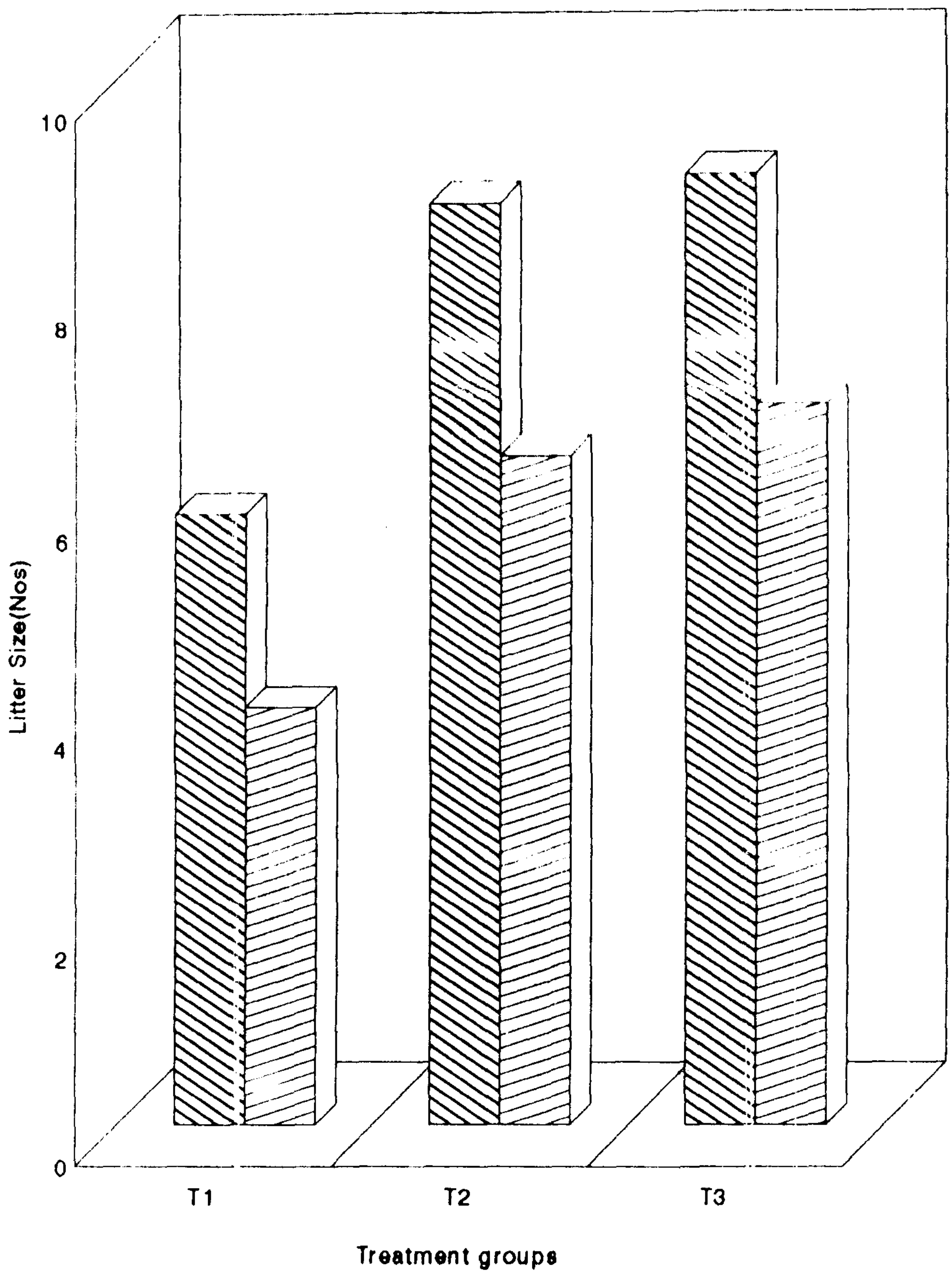

Fig. 4.8 LITTER WEIGHT AT BIRTH AND AT WEANING OF GILTS

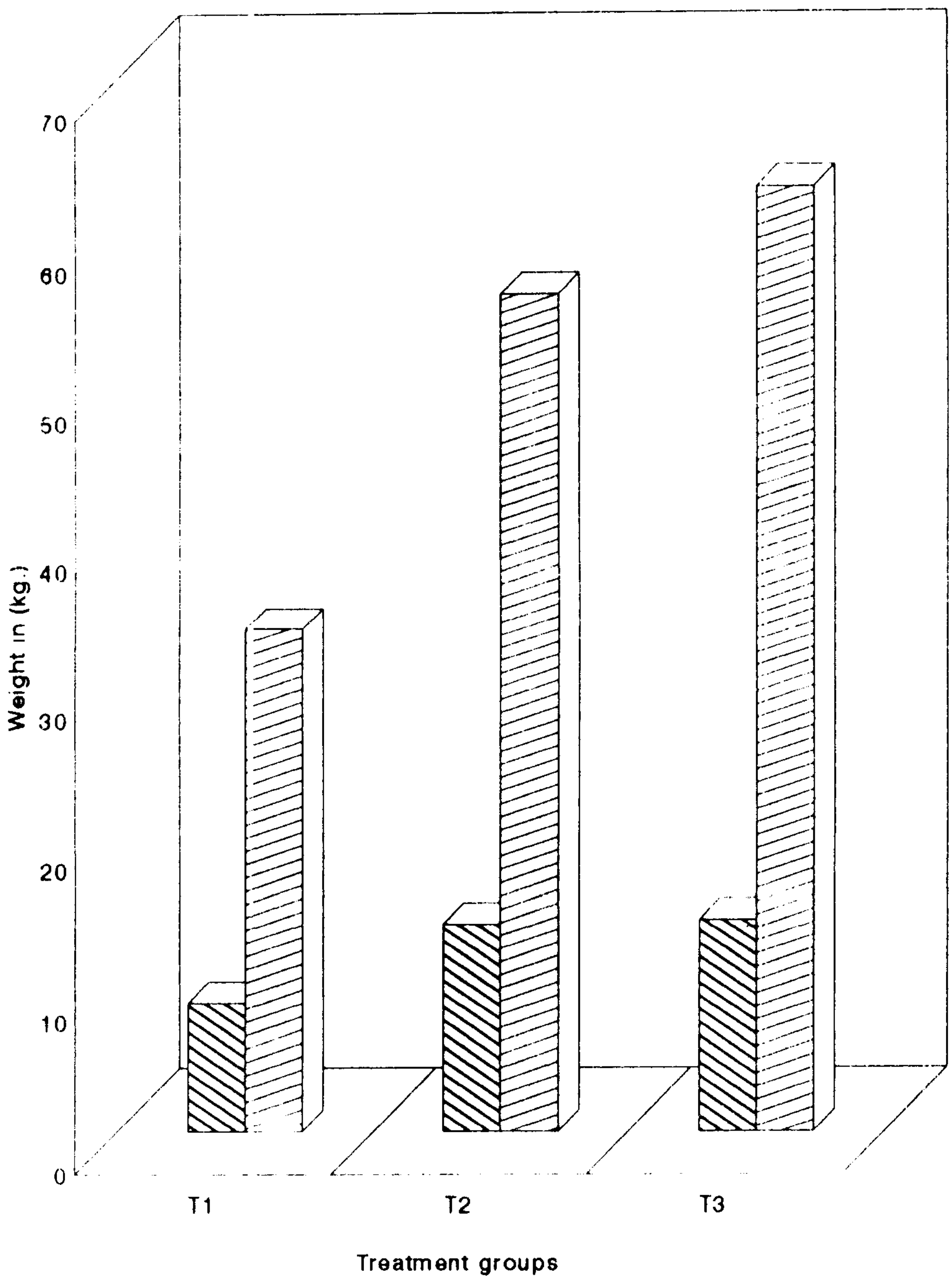

Table 4.14 Mean and SE of litter performance of sows

Treatment groups	T_1	T_2	T_3
Litter size at birth (live) (Nos)	7.09 ± 0.68^{a}	9.11 ± 0.31^{b}	9.38 ± 0.33^{b}
Litter weight at birth (live) (kg)	10.37 ± 0.95^{a}	14.21 ± 0.39^{b}	14.35 ± 0.52^{b}
Average piglet weight (kg) at birth	1.47 ± 0.04^{a}	1.56 ± 0.02^{b}	1.53 ± 0.02^{b}
Litter size at weaning (Nos)	4.63 ± 0.70^{a}	6.44 ± 0.34^{b}	6.92 ± 0.050^{b}
Litter weight at weaning (kg)	38.46 ± 5.48^{a}	59.21 ± 2.80^{b}	63.84 ± 4.04^{b}
Average piglet weight (kg) at weaning	8.42 ± 0.32^{a}	9.36 ± 0.58^{a}	9.34 ± 0.39^{a}
Percentage of preweaning mortality	40.27 ± 7.51^{a}	30.11 ± 3.20^{b}	29.31 ± 1.72^{b}

Figures having the different superscript in the same row differ significantly (P<0.01)

Fig. 4.9 LITTER SIZE AT BIRTH AND AT WEANING OF SOWS

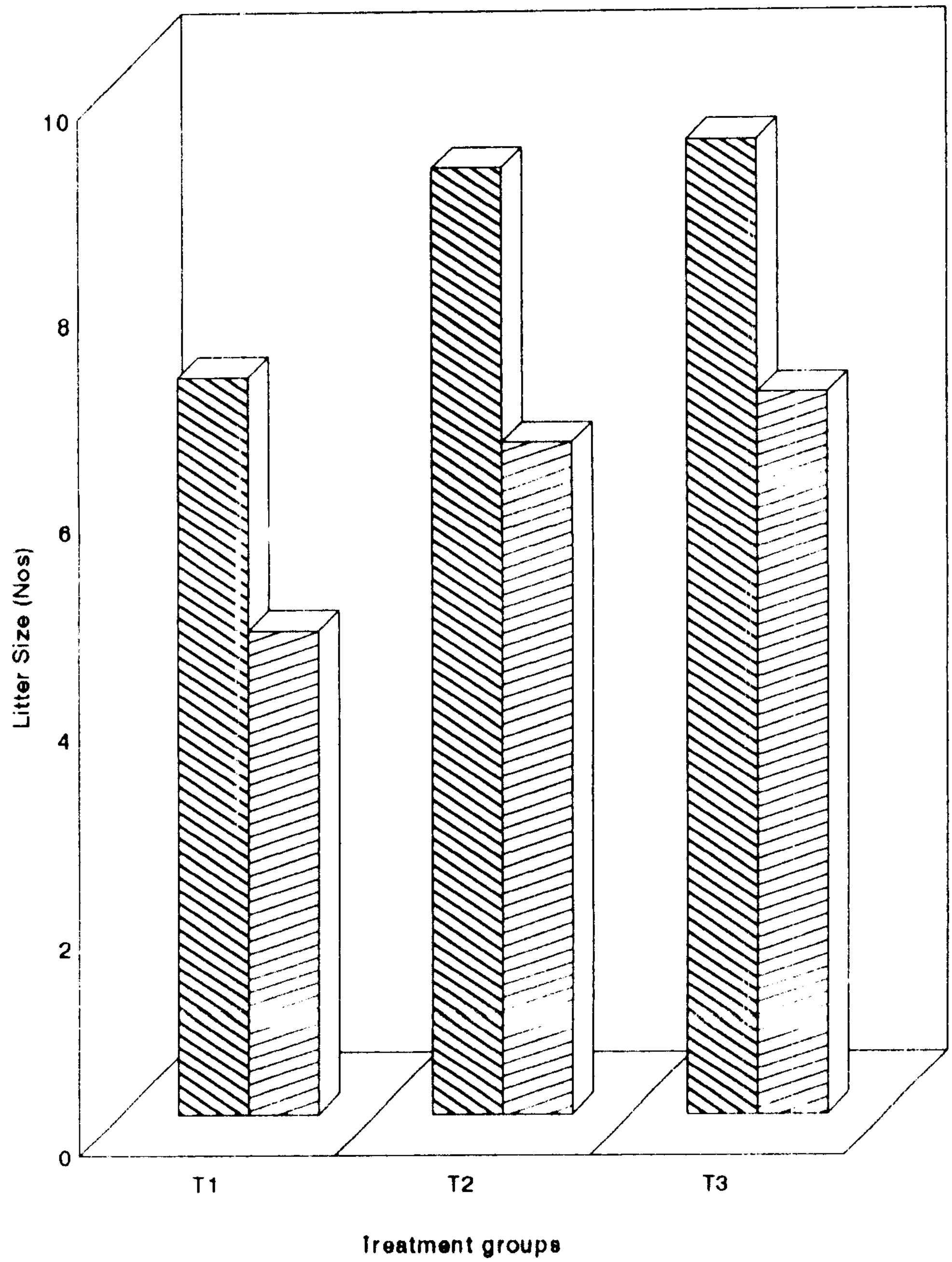

Fig. 4.10 LITTER WEIGHT AT BIRTH AND AT WEANING OF SOWS

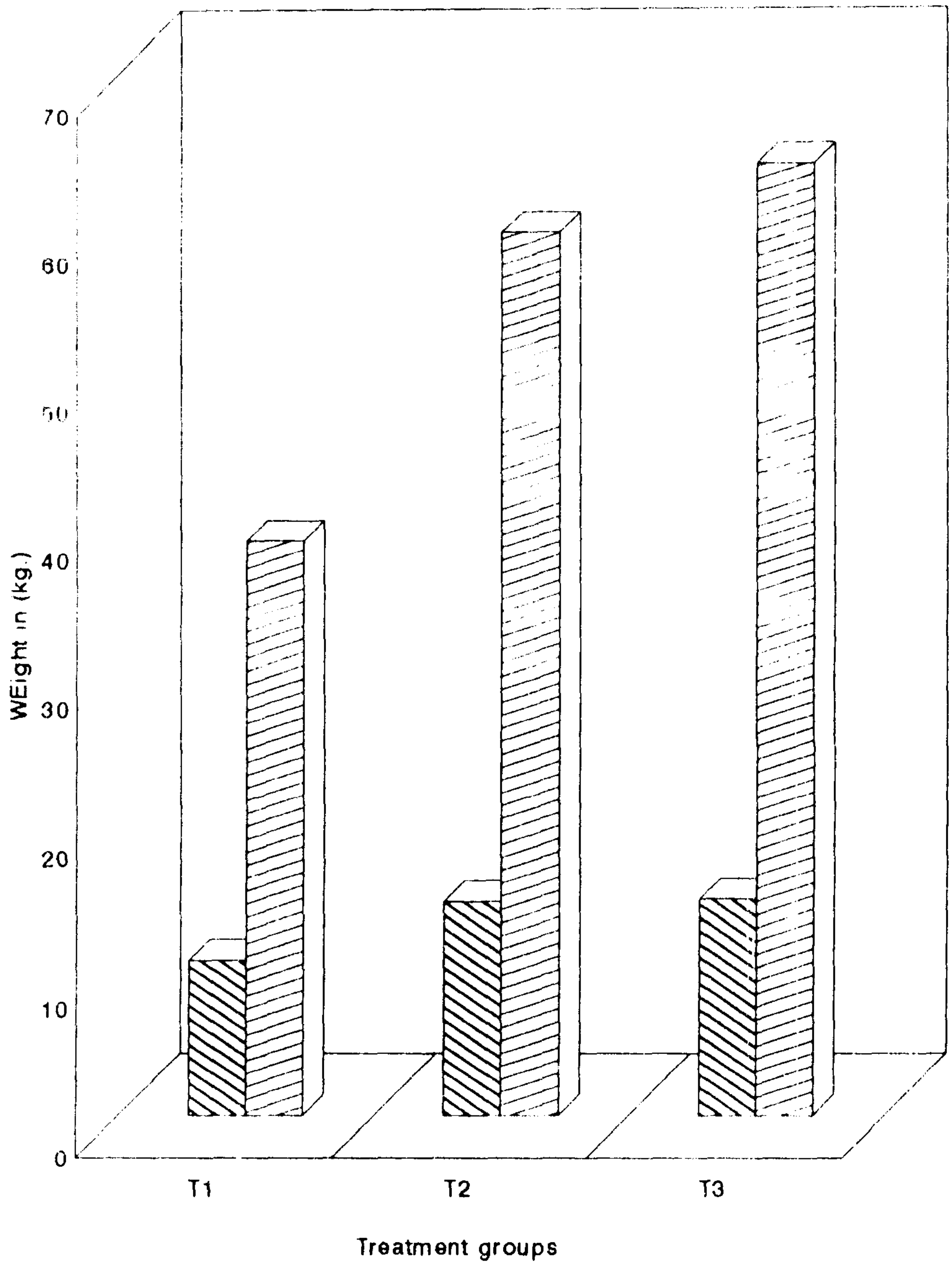

Table 4.15 Mean and SE of period of post weaning oestrus of gilts

Treatment groups	Period in days
T_1 Wallowing	$5.71^{a} \pm 0.16$
T_2 Wallowing and sprinkling	$5.00^{a} \pm 0.32$
T_3 Range system	$5.43^{a} \pm 0.20$

Figures having the same superscript in a column do not vary significantly

Table 4.16 Mean and SE of period of post weaning oestrus of sows

Treatment groups	Period in days
T_1 Wallowing	$5.36^a \pm 0.24$
T_2 Wallowing and sprinkling	$4.77^a \pm 0.28$
T_3 Range system	$5.23^a \pm 0.20$

Figures having the same superscript in a column do not vary significantly

Plate 10. Sow with litter (Treatment 1)

Plate 11. Sow with litter (Treatment 2)

Plate 12. Sow with litter (Treatment 3)

Discussion

DISCUSSION

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

5.1 Environmental changes

The average outside environmental temperature and humidity observed during the period of experiment from December to May were 34.35°C and 82 per cent respectively. In conventional house with cement asbestos roof and attached paddock, the temperature inside the pen was 35°C and relative humidity 84 per cent. The higher temperature and relative humidity observed in the pen in comparison to the range might be due to the reduced air flow and increased radiation heat from the roof, walls and concrete floors. However, when the conventional house was provided with sprinklers there was significant improvement in the microclimate in the pen. The temperature was reduced to 33.0°C which was significantly lower than the conventional pen with no modification and even better than the range system.

The improved microclimate seems to benefit the pigs. Provision of sprinklers (T_2) or range (T_3) has resulted in reduced age at puberty, increased oestrus occurrence and intensity of oestrus, conception rate and increased litter performance.

Heat stress is known to suppress oestrus, interfere in ovulation and cause early embryonic death. Exposure of gilts to 32.2°C from day 3 to 25 post-mating resulted in a significant reduction in viable embryoes than the gilts maintained at 15.6°C (Warnick *et al.*, 1965). In general the high environmental temperature during summer was found to delay oestrus and cause failure of the cycle (Edwards *et al.*, 1968) reduce farrowing rate, increase embryonic death and reduce litter size (Tompkins *et al.*, 1967). The reduced reproductive performance of breeding females exposed to high environmental temperature might be due to the suppression of gonadotrophin (FSH and LH) secretion with resultant decrease in estrogen and progesterone activity required for the increased ova release and the maintenance of fertilized ova (Farghaly, 1984).

5.2 Age of occurrence of first mating

The gilts reared in conventional pen (T_1) reached puberty at 305.47 ± 9.51 days. When the pen was provided with sprinklers during the hot season it significantly reduced the room temperature (33.0°C) in comparison to conventional pens (35.0°C). The improved environment resulted in a decrease in the age of puberty to 270.36 ± 8.75 days. A significant effect of early age at farrowing on litter size was also reported (Hughes and Cole, 1975). The 35 day reduction in age at puberty observed in sprayed group than the non-sprayed group has obvious economic benefits. Similar observations were made by Warnick *et al.* (1965); Tompkins *et al.* (1967) and Spitschak and Franke (1995). When the gilts were reared under range system (T_3) the age at puberty obtained was 276.22 ± 5.65 days. The improvement of 29 days in age at puberty in range system might be due to the increased availability of floor space and congenial atmosphere available to the pigs. The floor space available in range system was 24 m^2/pig. Whereas under confinement (T_1) it was only 4.8 m^2/pig. The early age at puberty among gilts reared under nonconfinement system was reported by (Meacham and Masincupp, 1970; Hoagland *et al.*, 1980; Christenson, 1981 and Rampacek *et al.*, 1981). The beneficial effects of increased floor space availability under range system for reducing the age at puberty were observed by (Christenson and Hruska, 1984; Clark *et al.*, 1985; Kuhlers *et al.*, 1985 and Joseph, 1997).

5.3 Body weight at different stages of Reproduction

From Tables 4.3 it can be seen that weight of gilts at the time of breeding in treatment groups T_1, T_2 and T_3 were 93.11 ± 3.37, 97.63 ± 3.09 and 75.39 ±3.19 respectively. The weight of gilts under range system was significantly lower at the time of breeding ($P<0.05$). It appeared that the range system provided a better environment for the growth of gilts as the gilts had 36 per cent gain over its initial weight one week after farrowing. In confined group the gain was only 18.27 per cent in T_1 group and 22.46 per cent in T_2 group. The increased weight gain for gilts under range system was observed by (Joseph, 1997). The weight of gilts one week after farrowing and at the time of weaning under range system were found to be more or less similar with the other treatment groups, T_1 and T_2. It also points out that weight at the time of breeding need not be around 90 kg under an ideal housing system as in the present experiment in which it was found that the 75 kg group in range system gained higher and reached similar body weight at the time of farrowing.

The weight of sows at the time of breeding in treatment groups T_1, T_2 and T_3 were 114.44 ± 4.56, 95.55 ± 2.38 and 111.58 ± 7.48 respectively (Table 4.4). In T_2 group the weight was significantly lower than the T_1 and T_3 group at the time of breeding. But the T_2 group did not gain enough to compensate for the lower initial weight and the lower weight one week after farrowing and at the time of weaning remained as such. Joseph (1997) also found a lower weight gain under confinement system in comparison to range system (45.56 kg vs 51.16 kg). The difference might be due to access to range and availability of additional nutrients and microelements through consuming the grass in the range and soil while doing rooting along with comfort and alleviation of stress in the range system.

5.4 Percentage of oestrus occurrence and breeding success

From Table 4.5 and 4.6 it can be seen that the percentage of oestrus occurrence and breeding success of gilts and sows were lower in treatment group T_1 when compared to group T_2 and T_3. The percentage of oestrus occurrence of gilts and sows in treatment groups T_1, T_2 and T_3 were 94.44, 100.00 and 100.00 whereas in sows 94.44, 100.00 and 100.00 respectively and the breeding success were 88.24, 94.44 and 100.00 of gilts and 88.88, 100.00 and 100.00 of sows. A higher percentage of oestrus occurrence and breeding success in gilts and sows in treatment groups

T_2 and T_3 when compared to group T_1 indicated that enrichments in the form of sprinklers and range beneficially contributed to this trait. These findings are in agreement to that of Reel (1966); Edwards *et al.* (1968); England and Spurr, (1969); Christenson and Young (1978); Hoagland *et al.* (1980); Christenson (1981) and Pearce *et al.* (1993). Hendel (1986) and Spitschak and Franke (1995) reported that gilts sprayed with cold water prior to insemination had better conception rate.

In conventional house T_1 the temperature inside the pen was significantly higher (35.0°C) than the sprinkler group T_2 (33.0°C) and range group (34.35°C) throughout the experimental period. The exposure to high ambient temperature might have delayed the onset of oestrus and decreased the percentage of conception (Warnick *et al.*, 1965; Edwards *et al.*, 1968 and Jensen *et al.*, 1970).

5.5 Intensity of oestrus

The intensity score of oestrus in gilts and sows in treatment groups T_1, T_2 and T_3 were 1.80 ± 0.14, 2.60 ± 0.24 and 2.81 ± 0.10 and 2.00 ± 0.13, 2.66 ± 0.16 and 2.84 ± 0.10 respectively (Table 4.8 and 4.9). A significantly high score in groups T_2 and T_3 when compared to T_1 clearly indicated that the provision of sprinklers in the pen and range area enhanced the intensity of oestrus and probably the high intensity of oestrus helped in easy detection of heat and timely mating. The oestrus intensity score was highest among the gilts and sows in the groups given access to a free range. The near-natural conditions seem to influence female sex-behaviour favourably. This observation was in agreement with that of Jensen *et al.* (1970) and Christenson (1981). The latter found that occurrence of "quiet oestrus" appeared to be more frequent among the tethered gilts than nontethered. Pearce *et al.* (1993) reported that the expression of regular oestrus cycles in gilts was lower in confinement when compared to range system. Joseph (1997) also observed a higher intensity of oestrus behaviour in sows which were maintained in sties with sprinklers and under range system.

5.6 Gestation period

The gestation length of gilts and sows of different treatment groups (Tables 4.9 and 4.10) did not vary significantly. This indicated that the length of gestation period is unaffected by external factors like housing systems. The present observation was also in aggrement with the reports of Young *et al.* (1977); Hale *et al.* (1981); Rocha (1994); Costa *et al.* (1995) and Joseph (1997).

5.7 Weight loss during lactation

The weight loss during lactation in treatment groups T_1, T_2 and T_3 were 4.46 ± 1.14, 5.76 ± 1.00 and 4.40 ± 0.98 in gilts and 4.51 ± 0.75, 6.31 ± 1.51 and 6.36 ± 1.11 in sows respectively (Table 4.11 and 4.12). Eventhough the differences between the treatment means were not significant, there was a clear trend showing higher weight loss among T_2 and T_3 animals in comparison to T_1. This may be a reflection of higher nutrient drain through milk due to raising more number of piglets and greater weaning weight of piglests in these groups (Tables 4.13 and 4.14).

5.8 Litter performance

From Tables 4.13 and 4.14 it can be seen that the litter size at birth in treatment group T_1, T_2 and T_3 were 5.85 ± 0.40, 8.8 ± 0.97 and 9.06 ± 0.26 in gilts and 7.09 ± 0.68, 9.11 ± 0.31 and 9.38 ± 0.33 in sows. A significantly higher ($P<0.01$) litter size at birth in treatment groups T_2 and T_3 when compared to T_1 was indicative of the fact that housing enrichments in the form of sprinkling or provision of range area during breeding and pregnancy period may have effect on these traits. Many earlier workers have reported similar findings (Danilenko and Fedotov, 1974; Kabanov, 1974 and Hale *et al.*, 1981). An increase in litter size may result from cooling sows with sprinklers and access to range area (Hendel, 1986; Joseph, 1997).

Litter weight at birth in treatment groups T_1, T_2 and T_3 were 8.39 ± 0.56, 13.6 ± 1.50 and 13.89 ± 0.43 in gilts and 10.37 ± 0.95, 14.21 ± 0.39 and 14.35 ± 0.52 in sows. A significantly higher ($P<0.01$) birth weight in treatment groups T_2 and T_3 when compared to T_1 indicated that if the dam was given certain type of environmental enrichments during breeding and pregnancy period, it may increase the litter weight at birth. Many workers observed that piglet weight was higher in range than in confinement (Kabanov *et al.*, 1974; Hale *et al.*, 1981; and Kunavongkrit *et al.*, 1989).

Litter size at weaning was significantly higher ($P<0.05$) in treatment group T_2 and T_3 when compared to group T_1. The higher litter size at weaning in T_2 and T_3 groups might be due to the carry over effect of environmental enrichments on mothering ability and health status of the sows and gilts. Similar observations were made by Dyck (1988).

Litter weight at weaning of gilts and sows in treatment group T_1, T_2 and T_3 were 33.26 ± 5.54, 55.73 ± 9.35 and 62.72 ± 1.99 of gilts and 38.46 ± 5.48, 59.21 ± 2.80 and 63.84 ± 4.04 of sows. A significantly higher ($P<0.01$) litter weight at weaning in treatment groups T_2 and T_3 when compared to T_1 confirmed the beneficial effects of environmental enrichments like water sprinkling and provision of range on health status, mothering ability, increased milk production and resultant improvement of litter weight. This was in aggrement with the related findings of (Kabanov *et al.*, 1974; Dyck, 1988; Costa *et al.*, 1995; Spitschak and Franke, 1995) but in contrast to that of (Earnst and Abramowsky, 1993).

The preweaning mortality rates were in the increasing orders of T_3, T_2 and T_1 (Table 4.13 and 4.14). It appeared that the chances for having still birth were more for piglets with low birth weight and hence it would be advantageous if the dams were given certain level of environmental enrichments during breeding and pregnancy period for their future litter performance. Similar observations of Dyck (1988) and Costa *et al.* (1995) supported the present finding.

5.9 Period of post weaning oestrus

The number of days required for onset of post-weaning oestrus did not differ significantly ($P<0.05$) between treatment groups (Table 4.15 and 4.16). The pigs in all treatment groups showed the signs of post weaning oestrus within a week. This may be due to the reason that all the animals were being housed in farrowing house with similar environmental conditions from seven day pre-partum to weaning. The introduction of all weaned sows to their respective treatment groups provided them more or less similar type of stress which might have triggered the exhibition of oestrus at similar time. The observation was in accordance with the findings of Ferket and Hacker (1985) and Rocha *et al.* (1994). In contrast Costa *et al.* (1995) reported that sows managed outdoors had a longer interval (7.67 days) from weaning to first oestrus than confined sows (5.40 days).

When the conventional house was provided with sprinklers the average air temperature inside the shed was reduced to 33.0°C which was significantly lower than the conventional pen temperature of 35.0°C with no modification and even lower than the temperature of 34.35°C in the range. There was no significant variation in relative humidity between the treatments during the study period. The gilts reared under the sprinkler and range systems had reached puberty and could be mated earlier than the gilts in conventional pens. Under the range system weight gain of gilts during pregnancy was higher than the other groups and compensated for the significantly lower weight the gilts in T_3 group had at the time of breeding. As a result there was no significant difference in weight of gilts one week after farrowing and at weaning. The weight of sows at the time of breeding, one week after farrowing and at weaning was significantly lower in sprinkler system than the sows under conventional pen and range system. The sprinkler and range systems were found to improve the percentage of oestrus occurrence and breeding success of gilts and sows. Similarly the intensity score of oestrus in gilts and sows was significantly higher in sprinkler and range systems when compared to conventional. The gestation length of gilts and sows of different treatment groups did not vary significantly. There was no significant difference between treatment groups in weight loss during lactation of gilts and sows. The litter performance of gilts and sows at birth and weaning such as litter size and litter weight was significantly higher in sprinkler and range groups when compared to conventional pen (T_1). The higher nutrient demand in the lactating sows under sprinkler and range systems resulted in a higher weight loss compared to the sows under conventional system. The large litters farrowed by sows and gilts reared under T_2 and T_3 systems had lower preweaning morality indicating improved vigour. The number of days required for onset of post-weaning oestrus did not differ significantly between treatment groups.

Environmental enrichments in the form of sprinkler and provision of range were found to improve the reproductive efficiency of sows and gilts.

While it may be feasible to provide ranges to pigs in areas where land is cheap or in pig farms established in orchards or plantations. However, in more intensive systems in sub-urban regions, conventional housing with the provision to operate sprinklers during the hot hours of the day in summer will be more advantageous.

Summary

SUMMARY

An experiment was conducted to find out the effect of housing systems on the reproductive performance of sows and gilts so as to recommend the efficient system of housing for better reproductive performance of sows and gilts.

Fifty four Large White Yorkshire gilts and fifty four Large White Yorkshire sows were randomly assigned to three types of housing systems namely conventional house with wallowing tank (control T_1), conventional house with wallowing tank and sprinklers (T_2) and range system (T_3). Eighteen sows and eighteen gilts consisting of three groups of six each were reared under each system. The effect of housing systems on the microclimate and reproductive performance of sows and gilts were studied.

A significantly lower temperature was observed in T_2 where sprinklers were provided. But there was no significant difference in relative humidity between the groups.

There was significant difference between treatment groups T_1 with T_2 and T_3 in age of occurrence of first oestrus in gilts. The gilts under the treatment group T_2 and T_3 had reached puberty and were mated earlier at 270.36 ± 8.75 days

and 276.22 ± 5.65 days respectively compared to 305.47 ± 9.51 days in T_1 group.

The weight of gilts at the time of breeding was significantly lower in treatment group T_3 (75.39 ± 3.19 kg) when compared to T_2 (97.63 ± 3.09 kg) and T_1 (93.11 ± 3.73 kg) but they gained 36 per cent over their weight at mating during pregnancy and no significant difference between treatment groups was evident in weight of gilts one week after farrowing and at weaning.

The weight of sows at the time of breeding was significantly lower in treatment group T_2 (95.55 ± 2.38 kg) when compared to T_3 (111.58 ± 7.48 kg) and T_1 (114.44 ± 4.56 kg). The weight gain of sows during gestation under sprinkler group (T_2) was found to be lower and had a significantly lower weight at the time of one week after farrowing and at weaning.

Environmental enrichments in the form of sprinkler and provision of range was found to increase the percentage of oestrus occurrence, breeding success, intensity of oestrus, litter size and weight at birth and weaning.

The gestation length and post weaning oestrus period were similar between the groups.

The reproductive performance of the breeding females improved under range system. But providing range required more area as 24 m^2/animal was given in the present experiment in comparison to the 4.8 m^2/pig under conventional pen. Considering the high cost of land and its scarcity in Kerala the option of rearing pigs under range system may not be practical and feasible always. The 24 m^2 provided for the pig was not sufficient for their sustenance but provided only a living space. Such systems are feasible in coconut and rubber plantations. In other situations, conventional pens with sprinklers may prove beneficial. The microclimate of the pen during hot season was found to be improved by providing sprinklers. The cost of installation of sprinkler in the conventional pen having a floor area of 28.82 m^2 was Rs.29/sq.m. This would amount to Rs.139/pig for providing 4.8 m^2/pig floor space under conventional system. This was found to be very practical and cost effective in improving the conventional pen. In the present study the reproductive performance of pigs maintained under sprinkler system (T_2) was found to be better than the pigs maintained under conventional system and almost on par with the range system. In fact in certain cases like improvement of microclimate and of age and weight at puberty, this sprinkler system appeared to give better results than the range.

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EFFECT OF HOUSING SYSTEMS ON THE REPRODUCTIVE PERFORMANCE OF SOWS AND GILTS

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ABSTRACT

An experiment was conducted to findout the effect of housing systems on the reproductive performance of sows and gilts. Three types of housing systems namely, conventional house with wallowing tank (control T_1), conventional house with sprinklers (T_2) and range system (T_3) were put to test. Eighteen sows and eighteen gilts were reared under each system. A significantly lower ($P<0.01$) temperature was observed in sprinkler system (33.0°C) when compared to conventional (35.0°C) and range (34.35°C). There was no significant difference in relative humidity between the groups. Significant difference ($P<0.01$) between treatment groups T_1 with T_2 and T_3 in age at puberty and mating in gilts which were 305.47 ± 9.51, 270.36 ± 8.75 and 276.22 ± 5.65 respectively. The gilts under the treatment group T_2 and T_3 had reached puberty and were mated earlier than T_1 group. The weight of gilts at the time of breeding was significantly ($P<0.05$) lower in treatment group T_3 (75.39 ± 3.19) when compared to T_2 (97.63 ± 3.09) and T_1 (93.11 ± 3.73). But T_3 group gilts had compensatory weight gain during pregnancy and difference between treatment groups in weight of gilts at one week after farrowing and at weaning were non significant. The weight of sows at the time of breeding, one week after farrowing and at weaning were significantly lower ($P<0.05$) in treatment group T_2 when compared to T_3 and T_1. Significantly

higher (P<0.01) percentage of oestrus occurrence, breeding success and intensity of oestrus were observed in T_2 and T_3 group than T_1 group. The gestation length and post weaning oestrus period were found to be non-significantly different between the groups. The litter size at birth and weaning were 9.06 ± 0.26 and 6.87 ± 0.22 respectively in gilts and 9.38 ± 0.33 and 6.92 ± 0.05 respectively in sows reared under range system (T_3) which were highly significant (P<0.01) than the litter size at birth and weaning obtained for gilts (5.85 ± 0.40 and 4.00 ± 0.69 respectively) and sows (7.09 ± 0.68 and 4.63 ± 0.70 respectively) reared under conventional system (T_1). Between T_2 and T_3 there was no significant difference. The litter weight at birth and weaning in T_3 groups of 13.89 ± 0.43 kg and 62.72 ± 1.99 kg respectively in gilts and 14.35 ± 0.52 kg and 63.84 ± 4.04 kg respectively in sows were found to be highly significant than T_1 group and non significantly higher than T_2 group. The cost of installing sprinkler in conventional pen and providing range in place of conventional pen were estimated to be Rs.29/m^2 and Rs.125/m^2 respectively.

In the present study the reproductive performance of pigs maintained under sprinkler and range system was found to be better than the pigs maintained under conventional system. But the range system may not be practical and economically feasible always when compared to sprinkler system.