EFFECT OF STOCKING DENSITY ON THE PERFORMANCE OF GROWING PIGS

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree

Master of Veterinary Science

Faculty of Veterinary and Animal Sciences
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Department of Livestock Production Management
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DECLARATION

I hereby declare that the thesis entitled **EFFECT OF STOCKING DENSITY ON THE PERFORMANCE OF GROWING PIGS** is a bonafide record of research work 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,

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(K. LEENA)

Dedicated to my

Husband and Parents

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Introduction

INTRODUCTION

Recently, greater attention has been drawn towards improving the economic conditions of rural small holdings. Most often the farm families remain under employed during off season. Under these circumstances pig rearing can easily be taken up by the farm families as a subsidiary occupation. Pigs excel other farm livestock by its efficient feed conversion and by its prolificacy in reproduction. Total meat production from sheep, [illegible] and cattle is not likely to overcome the demand of increasing population in future. It is obvious that sizable portion of meat supply will have to be expected from pigs and poultry. Pigs are probably the most accommodative of farm animals. They can be managed in different ways and brought on and sold off at different stages of growth.

Even in the present undeveloped stage, the value of the stock maintained by pig farmers can be estimated at Rs 250 million, and the annual contribution in the form of pork and pork products even on conservative estimate can be placed at more than 150 million. In addition to pork and pork products, 0.34 million kg of bristles, a valuable export commodity, valued at over Rs 15 million, are also produced by the pig industry.

Though pigs are maintained for the production of pork, their role in progressive agriculture is not fully recognised in the country. Pig farming is adapted to both diversified and intensive agriculture. Pigs convert inedible feeds, forages, certain byproducts obtained from grain mills, meat byproducts, damaged feeds and garbage into valuable nutritious meat. Most of these feeds are either not edible or not very palatable to human beings. Pig manure is another valuable output by the species useful in maintaining soil fertility.

The pig grows fast and is prolific breeder, with average litter size of 10-12. It is capable of producing two litters per year under good management conditions. Pigs can be reared economically if capital expenditure and expenditure on recurring expenditure are minimised.

However, modern pig facilities are extremely expensive to construct and operate. Thus the producer needs to maximise the amount of body weight gain (pork) that can be produced in a given facility within a specific time period, so that facility cost per unit of pork produced is minimized.

Eventhough pig producers are very much concerned with individual pig efficiency, the efficiency of a given facility or set of facilities (ie. the total herd) is of more concern, from an economic stand point.

For a pig producer to provide the proper amount of floor space per pig to maximise pork produced from a given facility, he must know the relationship between floor space per pig and performance. Crowding has been shown to decrease the performance. In modern times, animal welfare conditions are also important factors to be considered in fixing the minimum space allotment for animals. There is also evidence that increasing population density may lead to abnormal behaviour and vices such as tail-biting, cannibalism and an increased level of aggression. Such abnormal behaviour is likely to be detrimental in that the performance of individuals with low social status in the group may be depressed because of stress. The crowding that often occurs under intensive swine production consists of two elements: a decreased amount of space per pig and an increased number of pigs per group. Most researchers investigating housing density for swine have confounded group size and space allowance per animal by simply adding more pigs to a pen of a given size. Studies that have examined the separate effects of group size and space per

pig indicate that both factors may depress animal performance. Since an increase in group size may have a separate effect from a decrease in space per pig, these two variables should be studied in combination.

In light of the above, an experiment had been designed to investigate on the effect of stocking density on the performance of growing pigs. The main objectives of the study are:

1. To find out the minimum floor space requirement without affecting performance in growing pigs thereby reducing the cost of construction of pig housing.

2. To find out whether there is any change in the pattern of behaviour in pigs due to change in stocking rates.

3. To find out whether there is any effect of reduction in floor space upon the growth and carcass quality of pigs.

Information in this regard is available from temperate countries with very advanced swine production systems. But they may not be applicable to tropical regions with different climate and low to medium management conditions. The need for more definite information on such important problems stimulated this project.

Review of Literature

REVIEW OF LITERATURE

Traditionally, specialists on pig have recommended, and pig producers have tried to provide, environmental conditions, including floor space, that would produce maximum individual animal performance and efficiency. It is well known that within a given range, individual performance of weanling, growing and finishing pigs decreases as floor space is restricted.

The purpose of this review is to determine and evaluate the relationship between floor space per pig and the following criteria of efficiency:

1. Growth rate
2. Daily gain
3. Daily feed intake
4. Feed efficiency expressed as feed required per kg gain in weight
5. Behaviour in terms of aggressiveness
6. Carcass charcteristics
7. Rectal temperature as a measure of physiological adaptation

Growth rate, daily gain, feed intake and feed conversion efficiency

Bartlet and Janeson (1932) have reported a progressively increasing weight upto sixth month in cattle and there after a progressive decline. The above report was similar to the report of Brody (1945) in cattle. He has reported that the rate of growth was poor in the first month and then a sudden tendency to increase to a maximum by fifth month to seventh month. There after growth rate declined as the age advanced. Hammond (1955) explained that the rate at which an animal grows was of greater importance for the livestock owner than its mature weight as only a few animals live long enough to reach mature weight. Fairly rapid growth was desirable in almost all kinds of animals. In female age at puberty was increased by retarded growth rate. Maynard et al. (1979) observed an increase in body weight from birth in a way characteristic to the species. Morrison (1984) noticed that growth rate and daily gain increased gradually until the pigs reached a weight of about 225 lbs (102 kg) and then decreased slightly. If carried to heavier weights than 300 lbs (136 kg) the rate of gain would be considerably less.

Brody (1945) and Maynard et al. (1979) observed that the growth in terms of length from the initial stage to the final stage was showing a progressively increasing nature.

Heitman et al. (1961) observed significant differences in rate of gain and feed conversion in favour of greater space allowance per hog and in lowered feed consumption and feed conversion in favour of pens with more hogs. Clawson (1962) reported that average daily gain but not feed per pound of gain was significantly influenced by space treatment.

According to Gehlbach et al. (1966) the response of animals to space allowances were similar in units having either partially slotted or completely slotted concrete floors. Result of the study demonstrated the necessity of adequate floor space if maximum feed intake and rate of gain are to be realized.

Jensen et al. (1966) observed a significant reduction in average daily gain and average daily feed intake at higher stocking rate of pigs on expanded metal floor. There was no significant difference in average daily gain, average daily feed intake and gain per feed ratio due to number per pen or floor space allowance on wood slotted floor pens. However, in both trials average daily gain and average daily feed intake were lowest at lower space allowance.

Puhac et al. (1967) noticed reduction in average daily weight gain and increased food consumption per kg gain at lower stocking density, whereas Nigul (1968) showed that increased area did not improve weight gains or food conversion, but area reduced by 50 per cent decreased weight gains by 17 per cent and food conversion efficiency by 9 per cent.

Barenburg et al. (1969) reported reduced average daily gain and increased consumption of feed per kg gain at higher stocking densities. Handlin et al. (1969) found that rate and efficiency of gain were not significantly affected by space restriction.

According to Pickett et al. (1969) reducing the amount of outside pen from 11 to 5.5 m^2 and the amount of house space from 1.1 to 0.55 m^2 per pig by doubling the number of pigs per pen resulted in a significant reduction in rate of gain.

Skoknic et al. (1969) reported that there was no significant difference in live weight gain, feed consumption and feed conversion efficiency due to floor space restriction.

A report from Chile: Instituto De Investigaciones (1970) showed no significant effect of floor space on average daily gain and feed conversion efficiency.

A significant effect of stocking density on average daily gain, was reported by Devin (1970). He concluded that, for maximum live weight gain, each pig fattened to 98 to 100 kg must be allowed a basic area of 0.5 m^2 and 0.25 m^2 for food and excretion respectively. He further concluded that if fattening is to 115 to 120 kg, the areas allowed must be increased to 0.55 + 0.3 m^2.

Spers et al. (1970) reported that the daily weight gain improved with increasing space per pig, but the space per pig or the number of pigs in the pen had no significant effect on food utilization.

Cornejo et al. (1971) found no significant difference among different stocking density groups in weight gain, food intake or efficiency of food conversion, during Autumn and Winter period.

Skoknik et al. (1971) observed that the amount of space had no significant effect on weight gain, food intake or efficiency of food conversion.

Jensen et al. (1973) reported that the voluntary feed intake and weight gain were lower at higher stocking density. The authors also reported the feed conversion efficiency was not significantly affected by space. Barrows consumed more and gained significantly faster than gilts. The interaction between space and sex also reported to be non-significant.

Sinitsin (1974) noticed that in pigs fattened to 100 kg body weight with 0.3, 0.4, 0.5, 0.6 or 0.7 m^2 floor area per pig, daily gain averaged 407, 395, 452, 456 and 497 g respectively and consumption of feed per kg gain as 6.9, 5.6, 6.2, 4.8 and 5.0. respectively.

Krider et al. (1975) showed reduced average daily gains at higher stocking densities. Significant differences in daily weight gain and feed conversion at different floor space allocations, were reported by Schneider and Bronsch (1975).

Serebrennikov and Shurmukhin (1975) found that for pigs housed in cages and allowed 0.38, 0.43, 0.5 and 0.6 m^2 of floor area per pig, daily gain to 95 kg body weight averaged 488, 510, 595 and 595 g respectively and consumption of feed per kg gain 5.1, 4.8, 4.1 and 4.12 kg respectively

Voloshchik et al. (1975) conducted an experiment in which pigs were housed at stocking rate of 0.5, 0.4, 0.3 and 0.25m^2 floor area per pig. The body weight average 7.2, 7.2, 7.6 and 7.3 kg at 35 days and 24.9, 25.3, 27.1 and 27.5 kg at 100 days, and consumption of feed per kg gain averaged 3.5, 3.6, 3.3 and 3.1 for the four groups respectively.

Bublik and Gerasimove (1976) reported significant reduction in daily gain and feed conversion efficiency of fattening pigs at higher stocking rates. Fritschen (1976) observed that pigs receiving more space allowance gained more rapidly and more efficiently than pigs at less space allowance. Significant reduction in feed conversion at higher stocking density in autumn born pigs was reported by Mullaney (1976). No effect of pen density on feed conversion in spring born pigs was also noted by the same author.

Plumlee et al. (1976) found that gains up to 68 kg were not affected by floor space per pig (0.43 vs 0.63 m^2) but were reduced at 0.43 m^2 level during 68 to 100 kg phase. Increasing pig density reduced feed conversion efficiency after pig reached 68 kg.

Ross and Curtis (1976) reported a conspicuous difference in average daily gain at higher stocking density. The rate of feed intake per unit of time pigs spent at the feeder was greater in the pens with lower stocking rate.

Andreov et al. (1977) found a significant reduction in daily gain and food conversion at higher stocking density whereas Ohlen and Nilsson (1977) reported no significant differences between the pigs at different stocking density in daily gain or food conversion.

Ford and Teague (1978) reported that for pigs restricted to 75 per cent of the floor space available to controls, average daily gain and feed efficiency were not different from those of controls, where as for pigs restricted 50 per cent of the floor space available to controls average daily gain and feed efficiency decreased, but feed intake was not affected significantly.

Skoknik et al. (1979 a) reported that there was no significant effect of floor space allowance on average daily gain and feed consumed per kg gain.

Dinu and Pasculescu (1981) conducted an experiment in which the pigs were housed at three stocking rates,

of 0.43, 0.23 and 0.127 m^2. During a 35 days experiment with ad libitum feeding, daily gain per pig in the three groups averaged 243, 257 and 178 g respectively, daily gain per cage 1944, 1285 and 1602 g and daily gain per m^2 1700, 1120 and 1323 g respectively.

According to Kuhlers et al. (1981) the pen density effects were not significant for trait like average daily gain. The results of the study indicated that the pen density should be considered in performance testing schemes and in evaluation of sire breed dam breed combinations.

Lindwall (1981) reported that average daily gain was affected by stocking density of pigs. Increasing the number of pigs per pen had an increasingly detrimental influence on average daily gain in each successive weight period. Efficiency of gain was not affected by number of pigs per pen or flooring material. Sex of the pig had no effect on average daily gain.

Randolph et al. (1981) reported that the growth rate to 89.5 kg was decreased linearly as the space allowance per pig decreased. The authors also reported that increased stocking rate tended to reduce daily gain and increase feed efficiency.

Zin (1981) found a significant differences in daily gain between different stocking densities and different seasons. Krasnodebski et al. (1982) noticed that pigs at high stocking density on battery cages performed better in terms of daily gain, feed consumption per kg gain than pigs at low stocking density in pens. A significant effect of stocking density on daily gain from weaning to 25 kg live weight, was reported by Lunen (1983).

Mitchel et al. (1983) reported that there were no significant differences in growth rate and feed conversion efficiency due to differences in stocking rate. It was concluded that a stocking rate of 10 pigs per pen was found to be best (0.49 m^2 per pig).

Kornegay and Notter (1984) reported that individual pig performance was depressed as stocking density increased within a given range of floor space allocations with the magnitude of the depression increasing progressively as the pigs grew and floor space became more restrictive. Conversely, body weight gain per m^2 floor space was greatly improved as stocking density increased.

O' Grady (1985) stated that the effects of stocking rate and its interaction with live weight were not

significant for growth rate, feed intake or feed conversion efficiency. Bark et al. (1985) observed a significant effect of floor space allowance on the average daily gain of pigs from 11 to 35 kg live weight. Benkov et al. (1985) noticed significant reduction in live weight gain and daily gain at high stocking density.

Hisa and Lu (1985) reported that floor area significantly affected average daily gain between 81 and 108 kg. Between 19 to 80 kg daily gain, feed intake and feed conversion ratio were not significantly affected by floor area. Barrows had significantly higher daily gains than gilts from 19 to 80 kg, but not from 81 to 108 kg. Food intake was significantly poorer, for barrows than for gilts from 19 to 108 kg.

Hunt et al. (1985 a) reported that the feeding space per pig would not appear to have been limiting even at highest stocking density. They also reported that the weight gain, average daily feed intake and feed to live weight gain ratio were not significantly different. There were no significant differences between stocking densities in any aspect of performance during weeks four and five.

Hunt et al. (1985 b) noticed that the stocking density had no significant effect on daily feed intake, average daily gain and feed conversion ratio during weeks 1-3 or 4-5.

Kornegay et al. (1985) found that within the range of body weights and stocking densities compared, variance of body weights and daily gains of weaner pigs were not increased by increasing the stocking density. The reduction in body weight gain observed when stocking density was increased appeared uniform within a pen with all pigs reacting similarly.

Moser et al. (1985) reported that during the growing phase, daily gain, daily feed intake and feed conversion ratio decreased as floor space allowance decreased. The authors also found that during the finishing phase, daily gain and feed conversion ratio were reduced but daily feed intake was not affected by restricted floor space allowance. Moreira et al. (1986 a) observed a lower average daily gain and gain per kg feed consumed as housing density of finishing pigs increased. Pigs finished in spring had better feed conversion than those finished in autumn. They have futher concluded that average daily gain per kg feed consumed and final weight of growing pigs were lower at

higher stocking density. Pigs finished in autumn tended to have lower daily gains and poorer feed conversion than pigs finished in spring, and barrows performed better than gilts. The interaction between sex and season also was reported to be significant.

Paterson (1987) reported that average daily gain and feed conversion were not significantly affected by stocking density. Zin et al. (1987) observed a lesser daily gain when floor space was reduced.

Edwards et al. (1988) compared four space allowance for growing pigs housed on fully slatted floors. Space allowance (A, m^2) was defined in relation to live weight (M, kg) of pigs according to the equation $A = KM^{0.67}$ using values for the constant (K) of 0.024, 0.027, 0.03 and 0.034. Increasing space allowance increased live weight gain. Daily food intake was unaffected by stocking densities, but conversion ratio was significantly poorer at lower space allowance. Economic analysis of the results indicated an adverse effect on profitability of space allowance less than that defined by the equation $A\ (m^2) = 0.27\ M^{0.67}$ kg. A minimum allowance defined by the equation $A\ (m^2) = 0.030\ M^{0.67}$ was recommended in commercial practice for pigs in fully slatted housing.

Hunt (1988) reported a non-significant effect of floor space on feed intake, body weight, weight gain, feed:gain ratio whereas a significant difference in feed consumption per kg live-weight on two levels of stocking rate was reported by Jakob et al. (1988).

Spicer and Aherne (1988) observed that body weight gain and voluntary feed consumption were significantly lower for pigs housed at higher stocking densities. A significant reduction in feed intake and weight gain at higher stocking density, was reported by McGlone et al. (1989).

Walker (1990) could report no significant effects of stocking rate on feed intake and feed:gain ratio. Compared with meal, pellets produced faster growth and improved feed:gain ratio. Boars had a higher growth rate and a better feed:gain ratio than gilts. There were no significant interactions between main treatments except for the interactions between stocking rate x physical form of diet on growth rate.

Several workers have reported that as space is restricted, it gives only lesser chance for the animal to move around and therefore less energy was utilised for body activity and hence increased feed conversion efficiency

(Crampton, 1956; Morrison, 1984; Mc Donald et al., 1987; Gillespie, 1987).

Behaviour

Intesitive housing involving crowding caused behavioural changes in livestock. Animals have a need for a certain space around them which they regard as their own. When this space is reduced, the individual animal feels that its territory has been encroached upon and feelings of territoriality are aroused which leads to aggression and other behavioural changes.

Fritschen (1976) concluded that increased animal density resulted in a greater tail-biting incidence. Whether the decreased performance in pens with less space was the result of tail-biting or space restriction was not clear. Tail-biting outbreaks in many instances appeared to be related to weather changes and/or time of the day also. Cornelius et al. (1981) also observed that tail-biting increased as stocking density increased and reduced with age. Hamilton (1984) reported an increased possibility of tail-biting due to over crowding.

The evidence of increased agression due to crowding comes from several studies (Bryant and Ewbank, 1972; Ewbank and Bryant, 1972 and Kelly et al., 1980). The above workers have noticed an increase in the number of agonistic interactions.

Heitman et al. (1961) indicated that the pigs at greater space allowance tended to spent more time sleeping or resting and less time standing or walking. Ross and Curtis (1976) observed that total time spent "mounting", "pushing", "squabbling", and "fighting" indicated that these agonistic activities occured 175 per cent more often at higher stocking density. Hajek (1984) noticed that pigs at lower stocking densities spent more time resting than those in higher stocking densities.

Randolph et al. (1981) reported that crowding the pigs by reducing their space allowance tended to increase the level of aggressive behaviour. They also found that the space allowance had a greater effect on behaviour and performance than did group size and that the level of aggression or type of activity were not correlated to performance on any consistent pattern.

Plumlee et al. (1976) reported that cannibalism did not occur due to space restriction. Kelley et al. (1980) did not find evidence to show that increasing stocking rate altered tail-biting behaviour among finishing pigs fed ad libitum. Hunt et al. (1985 a) and Hunt (1988) found that there was no obvious effect on floor space allowance on the welfare of pigs assessed by behavioural, productivity and health parameters.

Ross and Curtis (1976) reported that pigs at lower stocking rate travelled around twice as far as did those at higher stocking density. Pigs at lower stocking density spent more time walking and running than those kept at higher stocking density. While at lower stocking rate pigs spent more time lying down. Spicer and Aherne (1988) on the other hand reported that different stocking densities did not seem to influence the time spent by pigs resting, active and non feeding or sitting.

Carcass characteristics

Carcass characteristics included in the study were dressing percentage, length of the carcass, half carcass weight, loin eye area, back fat thickness, and weight of the ham.

Heitman et al. (1961) found no significant change in the back fat thickness due to change in floor space in a study on live animals using probe. Handlin et al. (1969) reported that the quality of pork was not significantly affected by space restriction.

Skoknic et al. (1969) noticed that there were no significant differences in carcass length, carcass back fat thickness or yield due to space restriction.

Workers from Chile:Instituto De Investigaciones (1970) reported no significant effect of floor space allocation on carcass quality of fattening pigs.

Cornejo et al. (1971) observed no significiant effect of stocking density on carcass quality of growing and finishing pigs.

Skoknik et al. (1971) found that the amount of floor space had no significant effect on carcass quality of growing/finishing pigs. Serebrennikov and Shurmukhin (1975) showed that for pigs housed in cages and allowed 0.38, 0.43, 0.5 and 0.6 m^2 of floor area per pig, the production of meat/m^2 of cage were 130, 119, 119 and 98 kg respectively.

Ohlen and Nilsson (1977) reported that weight at slaughter was not significantly influenced by stocking density. Skoknik et al. (1979 b) observed that the carcass yield and length and back fat thickness were not significantly affected by floor space.

Kuhlers et al. (1981) reported that pen density effects were not significant for traits like ultrasonic backfat thickness and loin length, lean tissue growth rate, days needed to reach 100 kg whereas a significant effect of stocking density on days to market and back fat thickness was reported by Lunen (1983). He observed a shorter duration from weaning to slaughter and smaller back fat thickness as stocking density reduced. Mitchell et al. (1983) also reported similar trends.

Augustini et al. (1984) observed higher carcass weight, back fat thickness and carcass length at lower stocking density in deep litter pens than on slatted floor. The water content of longissimus dorsi muscle was higher for pigs on slatted floor and protein content was more for pigs in deep litter system. There were no significant differences between groups in taste pannel evaluation of meat.

Benkov et al. (1985) found differences in back fat thickness, eye muscle area and ham weight at different stocking densities.

Moreira et al. (1986 b) noticed a higher slaughter weight of finishing pigs on higher floor space allowance. Housing density had no significant effect on carcass quality. It was concluded that allowing 0.59 m^2/pig would give the best results.

Zin et al. (1987) reported a significant effect of floor space allowance on carcass characteristics. Age at slaughter was 162 days on 0.7 m^2 and 152 days on 0.4 m^2 floor space. Dressing percentage, back fat thickness, eye muscle area and internal fat weight were higher at lower space allowance.

Edwards et al. (1988) showed a shorter duration from weaning to slaughter weight and a smaller back fat thickness at lower stocking density.

Kirov et al. (1988) noticed a significant effect of stocking density on the finishing performance. According to the authors, optimum finishing performance was obtained with less stocking density.

Walker (1990) reported that there was no significant effect of stocking rate on killing out percentage or back fat thickness.

Rectal temperature

Pigs, like all other farm livestock are homeotherms. Martin (1970) reported that the body temperature of swine appears quite variable, with a range of 101.5 to 104°F (38.6 to 40°C) and a mean of 102°F (38.9°C). Campbell and Lasley (1977) have reported the rectal temperature of swine as 102.5°F (39.2°C). According to West (1985) pigs show a variation in body temperature between 100.9 to 104.9°F (38.2°C to 40.5°C) with an average of 103.5°F (39.7°C). They have also reported that diurnal variation in body temperature exist and is normal. The temperature according to them, is usually at its lowest in the early hours of morning and it is at its highest in the late afternoon. According to Mathur (1990) the average temperature of pigs vary from 101.7°C to 105.6°F (38.6°C to 40.9°C). The body temperature of mammals is seen affected by various factors like age, feeding, exercise, oestrus, terminal stages of pregnancy, time of ovulation, ambient temperature and relative humidity.

Findlay (1953) reported that pigs were ill-adapted to extremes of both heat and cold. Baby pigs may exhibit

discomfort at temperatures in the region of 80°F (26.7°C). About 60°F (15.6°C) to 75°F (23.9°C) seems to be the optimum temperature range for productivity in pigs depending on the breed and weight of the pigs.

Dukes (1955) noticed that rectal temperature of the pig began to increase at an environmental temperature of 85 to 90°F (29.4 to 32.2°C). If the relative humidity was 65 percentage or above, the pig could not tolerate prolonged exposure (seven hours) to an environmental temperature of 95°F (35°C). At an environmental temperature of 105°F (40.5°C) the pig was unable to stand an atmosphere of any humidity. A rectal temperature of 107°F (41.7°C) was near the danger point for the pig.

Sutherland (1967) observed that as ambient temperature rose above the upper critical temperature, the temperature of animals may began to increase. According to Martin (1970) the rectal temperature of pigs began to show a sharp increase when the environmental temperature rose from 60 to 80°F (15.6 to 26.7°C). The magnitude of the change was related to body size and was greater for heavier pigs.

Sainsbury and Sainsbury (1979) reported that critical temperatures for piglets were 35°C at birth, 29°C upto 5 kg live weight and 24°C at 10 kg live weight. If

temperature continue to go upwards or downwards, above or below the upper or lower critical temperatures, respectively, the animal continues to try and maintain its homeothermy by various metabolic means, but in due course the deep body temperature altered and it would at extremes eventually collapse and die.

Close and Mount (1981) calculated that each additional increase in group size between one and nine animals was associated with a seven percentage reduction in that rate at which heat production increased below the critical temperature. However, the extend to which this occurs for group size greater than nine animals was not known. Very large groups of animals may create unfavourable social environments and that may increase their heat production. For this reasons Sainsbury (1972) has recommended group size of 12-20 pigs per pen.

Rechciyl (1982) noticed as ambient temperature increased, daily feed consumption and average daily gain reduced ($P < 0.05$) whereas rectal temperature increased ($P < 0.05$).

Kotrabeck (1985) reported that heating the floor to 34 to 40°C did not have much effect on the rectal temperature of piglets of six to 25 days old.

Materials and Methods

MATERIALS AND METHODS

Twenty seven Large White Yorkshire weanling female pigs belonging to the Pig Breeding Farm, Kerala Agricultural University, Mannuthy having an average body weight of 8.5 kg and 56 days of age were assigned at random as uniformly as possible in regard to the body weight to three treatment groups. Pigs were maintained for a period of five months from weaning as per routine farm management.

Pigs were housed in three identical cement concrete floored open stye each having a net roofed area of 6.1m^2. The sheds had asbestos roof.

In the first group of six pigs, each received 1m^2 of floor space as per ISI (IS: 3916-1966) specification (control group) while in the second group there were nine pigs and in the third group of twelve pigs received 0.75m^2 and 0.5 m^2 of floor space per pig respectively.

The pigs were fed concentrate mixture which contained 18 per cent crude protein for a period of four months from weaning and there after a ration having 14 per cent crude protein. The rations contained a calculated level of 74 per cent total digestible nutrients/Digestible Energy 3256 K cal.

Every day at 09.00 hours, and 14.00 hours animals were provided with the concentrate in the feed trough and allowed to consume as much as they could within a period of one hour. Drinking water was provided at all times in the stye. The feed intake was recorded on three consecutive days in a fortnight.

The pen and pigs were cleaned and washed in the morning and evening before feeding. Malathion (0.5 percentage) was sprayed once in a month on pigs and premises to prevent ectoparasitic infestation. The animals were dewormed during the first week of experiment using Helatac* and repeated after a month. One ml of Imferon** (Iron Dextran) was given intra muscularly at weaning to prevent piglet anaemia.

The rectal temperature was recorded using a clinical thermometer once in every week in the morning at 09.00 hours and in the afternoon 14.00 hours.

The growth parameters in terms of live weight, height, length and girth were recorded at fortnightly intervals. The body weight of the pigs were recorded using a platform balance having a built-in cage.

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* Parbendazole 4% (Eskay Lab Ltd., Bangalore)

** Iron dextran 50 mg per ml (Rallis India Ltd., Bombay)

Front girth (just behind the forelegs), hind girth (just in front of the hind legs), body length and height upto the withers were recorded using a measuring tape. To measure the body length, an imaginary line was drawn from the anterior border of shoulder joint of one side to the same point of the other side. This line which bisected the mid-dorsal line was considered to be the anterior land mark. Similarly, an imaginary line was drawn upwards from the mid lateral aspect of the hock joint of one side to the same point of the other side. This line bisecting the mid dorsal line was taken as posterior land mark. The distance between the anterior and posterior land marks was taken as the length.

Behaviour of pigs were studied for a duration of one hour each at feeding time in the morning and evening. Competition and aggressive behaviour manifested were noticed during eating. Number of threats and biting were counted during feeding time. The other behavioural observations were noted just before, during and after feeding to find out any change in pattern of behaviour. One group was observed for their behaviour pattern on one day and other two groups were observed on subsequent days. This pattern was repeated.

After a period of five months three pigs were randomly selected from each of the groups and slaughtered to study the carcass characteristics such as dressing percentage of warm carcass, half carcass weight, weight of the ham, carcass length, eye muscle area and back fat thickness.

The data collected during the course of the study were statistically analysed as per methods described by Snedecor and Cochran (1967).

Results

RESULTS

The average fortnightly body weight of pigs at three stocking densities are presented in table 1, Fig. I. It can be seen that the average weaning weight of the pigs in control group (as per ISI specification of $1m^2$ of floor space per pig) was 8.50 ± 0.669 kg and the final weight was 67.0 ± 4.902 kg. A total weight gain of 58.5 kg was noticed in this group. The average weaning weight of the pigs housed at a stocking rate of 0.75 m^2/animal was 8.55 ± 0.546 kg and their mean final live weight was 64.77 ± 4.003 kg. Pigs in the above group gained on an average 56.22 kg during the experimental period. Similarly pigs receiving a floor area of $0.5m^2$/animal gained 55.46 kg of weight and their average weaning weight and final live weight were 8.54 ± 0.473 kg and 64.0 ± 3.466 kg respectively. The difference in gain in weight between control ($1m^2$/pig) and the group having $0.75m^2$/pig and $0.5m^2$/pig were 2.28 kg and 3.04 kg respectively. The gain in weight showed a decreasing tendency as the stocking density increased. Analysis of variance of the data showed that variation of average fortnightly body weight of pigs due to stocking density was not significant.

Table 1. Average fortnightly body weight of pigs, kg

Fortnight	group I ($1m^2$/pig)	group II ($0.75m^2$/pig)	group III ($0.5m^2$/pig)	F-value
Weaning 1	8.5± 0.669	8.55± 0.546	8.54± 0.473	0.00215 NS
2	-	-	-	- -
3	15.708± 1.593	16.0± 1.3	15.87± 1.126	0.01007 NS
4	21.0± 1.972	21.85± 1.610	20.83± 1.394	0.123 NS
5	26.58± 2.867	28.14± 2.341	26.87± 2.027	0.117 NS
6	33.66± 3.14	33.55± 2.56	31.75± 2.22	0.193 NS
7	39.42± 3.913	39.61± 3.195	38.458± 2.767	0.0427 NS
8	49.16± 3.979	47.94± 3.249	47.79± 2.813	0.0427 NS
9	57.42± 4.282	54.77± 3.496	53.83± 3.028	0.235 NS
10	63.7± 4.753	58.77± 3.881	58.75± 3.362	0.363 NS
11	67.0± 4.902	64.77± 4.003	64.0± 3.466	0.126 NS

NS - Non-significant

FIGURE 1. AVERAGE FORTNIGHTLY BODY WT.(kg) OF PIGS

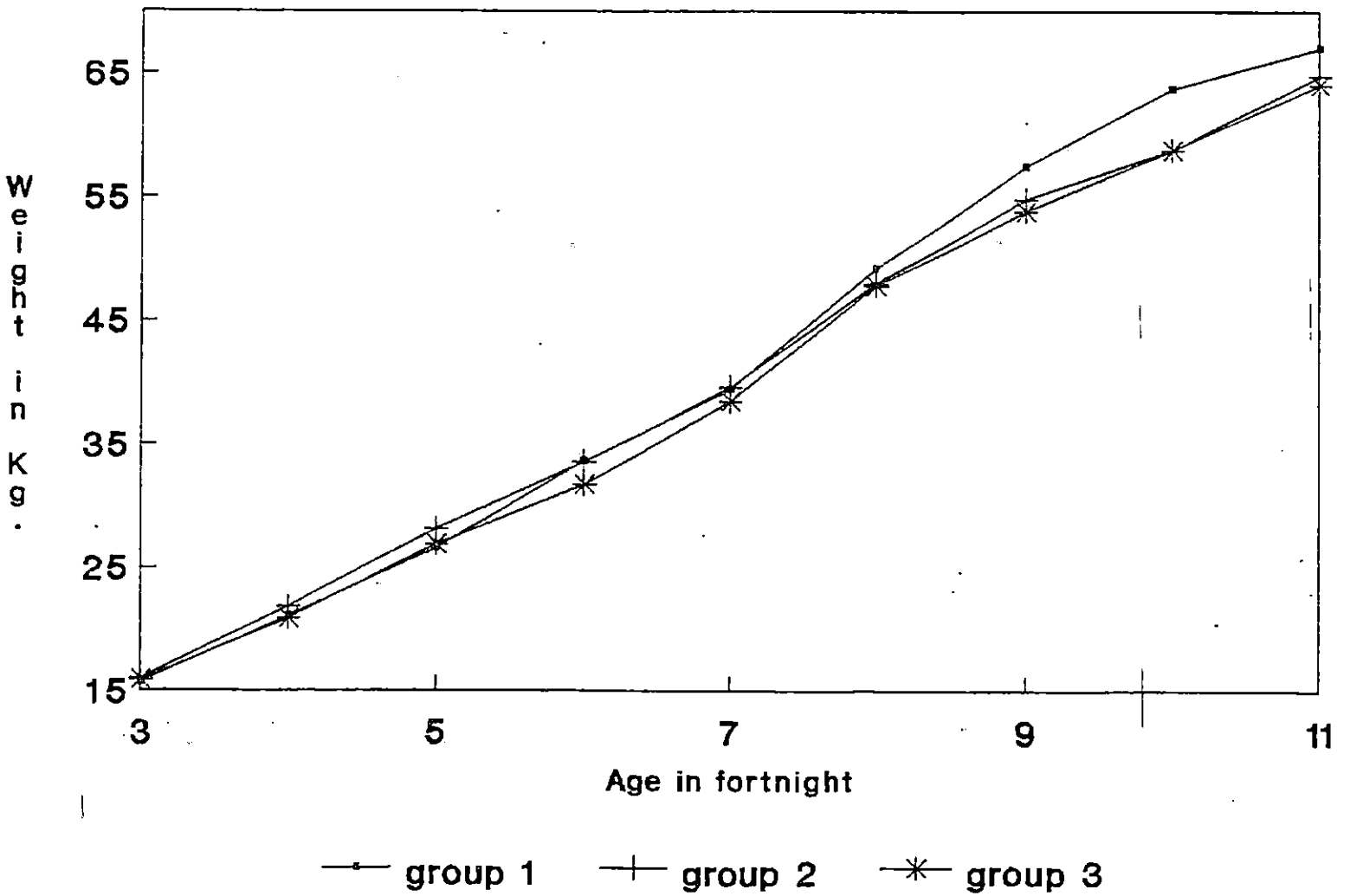


Table 2 and Fig.2 show the average monthly growth rate of pigs housed at three stocking densities. Maximum growth rate was observed during the fourth month in all the three groups. The maximum growth rates of 18.0, 15.16 and 15.37 kg were noticed in these groups having 1, 0.75 and 0.5 m^2 of floor space per pig respectively. Minimum growth was noticed during the first month of the experiment in all the three groups (7.21, 7.45 and 7.33 kg at $1m^2$, $0.75m^2$ and $0.5m^2$ floor space/gilt respectively). Comparison by t-test revealed non-significant difference between the three groups (Table 3).

Table 2. Average monthly rate of body weight gain

Months	group I ($1m^2$/pig)	group II ($0.75m^2$/pig)	group III ($0.5m^2$/pig)
1	7.21	7.45	7.33
2	10.87	12.14	11.00
3	13.00	11.47	11.59
4	18.00	15.16	15.37
5	9.58	10.00	10.17

FIGURE 2. AVERAGE MONTHLY RATE OF GROWTH

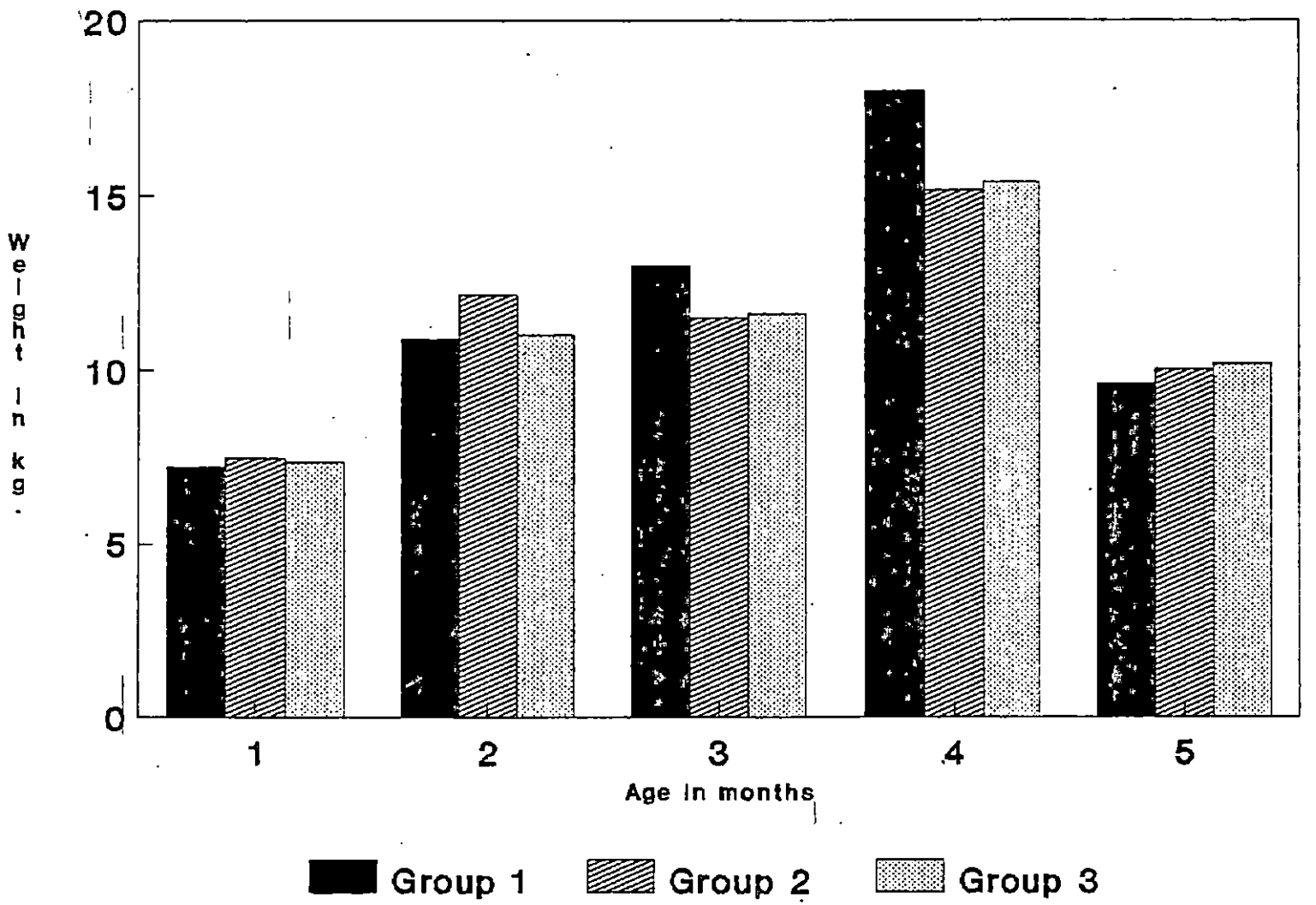


Table 3. Comparison of average monthly rate of body weight gain

Average monthly weight gain	t-value
group I ($1m^2$/pig) x group II (0.75 m^2/pig)	0.2195 NS
group I ($1m^2$/pig) x group III (0.5 m^2/pig)	0.2858 NS
group II(0.75m^2/pig) x group III (0.5 m^2/pig)	0.0839 NS

NS - Non-significant

Absolute daily gain during the experimental period was calculated for the three stocking density groups. The findings are presented in table 4 and Fig. 3. The peak absolute gain was noticed during the fourth month and minimum during the first month. The absolute gain varied from 218 to 600 g for the first group 225 to 505 g for the second group and 222 to 512 g for the third group. This was found to be reduced from the fourth month.

Growth rate of pigs expressed as percentage of the previous month's weight is given in table 5 and Fig. 4. Maximum percentage of growth rate was noticed during the first month in all the groups. It declined gradually with advance in age upto seventh month.

Table 4. Absolute daily gain in weight - grams

Months	group I ($1m^2$/pig)	group II ($0.75m^2$/pig)	group III ($0.5m^2$/pig)
1	218	225	222
2	362	405	366
3	433	382	386
4	600	505	512
5	319	333	339

Table 5. Growth rate expressed as percentage of previous month's weight

Months	group I ($1m^2$/pig)	group II ($0.75m^2$/pig)	group III ($0.5m^2$/pig)
1	84.82	87.13	85.83
2	69.19	75.9	69.31
3	48.9	40.74	43.13
4	45.66	38.26	39.96
5	16.68	18.25	18.89

FIGURE 3. ABSOLUTE DAILY GAIN IN WEIGHT (g)

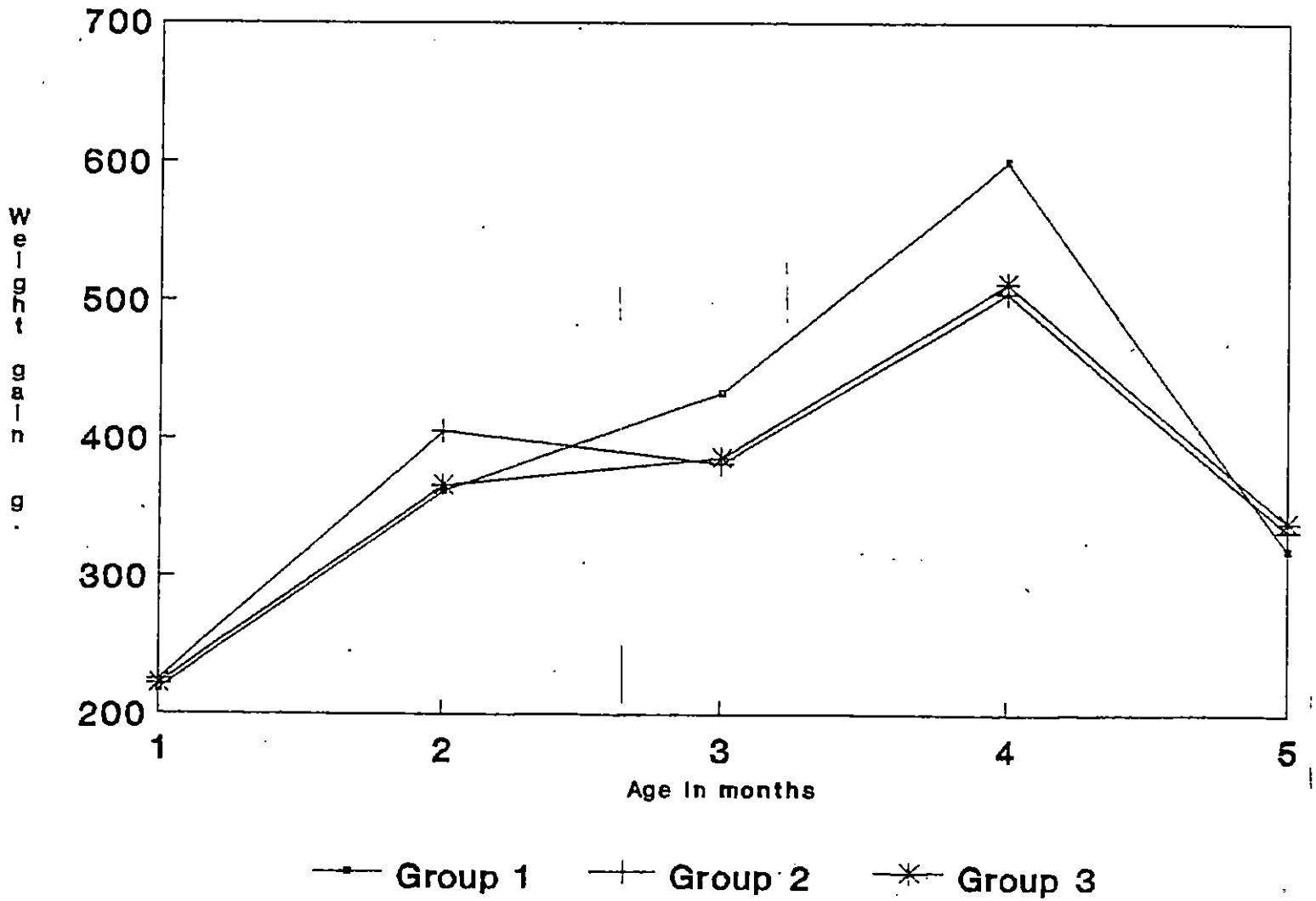
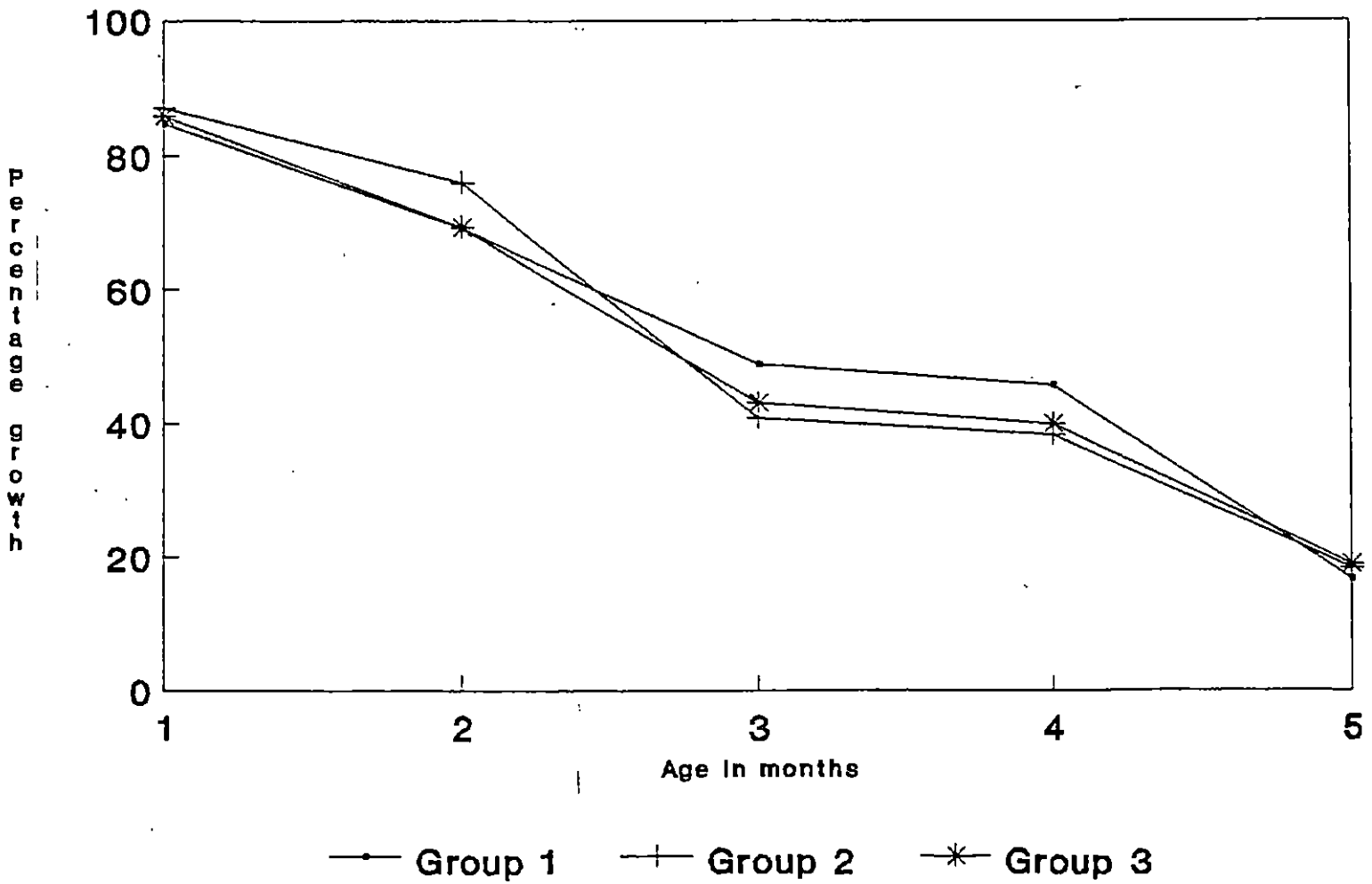


FIGURE 4. GROWTH RATE EXPRESSED AS PERCENTAGE OF PREVIOUS MONTHS WEIGHT



Length, height and girth were measured from the third fortnight onwards. The average fortnightly length of the pigs at three stocking rates are listed in table 6 and Fig. 5. The average fortnightly length of the pigs at stocking density of $1m^2$ floor space per pig increased from 52.33±2.01 cm to 87.33±2.46cm with a gain of 35.0 cm. The group given 0.75 m^2/pig starting from 51.33±1.64 cm reached 87.11±2.01 cm with an increase of 35.78 cm in length. At $0.5m^2$ of floor area per pig the length increased from 53.16±1.42 cm to 82.83±1.74 cm, giving a gain of 29.67 cm. Eventhough the gain showed mild variation between the groups, it was found to be non-significant except during the fifth fortnight where the variation was found to be significant.

The average monthly rate of gain in length in the first group showed a maximum in the second month (13.34 cm) and a sudden declining trend to 3.16 cm in the third month. Thereafter this parameter increased to 11.17 cm in the fourth month and again dropped to 7.33 cm in the fifth month. The trend in the second group (having $0.75m^2$ per pig) showed a gradual increase from second month (5.11 cm) to fourth month (11.22 cm) and then dropped to fifth month (8.78 cm). The rate of gain in the third group (having $0.5m^2$/pig) showed a sudden increase from second month

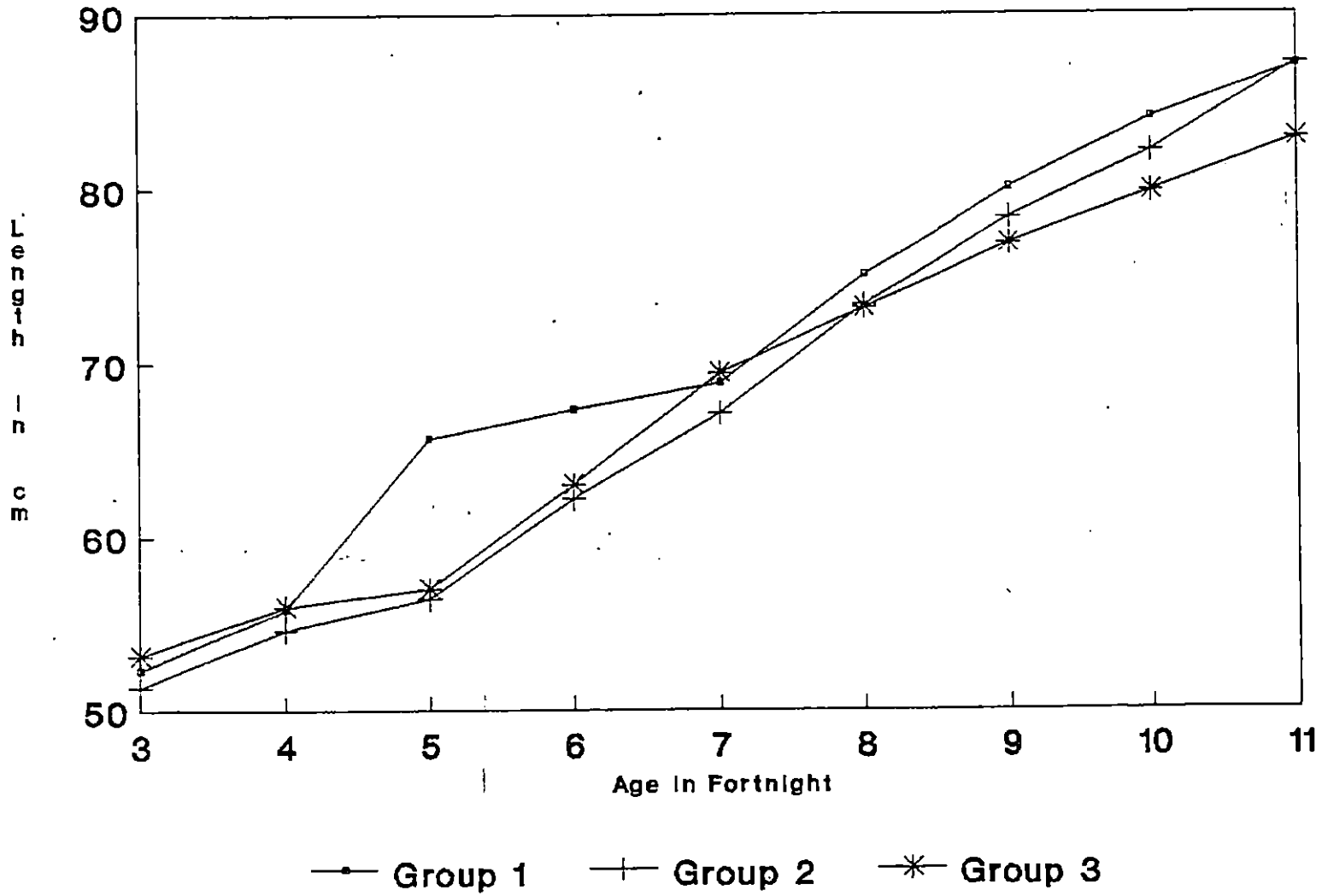
Table 6. Average fortnightly length of pigs - (cm)

Fortnight	group I ($1m^2$/pig)	group II ($0.75m^2$/pig)	group III ($0.5m^2$/pig)	F-value
3	52.33± 2.01	51.33± 1.64	53.16± 1.42	0.35602 NS
4	55.83± 2.39	54.66± 1.95	56.0± 1.69	0.14377 NS
5	65.66± 2.6	56.44± 2.13	57.42± 1.84	4.36736 S*
6	67.33± 2.56	62.22± 2.09	63.33± 1.81	1.26978 NS
7	68.83± 2.65	67.11± 2.16	69.42± 1.87	0.33009 NS
8	75.0± 2.67	73.33± 2.18	73.16± 1.89	0.17044 NS
9	80.0± 2.81	78.33± 2.29	76.83± 1.99	0.43499 NS
10	84.16± 2.36	82.11± 1.92	79.83± 1.67	1.18445 NS
11	87.33± 2.46	87.11± 2.01	82.83± 1.74	1.74824 NS

S* - Significant at 5% level.

NS - Non-significant

FIGURE 5. AVERAGE FORTNIGHTLY LENGTH OF PIGS(Cm)



(4.25 cm) to third month (12.0 cm) and then gradually decreased to fifth month (6.0 cm) (Table 7 and Fig. 6).

Table 7. Average monthly rate of gain in length (cm)

Months	group I ($1m^2$/pig)	group II ($0.75m^2$/pig)	group III ($0.5m^2$/pig)
2	13.34	5.11	4.25
3	3.16	10.67	12.0
4	11.17	11.22	7.41
5	7.33	8.78	6.0

The absolute daily gain in length of pigs at three different pen densities are recorded in table 8 and Fig. 7. The maximum absolute gain in length was observed during second, fourth and third months in pigs housed at stocking rate of $1m^2$, $0.75m^2$ and $0.5m^2$/pig respectively. The absolute daily gain in length varied from 0.105 cm to 0.44 cm at $1m^2$/pig; 0.17 cm to 0.374 cm at $0.75m^2$/pig and 0.142 cm to 0.4 cm at $0.5m^2$/pig. This trend is similar to that of the fortnightly length recorded in the three groups.

The rate of gain in length expressed as percentage of previous month's length showed an increasing trend from second (2.55) to fourth month (16.22) in the control group. This showed a declining trend thereafter to fifth month.

FIGURE 6. AVERAGE MONTHLY RATE OF GAIN IN LENGTH (Cm)

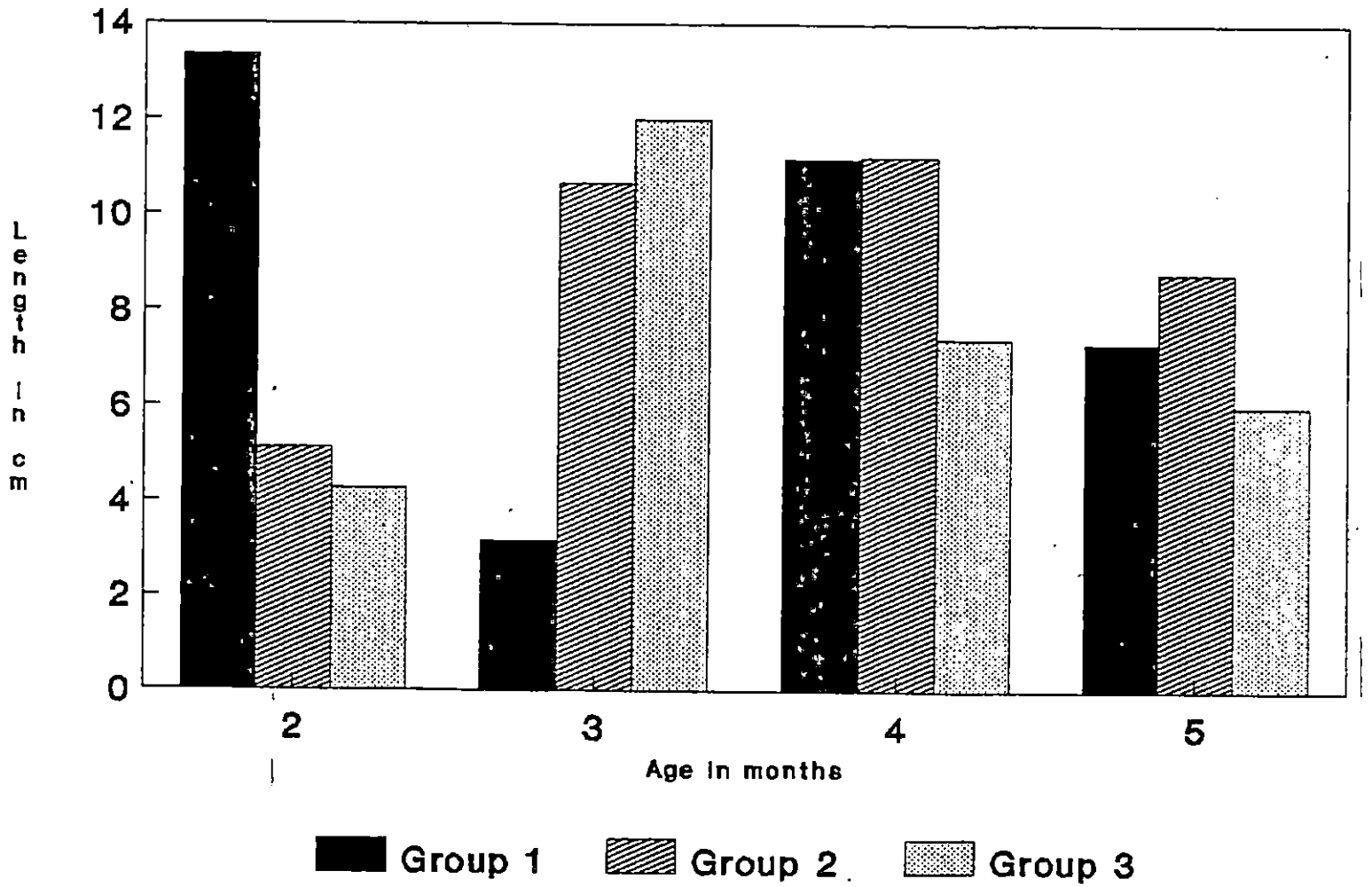


Table 8. Absolute daily gain in length - (cm)

Months	group I ($1m^2$/pig)	group II ($0.75m^2$/pig)	group III ($0.5m^2$/pig)
2	0.44	0.170	0.142
3	0.105	0.356	0.40
4	0.372	0.374	0.247
5	0.244	0.293	0.20

The tendency for this character in the second group showed an increasing trend from the second month (9.95) to third month (18.9) and then a gradual decline to fifth month (11.21). The same was the tendency in the third group where it showed an increase from 7.99 in the second month to 20.09 in the third month and then a gradual decrease to 7.81 in the fifth month (Table 9 and Fig. 8).

Table 9. Rate of gain in length expressed as percentage of previous month's length.

Months	group I ($1m^2$/pig)	group II ($0.75m^2$/pig)	group III ($0.5m^2$/pig)
2	2.55	9.95	7.99
3	4.81	18.90	20.09
4	16.22	16.72	10.67
5	9.16	11.21	7.81

FIGURE 7. ABSOLUTE DAILY GAIN IN LENGTH (Cm)

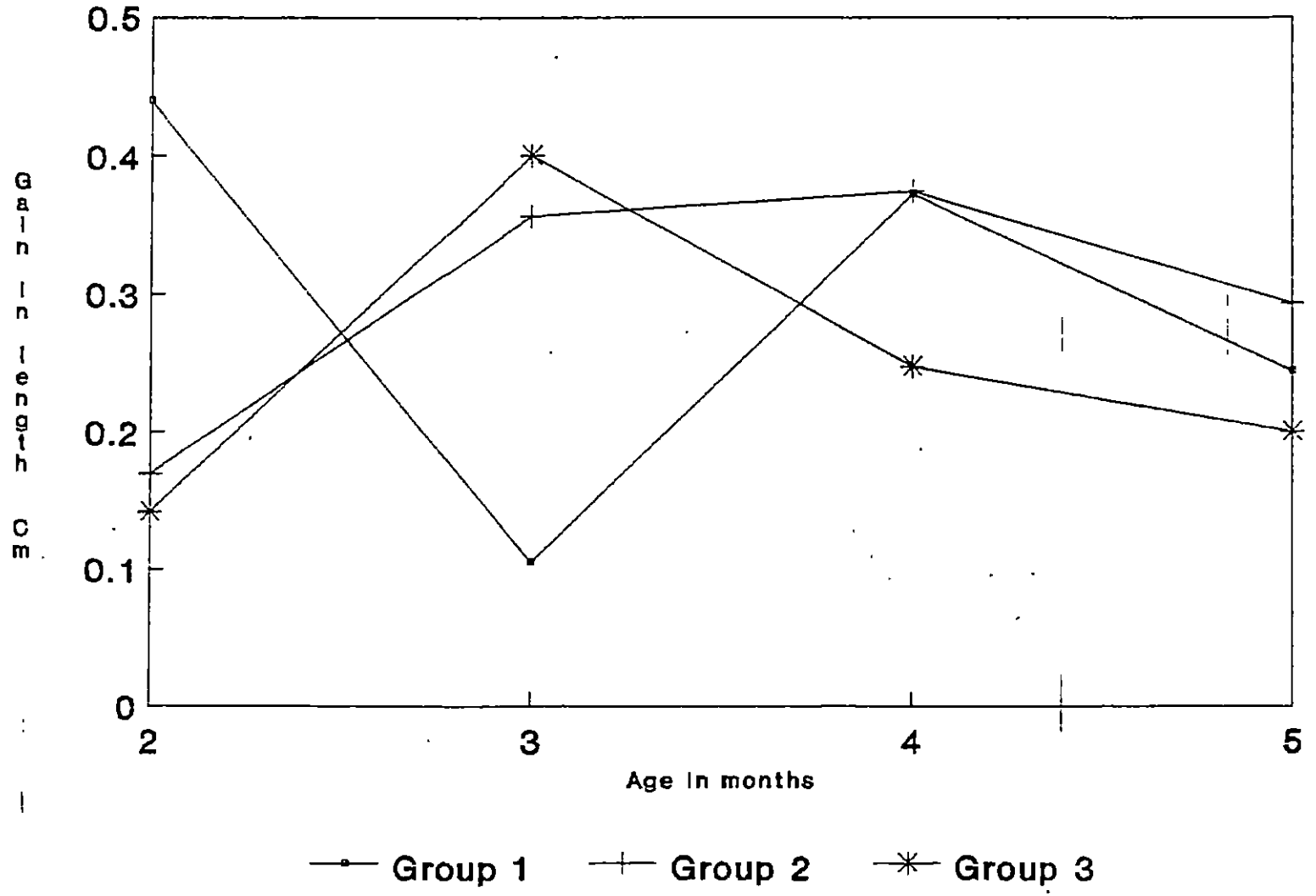
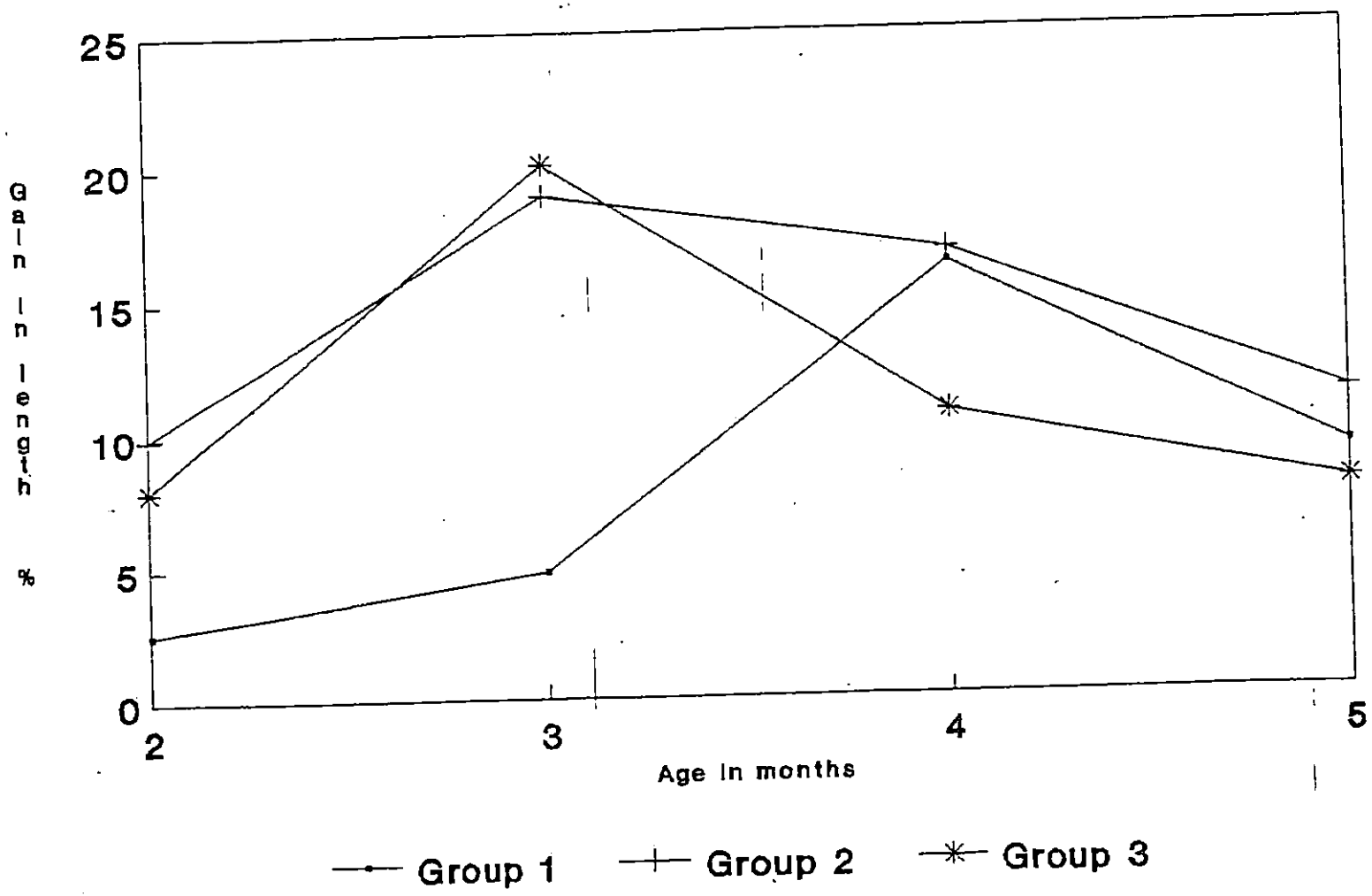


FIGURE 8. RATE OF GAIN IN LENGTH EXPRESSED AS PERCENTAGE OF PREVIOUS MONTH'S LENGTH



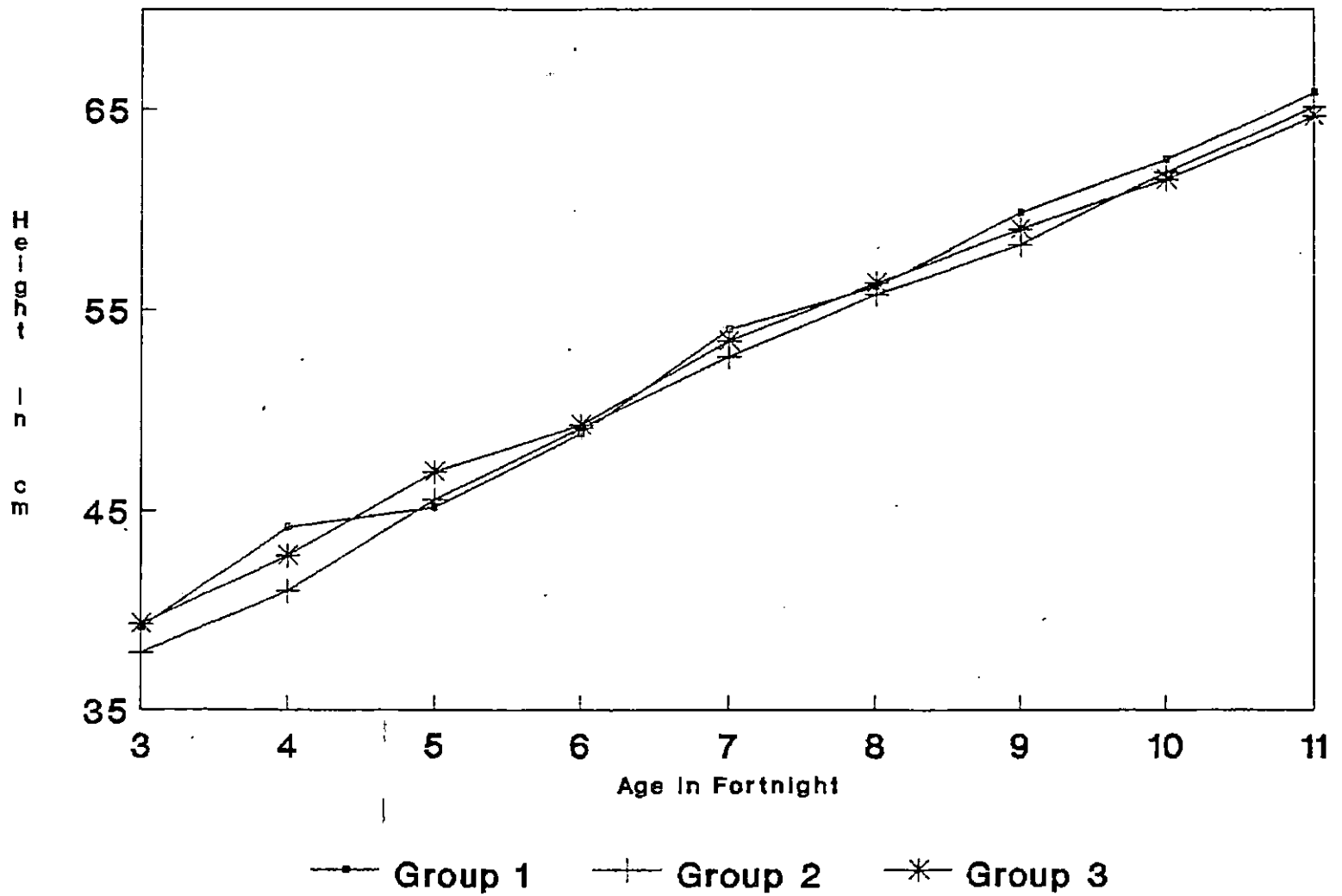
Average fortnightly height of pigs recorded are given in table 10 and Fig. 9. The total gain in height during experimental period was observed to be 26.67 cm starting with a height of 39.16±1.37 and ending at 65.83±1.74 cm, in pigs receiving $1m^2$ of floor space/gilt. From an initial

Table 10. Average fortnightly height of pigs - (cm)

Fortnight	group I ($1m^2$/pig)	group II ($0.75m^2$/pig)	group III ($0.5m^2$/pig)	F-value
3	39.16± 1.37	37.88± 1.12	39.33± 0.97	0.8719 NS
4	44.16± 1.71	41.0± 1.39	42.75± 1.21	1.078 NS
5	45.16± 1.59	45.55± 1.31	46.92± 1.13	0.5179 NS
6	48.83± 1.74	49.11± 1.42	49.25± 1.23	0.01905 NS
7	54.0± 1.44	52.66± 1.17	53.42± 1.02	0.27122 NS
8	56.16± 1.49	55.77± 1.22	56.33± 1.11	0.0602 NS
9	59.83± 1.59	58.22± 1.29	59.0± 1.12	0.31328 NS
10	62.5± 1.82	61.88± 1.48	61.5± 1.28	0.101364 NS
11	65.83± 1.74	65.11± 1.42	64.66± 1.23	0.1501665 NS

NS - Non-significant

FIGURE 9. AVERAGE FORTNIGHTLY HEIGHT OF PIGS (Cm)



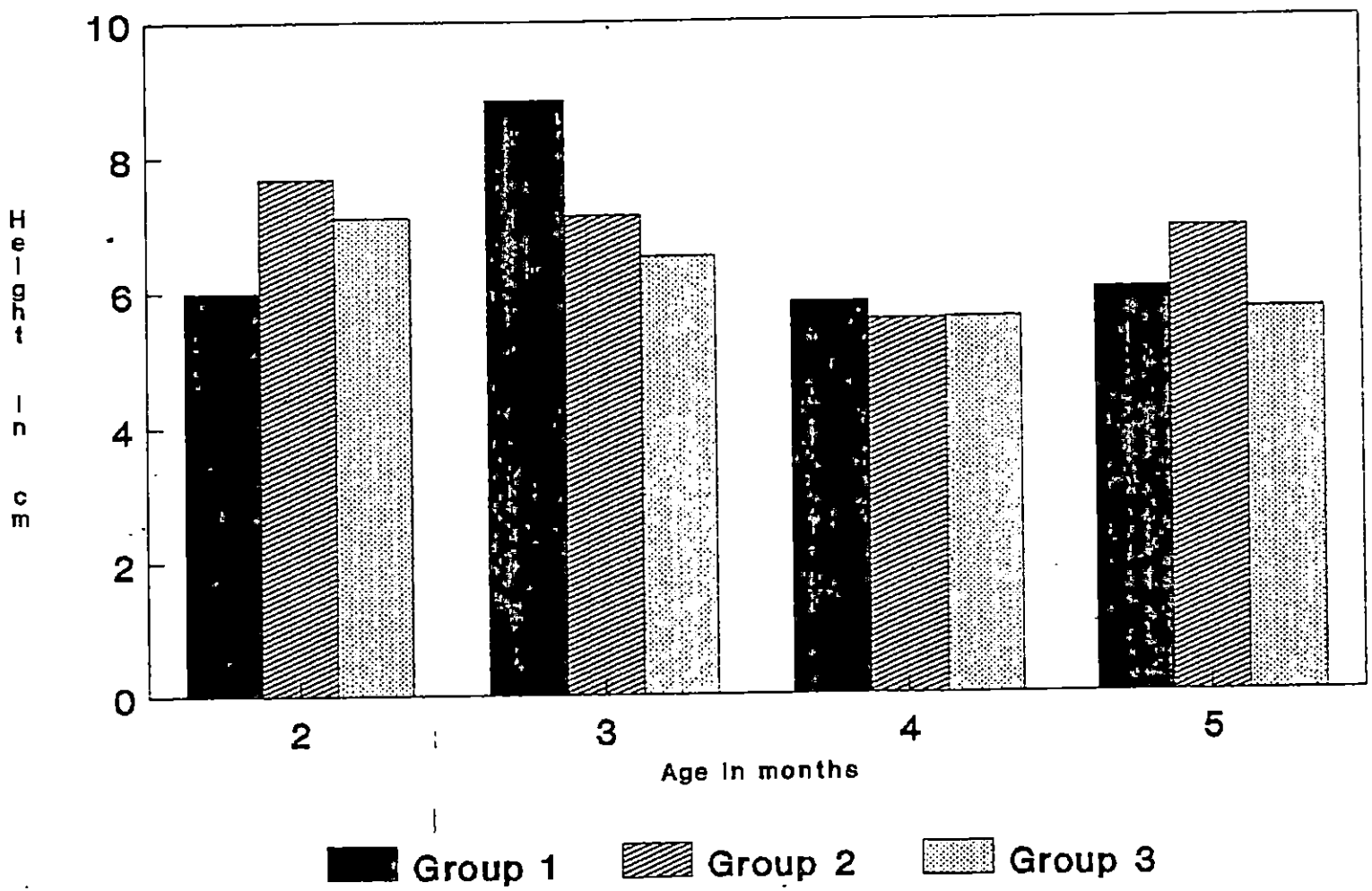
height of 37.88±1.12 cm pigs given a stocking density of 0.75m^2 per pig gained 27.23 cm to reach a height of 65.11±1.42 cm. Pigs housed at floor space of 0.5m^2/pig, starting from 39.33±0.97 cm reached 64.66±1.23 cm with a total gain of 25.33 cm. Eventhough the total gain in height in the three groups showed some variation the analysis of variance showed no significant difference in average fortnightly height of pigs between the three groups.

The maximum average monthly rate of gain in height (table 11 and Fig. 10) was noticed during the third month in control group and during the second month in pigs having floor space of 0.75 and 0.5m^2/animal. Maximum average rate of gain in height noticed were 8.83, 7.67 and 7.09 cm at stocking density of 1, 0.75 and 0.5m^2/pig respectively.

Table 11. Average monthly rate of gain in height - (cm)

Months	group I (1m^2/pig)	group II (0.75m^2/pig)	group III (0.5m^2/pig)
2	6.0	7.67	7.09
3	8.83	7.11	6.5
4	5.83	5.55	5.58
5	6.0	6.89	5.67

FIGURE 10. AVERAGE MONTHLY RATE OF GAIN IN HEIGHT (Cm)



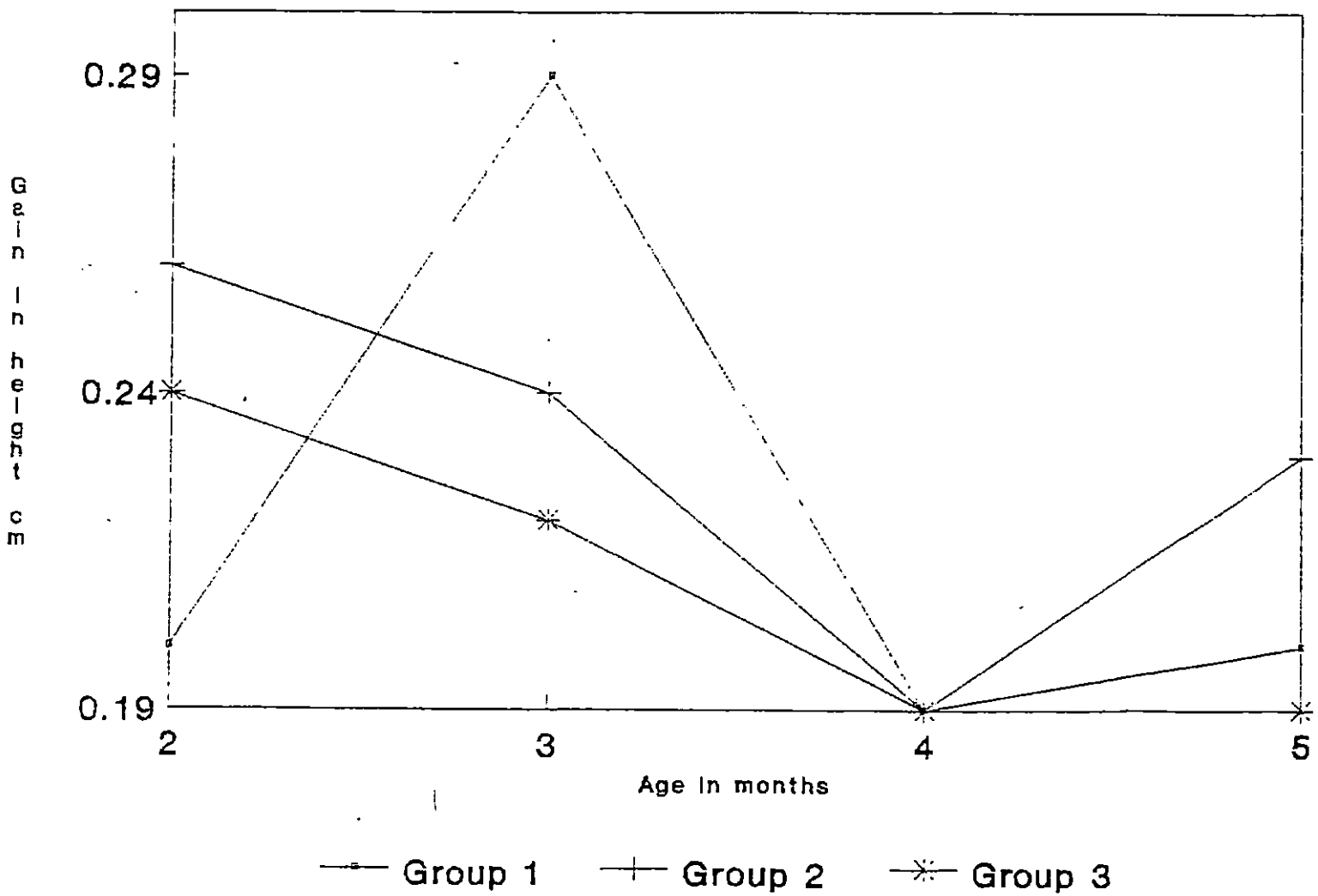
Corresponding minimum values were 5.83, 5.55 and 5.58 and these were observed during fourth month in all the pen densities.

The absolute daily gain in height showed a tendency to decrease from the second month to fourth month in all groups and thereafter it was steady or slightly increasing to fifth month. The tendency for the character was same in all groups except in the first group where the gain showed slight increase from 0.20 cm to 0.29 cm from second to third month (Table 12 and Fig. 11).

Table 12. Abosolute daily gain in height - (cm)

Months	group I ($1m^2$/pig)	group II ($0.75m^2$/pig)	group III ($0.5m^2$/pig)
2	0.20	0.26	0.24
3	0.29	0.24	0.22
4	0.19	0.19	0.19
5	0.20	0.23	0.19

FIGURE 11. ABSOLUTE DAILY GAIN IN HEIGHT (Cm)

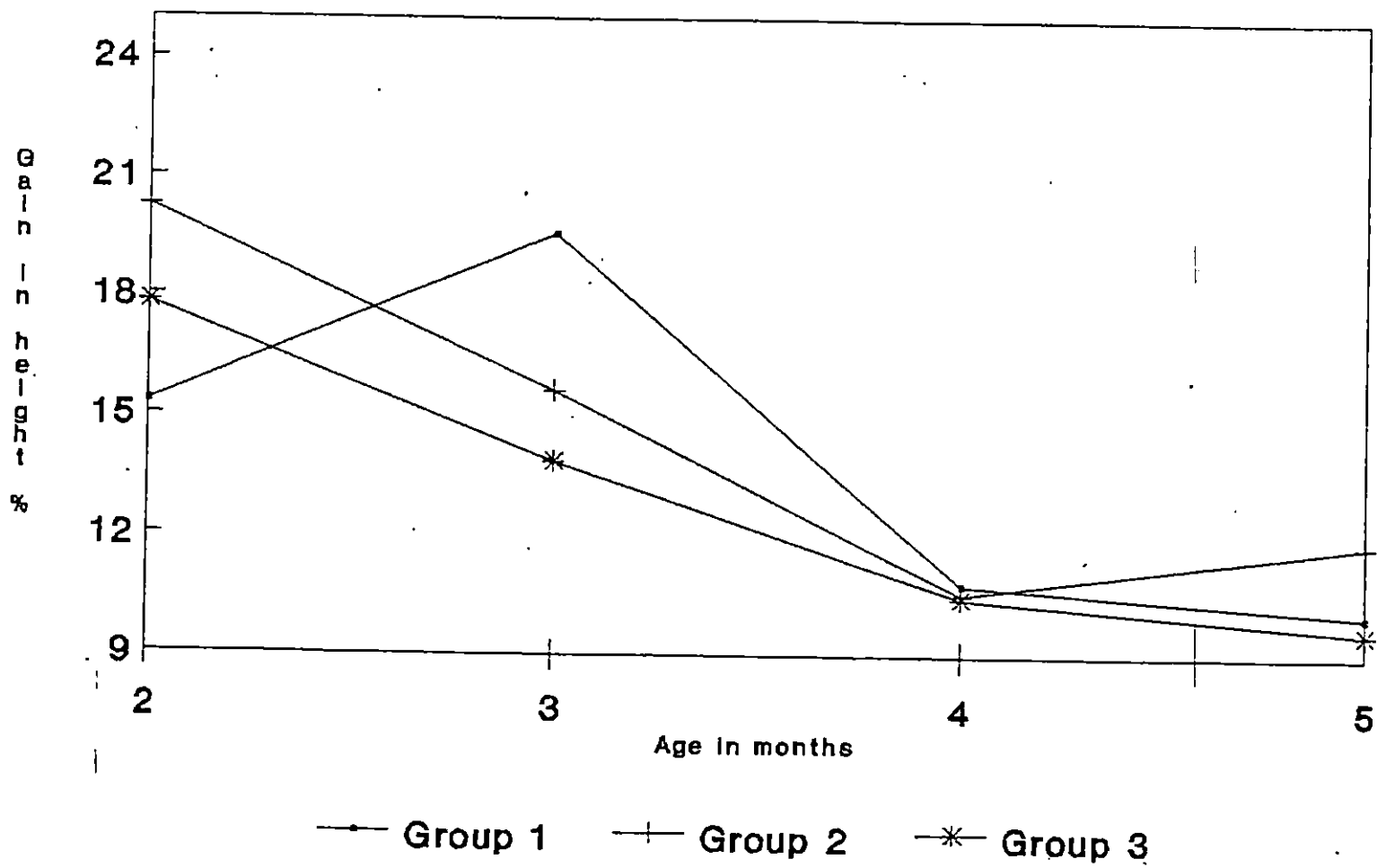


Rate of gain in height expressed as percentage of previous month's height is given in table 13 and Fig. 12. Highest percentage of rate of gain in height (19.55, 20.24 and 17.80 cm) were noticed during third month in group one and second month of experiment for group two and three respectively. The general trend in the rate of gain in height expressed as percentage of previous month's height showed a decline from second month to fifth month in all the groups except in the control group where it showed an increase from second to third month and thereafter decreased.

Table 13. Rate of gain in height expressed as percentage of previous month's height

Months	group I ($1m^2$/pig)	group II ($0.75m^2$/pig)	group III ($0.5m^2$/pig)
2	15.31	20.24	17.8
3	19.55	15.61	13.85
4	10.79	10.54	10.45
5	10.03	11.83	9.61

FIGURE 12. RATE OF GAIN IN HEIGHT EXPRESSED AS PERCENTAGE OF PREVIOUS MONTH'S HEIGHT



The average fortnightly front girth and hind girth are given in tables 14 and 18 and mean monthly girths are shown in Fig. 13 and Fig. 17. The average fortnightly front girth showed an increase of 39.34 cm (56.66±1.93 to 96.0±3.46) in the control group. The same for the second group was 39.66 cm (55.11±1.57 to 94.77±2.83 cm) and 37.92 cm (54.66±1.36 to 92.58±2.85) in the third group. The average hind girth also showed a similar trend in growth. This showed an increase of 39.83 cm (58.33±2.86 cm to 98.16±4.14 cm) in the control group and 38.23 cm (54.88±2.34 cm to 93.11±3.38 cm) in the second group and 33.41 cm (59.92±2.02cm to 93.33±2.93 cm) in the third group. Analysis of variance of average fortnightly girths (both front girth and hind girth) revealed no significant differences between the groups.

The average monthly rate of gain in front girth and hind girth were maximum during the fourth month in all groups. The maximum average monthly rate of gain in front girth were 12.5 cm, 10.89 cm and 10.58 cm at $1m^2$, 0.75 m^2 and $0.5m^2$ floor space/pig respectively. The corresponding minimum values were 5.83, 7.22 and 9.50 for group one, two and three respectively. In all groups minimum value was observed during fifth month (Table 15 and Fig. 14). The average rate of gain in hind girth also showed a similar trend like that of front girth. This character showed an

increasing trend to a peak in the fourth month (12.17, 13.22 and 12.58 cm in case of control, group two and group three respectively) and then a decline to the fifth month. This trend was similar in all groups except in the first group where rate of gain showed a peak in the second month itself (12.84 cm) and then again in the fourth month (12.17 cm) (Table 19 and Fig. 18).

Absolute daily gain in front girth showed an increasing tendency in all groups to the fourth month (0.42 cm, 0.36 cm and 0.35 cm respectively for group one, two and three) and then declined to the fifth month. In the case of groups one and two the absolute gain showed a sudden decrease in the third month before the peak growth rate in fourth month (Table 16 and Fig. 15). The same was the trend for absolute gain in hind girth. From an initial increase in the absolute gain it increased again to a peak at fourth month (0.41, 0.44 and 0.42 cm for group I, II and III respectively) and then a decline to the fifth month (Table 20 and Fig. 19).

Rate of gain in front girth expressed as percentage of previous month's front girth was maximum during the second month in all the three stocking density groups; but the same

data for hind girth were maximum during the second month in $1m^2$, and 75 m^2 stocking rate. In the third group maximum was recorded during fourth month. Maximum percentage noticed were 21.17; 19.76 and 18.89 for the control, group two and three respectively. Minimum percentages were observed during the fifth month (6.46, 8.25 and 11.04 for group one, two and three respectively). Maximum rate of gain in hind girth expressed as percentage were 22.01, 23.64 and 16.65 at 1, 0.75 and $0.5m^2$ of stocking rates respectively. Minimum percentages (8.27, 3.33 and 5.36) were recorded during the fifth month (Tables 17 and 21; Fig. 16 and 20)

The average daily feed intakes taken at fortnightly interval are presented in table 22. Voluntary feed intake showed a steady increase from fortnight to fortnight except in the nineth fortnight in which there was a slight depression in all the three groups. The difference in the feed intakes when tested were found to be non-significant between groups (Table 23).

The average monthly feed intake was found to increase from the first month to the fifth month in all groups (Table 24). Maximum feed consumption was noticed in the control group and least in the third group. The difference

Table 14. Average fortnightly front girth (G_1) - cm

Fortnight	group I ($1m^2$/pig)	group II ($0.75m^2$/pig)	group III ($0.5m^2$/pig)	F-value
3	56.66± 1.93	55.11± 1.57	54.66± 1.36	0.364 NS
4	62.0± 2.63	61.22± 2.15	59.08± 1.86	0.507 NS
5	68.66± 2.93	66.0± 2.39	65.0± 2.07	0.524 NS
6	70.83± 3.09	71.66± 2.53	69.75± 2.19	0.167 NS
7	77.66± 3.32	76.66± 2.71	75.5± 2.35	0.151 NS
8	86.16± 3.54	81.22± 2.89	81.0± 2.51	0.798 NS
9	90.16± 3.31	87.55± 2.69	86.08± 2.34	0.509 NS
10	93.5± 3.56	91.22± 2.91	89.92± 2.52	0.338 NS
11	96.0± 3.46	94.77± 2.83	92.58± 2.85	0.370 NS

NS - Non-significant

FIGURE 13. AVERAGE FORTNIGHTLY FRONT GIRTH (Cm)

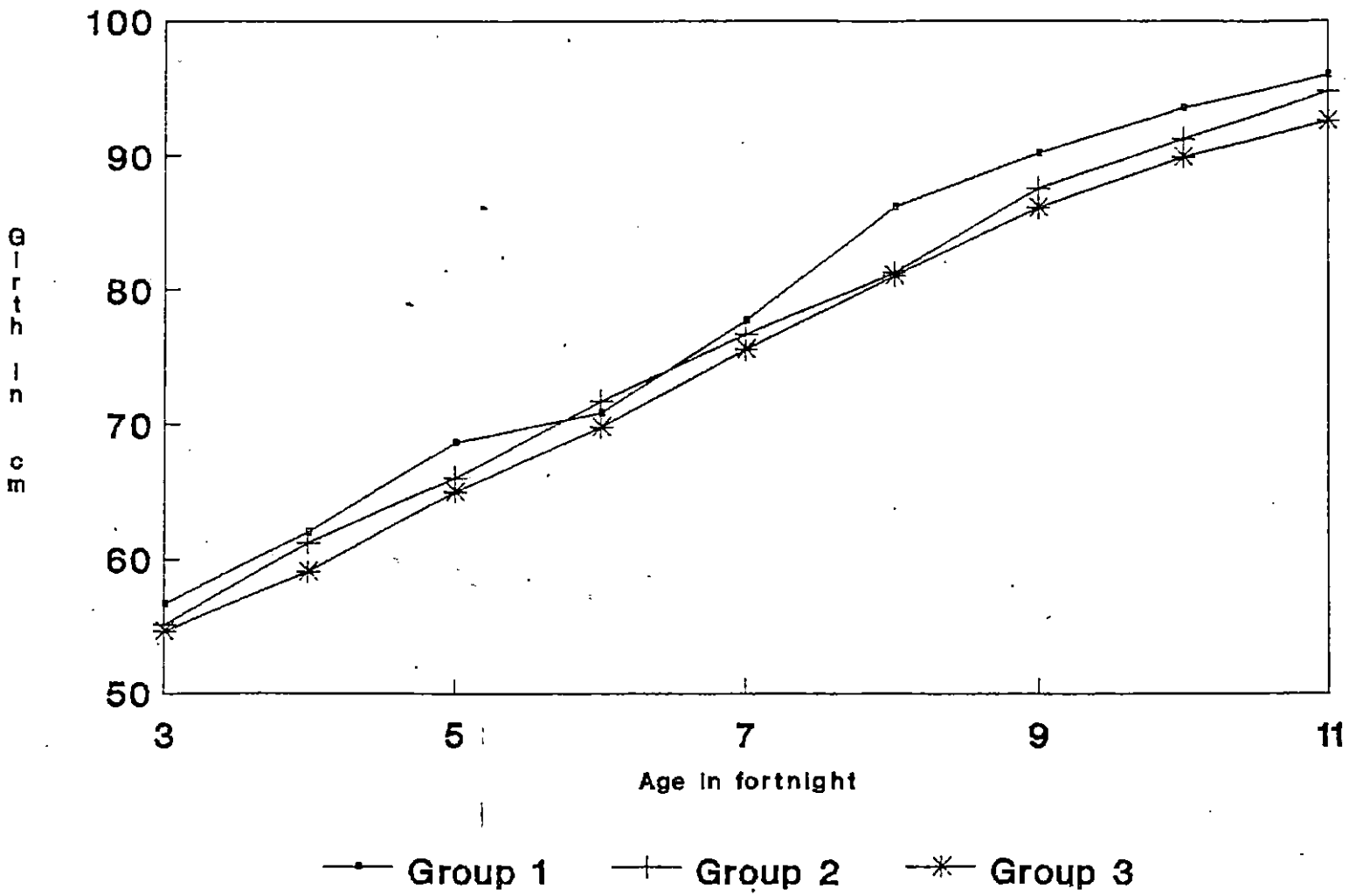


Table 15. Average monthly rate of gain in front girth - cm

Months	group I ($1m^2$/pig)	group II ($0.75m^2$/pig)	group III ($0.5m^2$/pig)
2	12.00	10.89	10.33
3	9.00	10.67	10.50
4	12.50	10.89	10.58
5	5.83	7.22	9.50

Table 16. Absolute daily gain in front girth - cm

Months	group I ($1m^2$/pig)	group II ($0.75m^2$/pig)	group III ($0.5m^2$/pig)
2	0.40	0.36	0.34
3	0.30	0.35	0.35
4	0.42	0.36	0.35
5	0.19	0.24	0.32

FIGURE 14. AVERAGE MONTHLY RATE OF GAIN IN FRONT GIRTH (Cm)

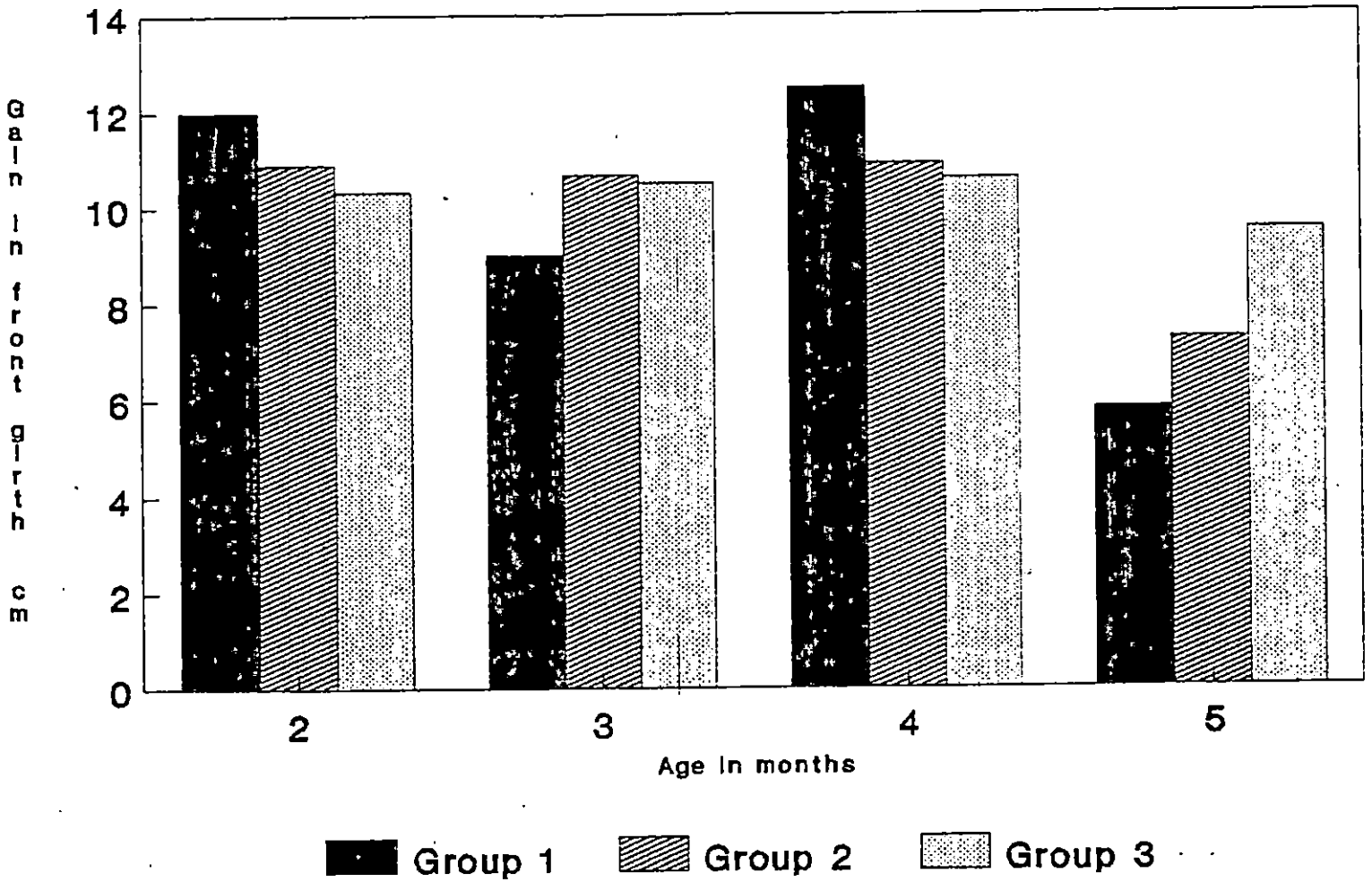


FIGURE 15. ABSOLUTE DAILY GAIN IN FRONT GIRTH -(Cm)

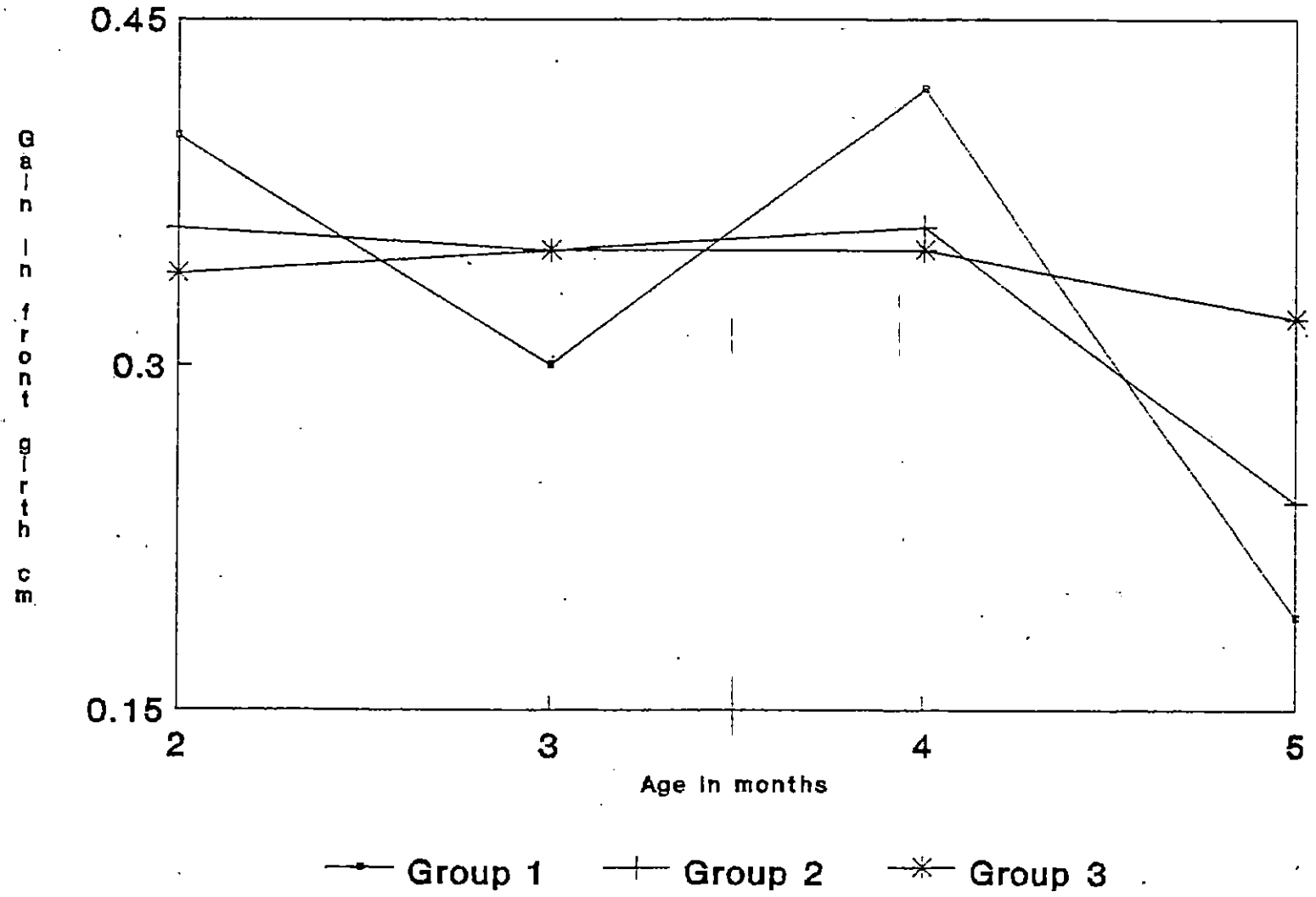


Table 17. Rate of gain in front girth expressed as percentage of previous month's front girth.

Months	group I ($1m^2$/pig)	group II ($0.75m^2$/pig)	group III ($0.5m^2$/pig)
2	21.17	19.76	18.89
3	13.11	16.16	16.15
4	16.09	14.20	14.01
5	6.46	8.25	11.04

Table 18. Average fortnightly hind girth - cm

Fortnight	group I ($1m^2$/pig)	group II ($0.75m^2$/pig)	group III ($0.5m^2$/pig)	F-value
3	58.33± 2.86	54.88± 2.34	59.92± 2.02	1.338 NS
4	64.5± 3.02	59.66± 2.46	58.25± 2.14	1.452 NS
5	71.66± 3.65	68.0± 2.98	66.42± 2.58	0.564 NS
6	71.0± 3.4	68.88± 2.78	69.75± 2.41	0.115 NS
7	78.5± 3.66	76.88± 2.99	76±2.59	0.156 NS
8	83.16± 3.29	81.55± 2.69	81.5± 2.33	0.0967NS
9	90.66± 3.71	90.11± 3.03	88.58± 2.62	0.130 NS
10	93.83± 3.57	92.22± 2.92	87.58± 2.52	1.277 NS
11	98.16± 4.14	93.11± 3.38	93.33± 2.93	0.552 NS

NS - Non-significant

FIGURE 16. GAIN IN FRONT GIRTH EXPRESSED AS PERCEN-
-TAGE OF PREVIOUS MONTH'S FRONT GIRTH

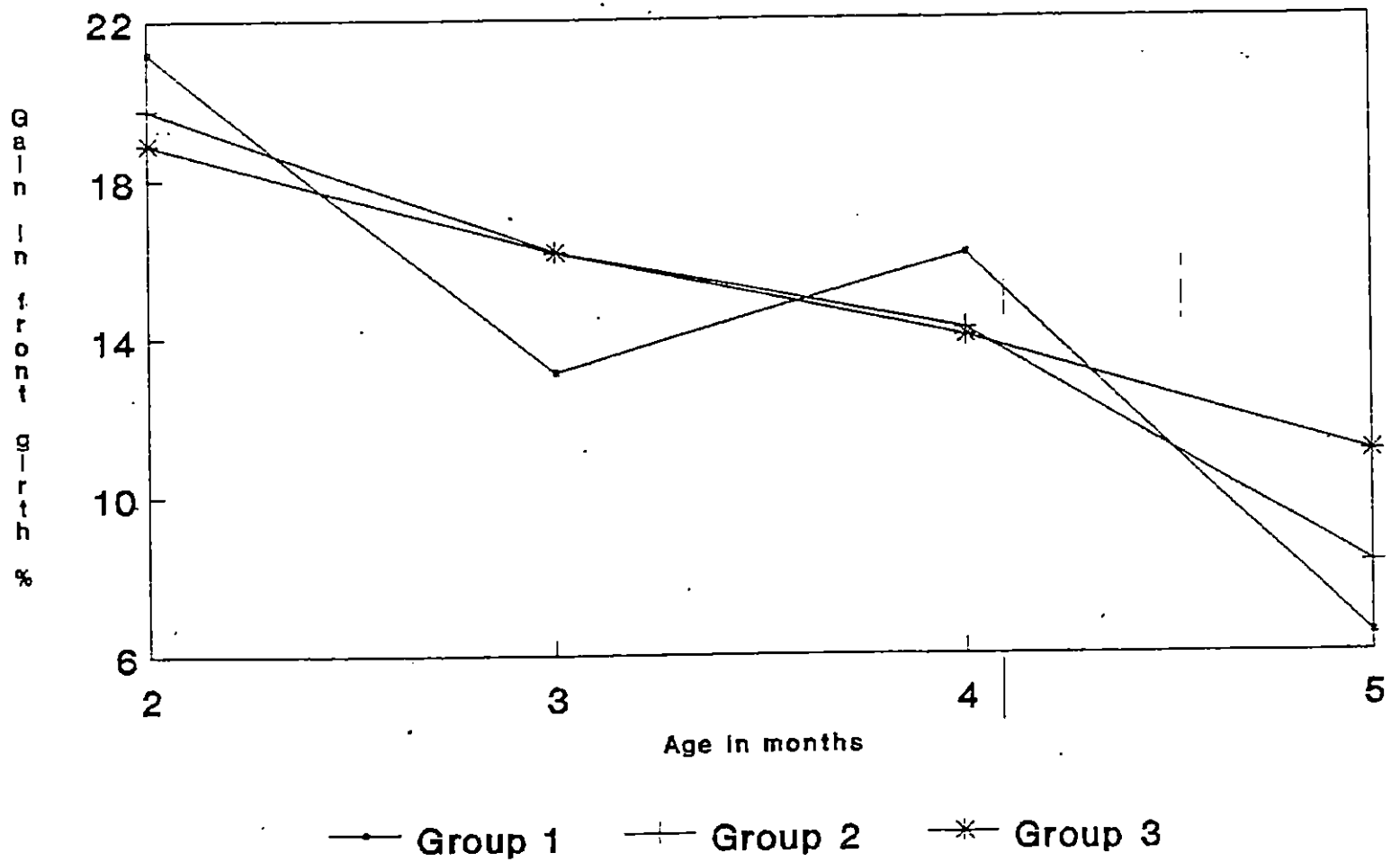


FIGURE 17.. AVERAGE FORTNIGHTLY HIND GIRTH (Cm)

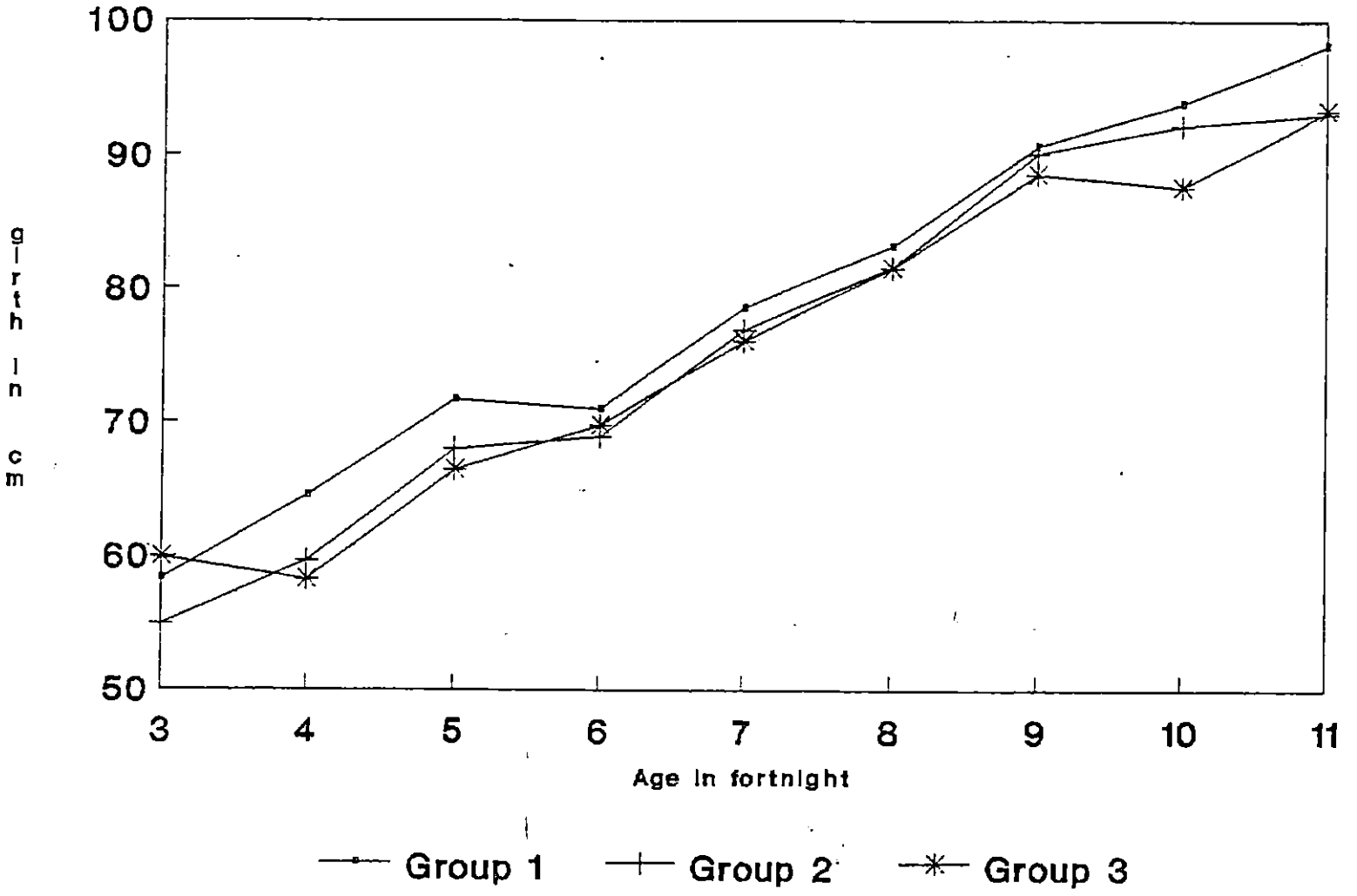


Table 19. Average monthly rate of gain in hind girth - cm

Months	group I ($1m^2$/pig)	group II ($0.75m^2$/pig)	group III ($0.5m^2$/pig)
2	12.84	13.00	6.50
3	7.39	8.89	9.58
4	12.17	13.22	12.58
5	7.50	3.00	4.75

Table 20. Absolute daily gain in hind girth - cm

Months	group I ($1m^2$/pig)	group II ($0.75m^2$/pig)	group III ($0.5m^2$/pig)
2	0.43	0.43	0.22
3	0.25	0.29	0.34
4	0.41	0.44	0.42
5	0.25	0.10	0.16

FIGURE 18. AVERAGE MONTHLY RATE OF GAIN IN HIND GIRTH (Cm)

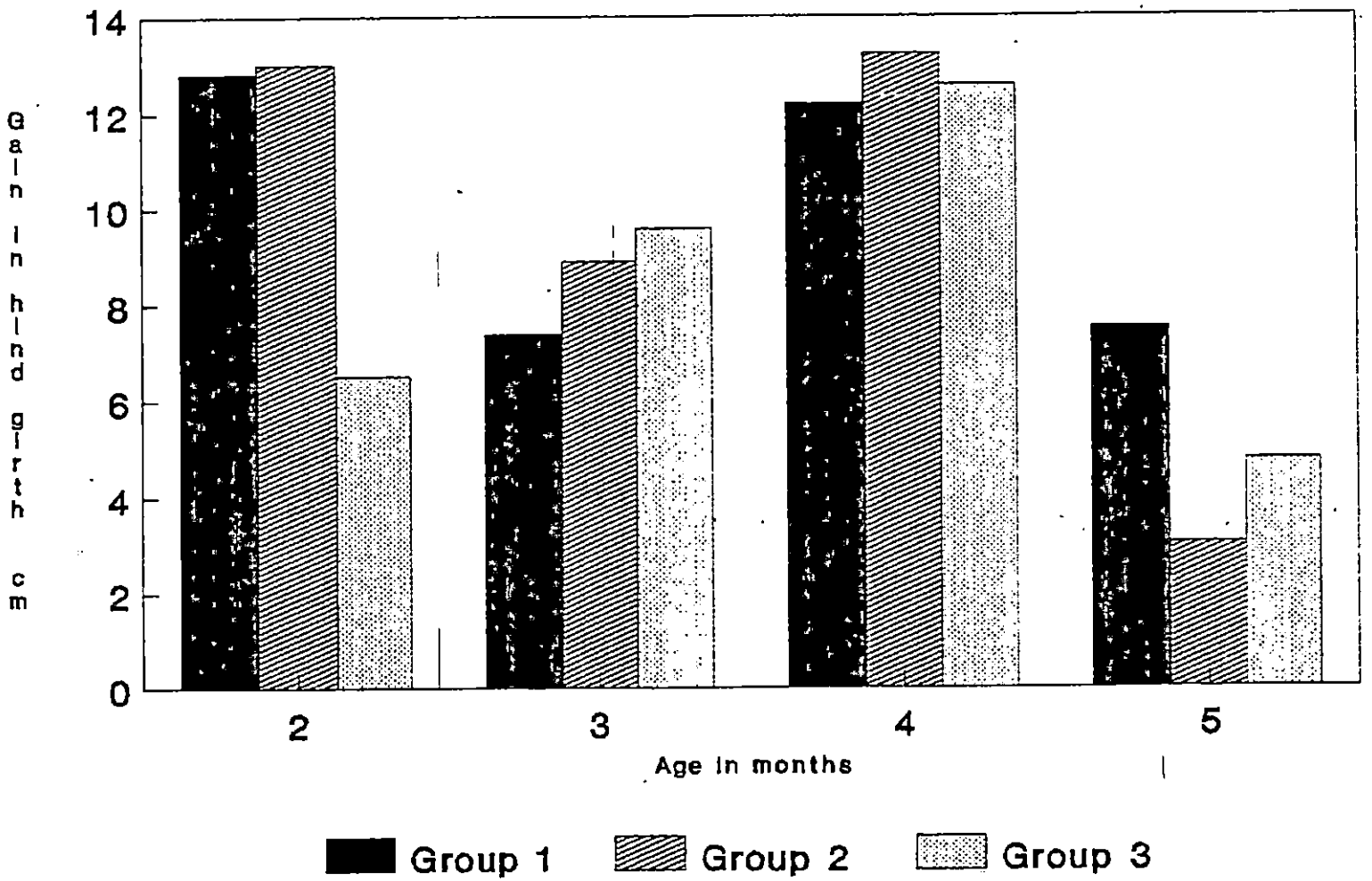


FIGURE 19. ABSOLUTE DAILY GAIN IN HIND GIRTH (Cm)

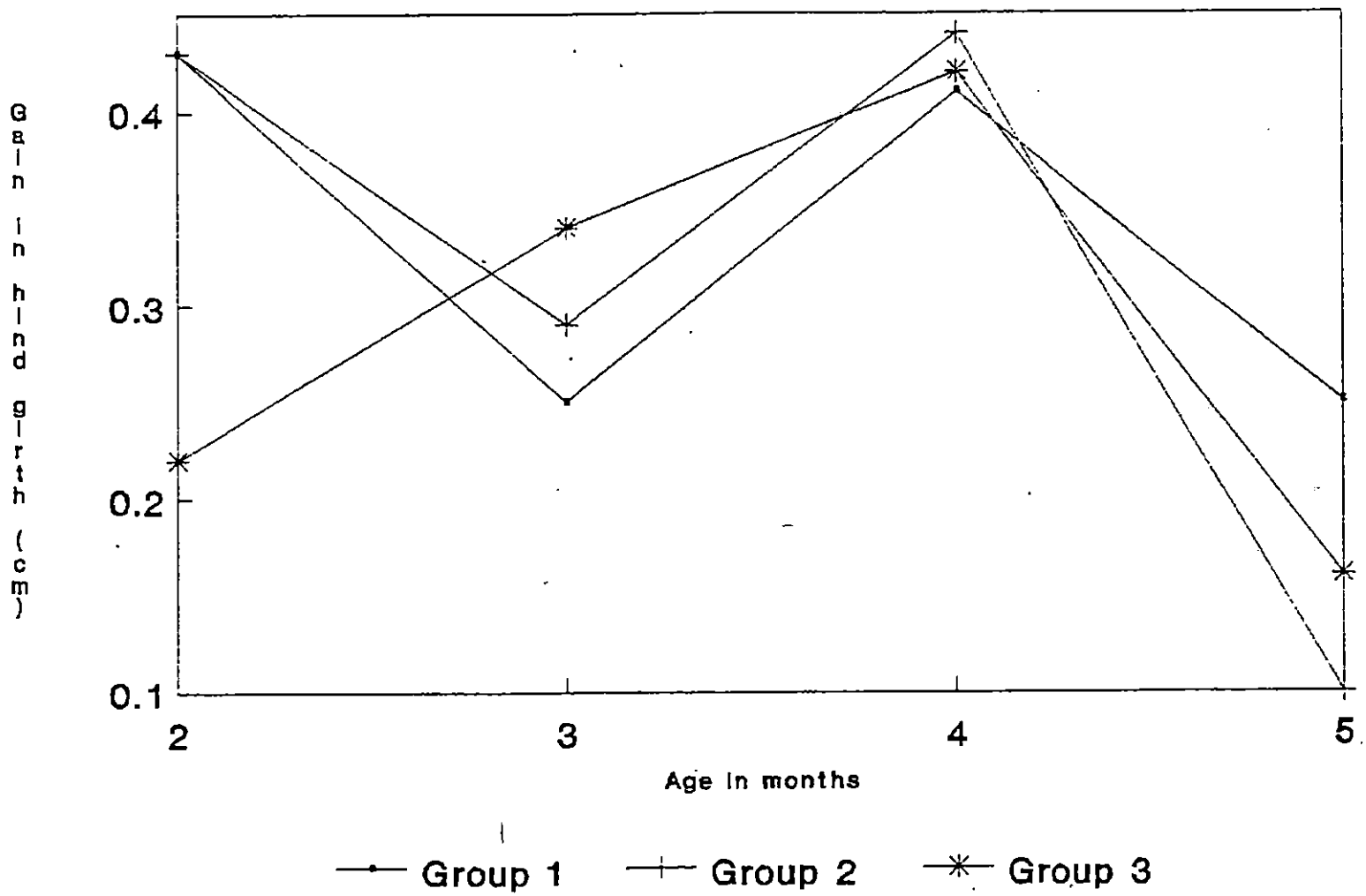


Table 21. Rate of gain in hind girth expressed as percentage of previous month's hind girth.

Months	group I ($1m^2$/pig)	group II ($0.75m^2$/pig)	group III ($0.5m^2$/pig)
2	22.01	23.64	10.85
3	10.38	13.07	14.42
4	15.5	17.19	16.55
5	8.27	3.33	5.36

Table 22. Average daily feed in take - kg

Fortnignt	group I ($1m^2$/pig)	group II ($0.75m^2$/pig)	group III ($0.5m^2$/pig)
1	0.575	0.571	0.569
2	0.736	0.666	0.663
3	0.876	0.798	0.830
4	1.128	1.092	1.086
5	1.432	1.400	1.403
6	1.878	1.850	1.846
7	2.206	2.065	1.906
8	2.473	2.269	2.234
9	2.463	2.135	2.113
10	2.618	2.432	2.341

FIGURE 20. GAIN IN HIND GIRTH EXPRESSED AS PERCEN--TAGE OF PREVIOUS MONTH'S HIND GIRTH

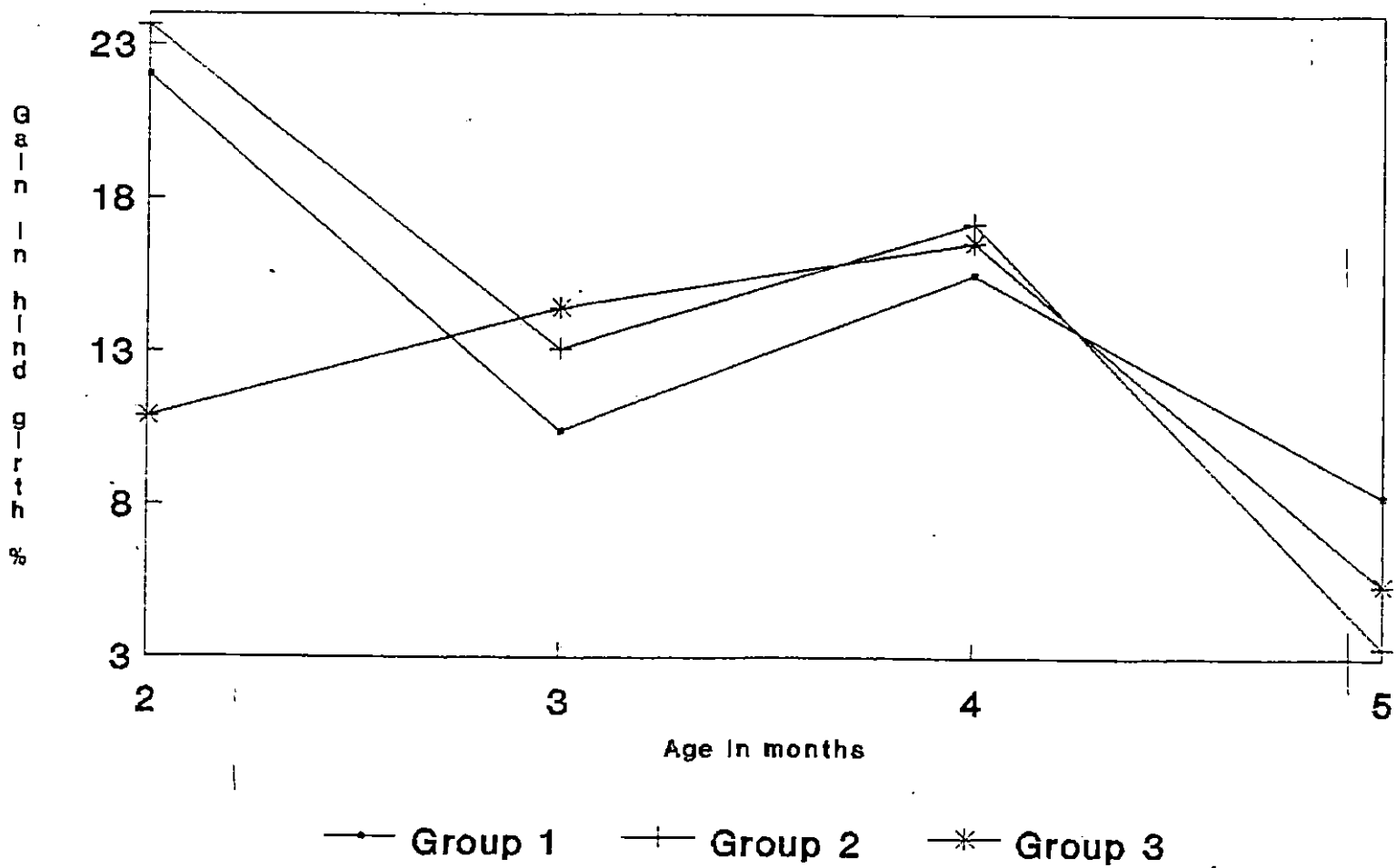


Table 23. Comparison of average daily feed in take - kg

Average daily feed in take (kg)	t-value
group I ($1m^2$/pig) x group II ($0.75m^2$/pig)	0.3309 NS
group I ($1m^2$/pig) x group III ($0.5m^2$/pig)	0.4257 NS
group II ($0.75m^2$/pig) x group III ($0.5m^2$/pig)	0.0927 NS

NS - Non-significant

Table 24. Average monthly feed in take - kg

Months	group I ($1m^2$/pig)	group II ($0.75m^2$/pig)	group III ($0.5m^2$/pig)
1	20.23	19.16	19.05
2	27.60	25.87	26.22
3	45.60	44.82	44.87
4	65.15	61.48	57.73
*5	70.11	63.94	62.35

* 14% CP ration

noticed with three groups were found to be non-significant when tested between groups (Table 25).

Average monthly feed conversion efficiency (Table 26) in all the groups increased from first month to second month and then gradually decreased to the fifth month. The highest feed conversion efficiency of 2.54, 2.13 and 2.38 was noticed in group I, II and III respectively. The highest feed efficiency when compared between groups was noticed in the group II (2.13) followed by group III (2.38) and control (2.54). The differene in the feed efficiency noticed between groups were found to be non-significant (Table 27). Table 28 contains data on average monthly weight gain, feed intake and feed conversion efficiency of the three stocking density groups.

The average weight gain was more in group one (11.732±1.826 kg). The same was less in group two (11.244±1.267 kg) and least in group three(11.092±1.296 kg).

The average feed intake was highest in control group (45.738±9.875 kg) and lower in group two (42.854±8.969 kg) and lowest in group three (42.044±8.502 kg).

Table 25. Comparison of average monthly feed in take - kg

Average monthly feed in take	t-value
group I ($1m^2$/pig) x group II ($0.75m^2$/pig)	0.2162 NS
group I ($1m^2$/pig) x group III ($0.5m^2$/pig)	0.2835 NS
group II ($0.75m^2$/pig) x group III ($0.5m^2$/pig)	0.0655 NS

NS - Non-significant

Table 26. Average monthly feed conversion efficiency

Months	group I ($1m^2$/pig)	group II ($0.75m^2$/pig)	group III ($0.5m^2$/pig)
1	2.81	2.57	2.59
2	2.54	2.13	2.38
3	3.51	3.91	3.87
4	3.62	3.99	3.76
*5	7.32	6.39	6.13

* 14% CP ration.

Table 27. Comparison of average monthly feed efficiency

Average monthly feed efficiency	t-value
group I ($1m^2$/pig) x group II ($0.75m^2$/pig)	0.1421 NS
group I ($1m^2$/pig) x group III ($0.5m^2$/pig)	0.1960 NS
group II ($0.75m^2$/pig) x group III ($0.5m^2$/pig)	0.0521 NS

NS - Non-significant

Table 28. Average weight gain (kg), feed intake (kg) and feed conversion efficiency.

	group I ($1m^2$/pig)	group II ($0.75m^2$/pig)	group III ($0.5m^2$/pig)
Average weight gain - kg	11.732± 1.826	11.244± 1.267	11.092± 1.296
Average feed intake - kg	45.738± 9.875	42.854± 8.969	42.044± 8.502
Average feed conversion efficiency	3.96± 0.864	3.798± 0.744	3.746± 0.667

When the feed conversion efficiency is taken as whole, it was found to be highest in group III (3.746±0.667) and lowest in group I (3.96±0.864). The animals of group II were showing feed conversion efficiency between group one and three (3.798±0.744).

The coefficient of correlation between average weight gain and average feed intake was computed for the three groups. The values when tested were found to be non-significant in all the groups (Table 29). Same result was obtained by calculating correlation coefficient of average weight gain and average feed conversion efficiency (Table 30).

Table. 29 Correlation between average weight gain and average feed intake.

	Average weight gain(kg)	Average feed intake(kg)	Correlation coeff:
group I ($1m^2$/pig)	11.732± 1.826	45.74± 9.875	0.555 NS
group II ($0.75m^2$/pig)	11.244± 1.267	42.85± 8.969	0.519 NS
group III ($0.5m^2$/pig)	11.092± 1.296	42.04± 8.502	0.625 NS

NS - Non-significant

Table. 30 Correlation between average weight gain and average feed conversion efficiency.

	Average weight gain(kg)	Average feed conversion efficiency	Correlation
group I ($1m^2$/pig)	11.732± 1.826	3.96± 0.864	-0.111 NS
group II ($0.75m^2$/pig)	11.244± 1.267	3.80± 0.744	0.038 NS
group III ($0.5m^2$/pig)	11.092± 1.296	3.750± 0.667	0.139 NS

NS - Non-significant

The coefficient of correlations of average feed intake on average feed conversion efficiency were 0.764, 0.867 and 0.857 at stocking rates of $1m^2$, $0.75m^2$ and $0.5m^2$ respectively. Eventhough high values were obtained when tested were found to be non-significant in group one and significant in group two and three (Table 31).

Aggressive behaviour was measured by counting the number of threats and ear-biting incidence during the feeding time (Table 32 and 33). Comparison by t-test showed significant differences in number of threats between the

Table. 31 Correlation between average feed intake and average feed conversion efficiency.

	Average feed intake(kg)	Average feed conversion efficiency	Correlation
group I ($1m^2$/pig)	45.74± 9.875	3.96± 0.864	0.764 NS
group II ($0.75m^2$/pig)	42.85± 8.969	3.80± 0.744	0.867 S*
group III ($0.5m^2$/pig)	42.04± 8.502	3.750± 0.667	0.857 S*

NS - Non-significant
S* - Significant at 5% level

Table 32. Behaviour - Number of threats/day

Behaviour	group I ($1m^2$/pig)	group II ($0.75m^2$/pig)	group III ($0.5m^2$/pig)
Number of threats	10.24± 0.706	12.65± 0.716	15.21± 0.775

Table 33. Behaviour - Number of ear-biting/day

Behaviour	group I ($1m^2$/pig)	group II ($0.75m^2$/pig)	group III ($0.5m^2$/pig)
Number of ear biting	1±0	1.2±0.133	2.1±0.211

three stocking density groups (Table 34). Number of ear-biting during the feeding time also revealed significant differences between control group and group III ($0.5m^2$/pig) and also between group II (0.75 m^2/pig) and group III (Table 35). During feeding time the animals tried to displace the other animals from the manger. This activity was noticed from third month onwards. Before feeding they huddled together for sleeping. Immediately after feeding the animals from control group used to go for sleeping and in the other groups, some animals tried to chase, mount and attack the other animals. Few incidence (33.3 per cent in control and in group II and 50 per cent in group III) of tail-biting was also noticed during the first two months of experiment and it was absent afterwards. The pigs marked an area near the door for defecation and urination. Animals in heat showed frequent mounting on the other animals. Pigs used the drinking water tank for wallowing during the

Table 34. Comparison of behaviour (threats) between the groups.

Number of threats during feeding time	t-value
group I ($1m^2$/pig) x group II ($0.75m^2$/pig)	-2.4017 S*
group I ($1m^2$/pig) x group III ($0.5m^2$/pig)	-4.7462 S**
group II ($0.75m^2$/pig) x group III ($0.5m^2$/pig)	-2.4279 S*

S* - Significant at 5% level
S** - Significant at 1% level

Table 35. Comparsison of behaviour (Number of ear-biting) between the groups

Number of ear biting during feeding time	t-value
group I ($1m^2$/pig) x group II ($0.75m^2$/pig)	1.5 NS
group I ($1m^2$/pig) x group III ($0.5m^2$/pig)	3.596 S**
group II ($0.75m^2$/pig) x group III ($0.5m^2$/pig)	-3.750 S**

S** - Significant at 1% level
NS - Non-significant

initial periods of experiment and afterwards they used to dip only their head portion in the tank.

Three animals from each group were randomly selected for slaughter and their carcass characterstics were recorded in table 36. Dressing percentage with head on and without head were maximum (75.8 per cent and 67.8 per cent) in animals of group I and minimum (68.06 per cent and 59.74 per cent) in group II respectively. In the third group the dressing percentage with head on was 74.18 and dressing percentage without head was 66.37 per cent. Half carcass weight of pigs were 23.45 kg, 15.08 kg and 22.0 kg in group I, group II and group III respectively. Average carcass length was same in control group and group II (71.33 cm). A lesser carcass length (64.66 cm) was observed in pigs of group II. Weight of ham were 5.583, 3.573 and 5.403 kg in control group, group II and III respectively. Maximum eye muscle area (31.623 m^2) was noticed in pigs of group I. Average eye muscle area of 24.213 and 27.42 cm^2 were recorded in pigs group II and group III respectively. Back fat thickness at first rib, last rib last lumbar region and average back fat thickness are also given in table 36. Minimum back fat thickness (1.499 cm) was recorded in pigs of group II.

Table 36. Carcass characteristics.

	group I ($1m^2$/pig)	group II ($0.75m^2$/pig)	group III ($0.5m^2$/pig)
Dressing percentage with head on	75.814	68.064	74.189
Dressing percentage without head	67.825	59.735	66.376
Half carcass weight (kg)	23.458	15.083	22.00
Weight of the ham (kg)	5.583	3.573	5.403
Carcass lenght (cm)	71.33	64.66	71.33
Eye muscle area (cm^2)	31.623	24.213	27.42
Back fat thickness, (cm)			
First rib	3.660	1.833	3.166
last rib	1.566	1.266	1.866
last lumbar	2.000	1.400	2.133
Average	2.410	1.499	2.388

Average rectal temperature of pigs at three stocking densities was presented in table 37.

Table 37. Average rectal temperature (° F)/(° C)

	group I ($1m^2$/pig)		group II ($0.75m^2$/pig)		group III ($0.5m^2$/pig)	
	° F	° C	° F	° C	° F	° C
Morning	102.2±0.056	{39.0±0.034}	102.3±0.038	{39.1±0.024}	102.4±0.043	{39.1±0.025}
Evening	102.9±0.038	{39.4±0.021}	103.0±0.037	{39.5±0.023}	103.1±0.032	{39.5±0.022}

Morning rectal temperature in control group showed a variation from 101.5 to 102.4 °F (38.6 to 39.1°C) with an average of 102.2±0.56°F, (39.0±0.034°C). In group II the body temperature in the morning ranged from 102.2 to 102.6°F (39.0 to 39.2°C) with an average of 102.3±0.038°F (39.1±0.024°C). The same in group III ranged from 102.1 to 102.7°F (38.9 to 39.3°C) with an average of 102.4±0.043°F (39.1±0.025°C) (Tables 37, 39 and Fig. 21).

Average evening rectal temperature in the first group was 102.9±0.038°F (39.4±0.021°C) (range was 102.7 to 103.5°F ie. 39.3 to 39.7°C), in the second group 103.0±0.037°F (39.5±0.023°C) (range was 102.78 to 103.38°F ie. 39.3 to 39.6°C) and in the third group 103.1±0.032 (39.5±0.022°C) (102.95 to 103.22°F ie. 39.4 to 39.6°C). The lowest rectal

temperature was shown in the morning and evening in group one and highest in group III (Tables 37, 40 and Fig. 22).

Significant difference in evening rectal temperature between control group and group III and group II and group III were observed whereas a non-significant difference in evening rectal temperature between control group and group II was recorded. Comparison by t-test showed significant differences in morning and evening temperature in the same group in all the three stocking densities. Non-significant differences were noticed in morning temperature among the three groups (Table 38).

Table 38. Comparison of Average rectal temperature (°F) of pigs, between groups.

Rectal temperature	t-value
group I ($1m^2$/pig) morning x group II ($0.75m^2$/pig) morning	-1.2778 NS
group I ($1m^2$/pig) morning x group III ($0.5m^2$/pig) morning	-1.8563 NS
group II ($0.75m^2$/pig) morning x group III ($0.5m^2$/pig) morning	-0.7657 NS
group I ($1m^2$/pig) evening x group II ($0.75m^2$/pig) evening	-0.3327 NS
group I ($1m^2$/pig) evening x group III ($0.5m^2$/pig) evening	-2.7298 S**
group II ($0.75m^2$/pig) evening x group III ($0.5m^2$/pig) evening	-2.4402 S**
group I ($1m^2$/pig) morning x group I ($1m^2$/pig) evening	-11.2685 S**
group II ($0.75m^2$/pig) morning x group II ($0.75m^2$/pig) evening	-13.1265 S**
group III ($0.5m^2$/pig) morning x group III ($0.5m^2$/pig) evening	-14.4761 S**

S** - Significant at 1% level
NS - Non-significant.

Table 39. Morning rectal temperature (°F)/(°C)

Weeks	group I ($1m^2$/pig)		group II ($0.75m^2$/pig)		group III ($0.5m^2$/pig)		Average	
	°F	°C	°F	°C	°F	°C	°F	°C
1	101.56	38.6	102.33	39.1	102.57	39.2	102.15	39.0
2	102.33	39.1	102.67	39.3	102.63	39.2	102.54	39.2
3	102.9	39.4	102.58	39.2	102.7	39.3	102.72	39.3
4	102.4	39.1	102.29	39.1	102.3	39.1	102.33	39.1
5	102.16	39.0	102.62	39.2	102.45	39.1	102.41	39.1
6	101.93	38.8	102.38	39.1	102.08	38.9	102.13	39.0
7	102.3	39.1	102.47	39.1	102.13	38.9	102.3	39.1
8	102.1	38.9	102.24	39.0	102.3	39.1	102.21	39.0
9	102.06	38.9	102.09	38.9	102.72	39.3	102.29	39.1
10	102.06	38.9	102.38	39.1	102.33	39.1	102.25	39.0
11	102.16	39.0	102.09	38.9	102.18	39.0	102.14	39.0
12	102.2	39.0	102.11	38.9	102.27	39.0	102.19	39.0
13	102.16	39.0	102.2	39.0	102.3	39.1	102.22	39.0
14	102.06	38.9	102.58	39.2	102.45	39.1	102.36	39.1
15	102.46	39.1	102.24	39.0	102.13	38.9	102.27	39.0
16	102.36	39.1	102.31	39.1	102.33	39.1	102.33	39.1
17	102.36	39.1	102.6	39.2	102.63	39.2	102.53	39.2
18	102.43	39.1	102.24	39.0	102.38	39.1	102.35	39.1
19	102.16	39.0	102.27	39.0	102.23	39.0	102.22	39.0
20	102.3	39.1	102.24	39.0	102.33	39.1	102.29	39.1
21	102.4	39.1	102.18	39.0	102.35	39.1	102.52	39.2
Average	102.23	39.0	102.338	39.1	102.37	39.1	102.31	39.1

FIGURE 21. MORNING RECTAL TEMPERATURE (F)

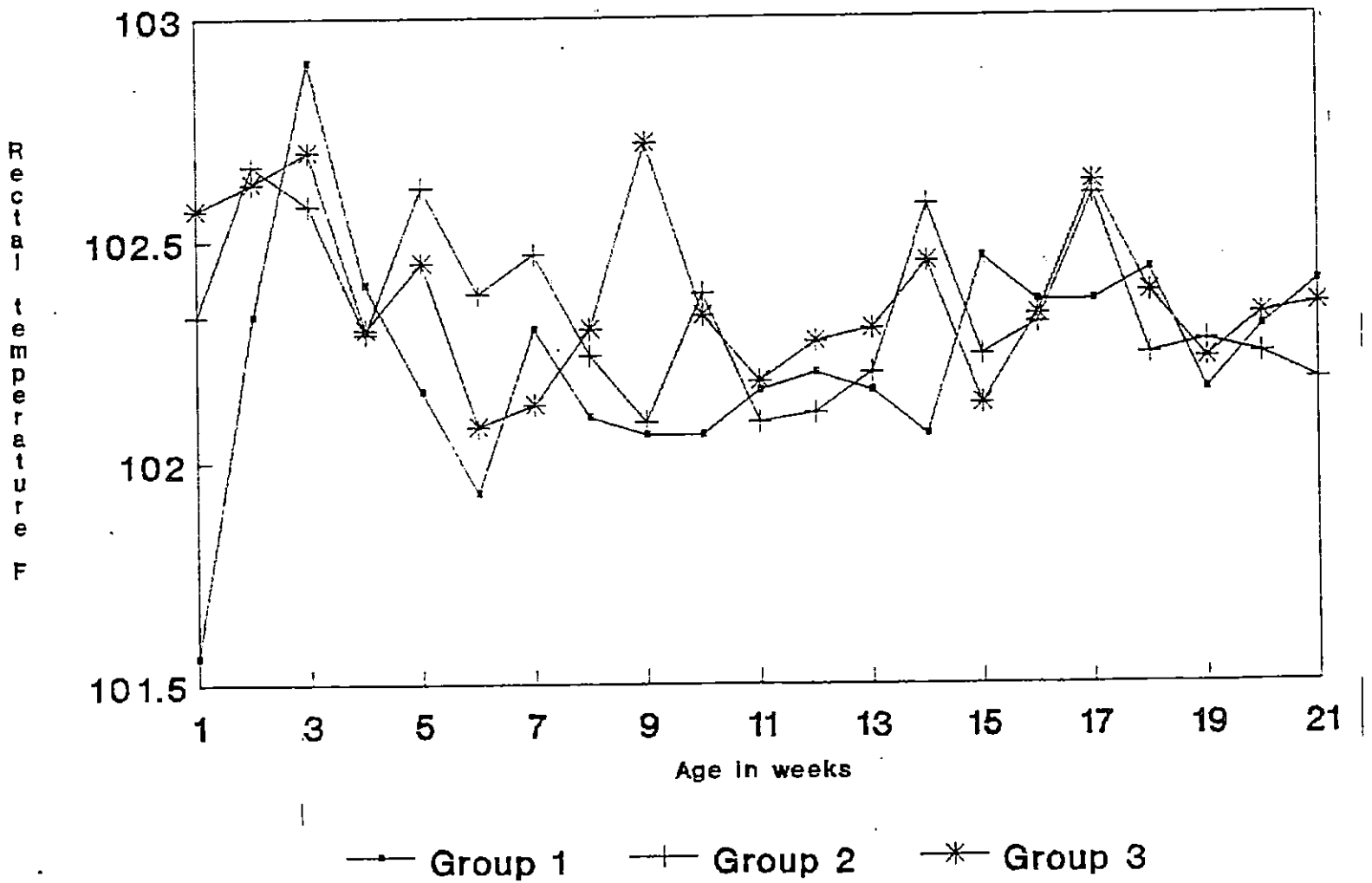
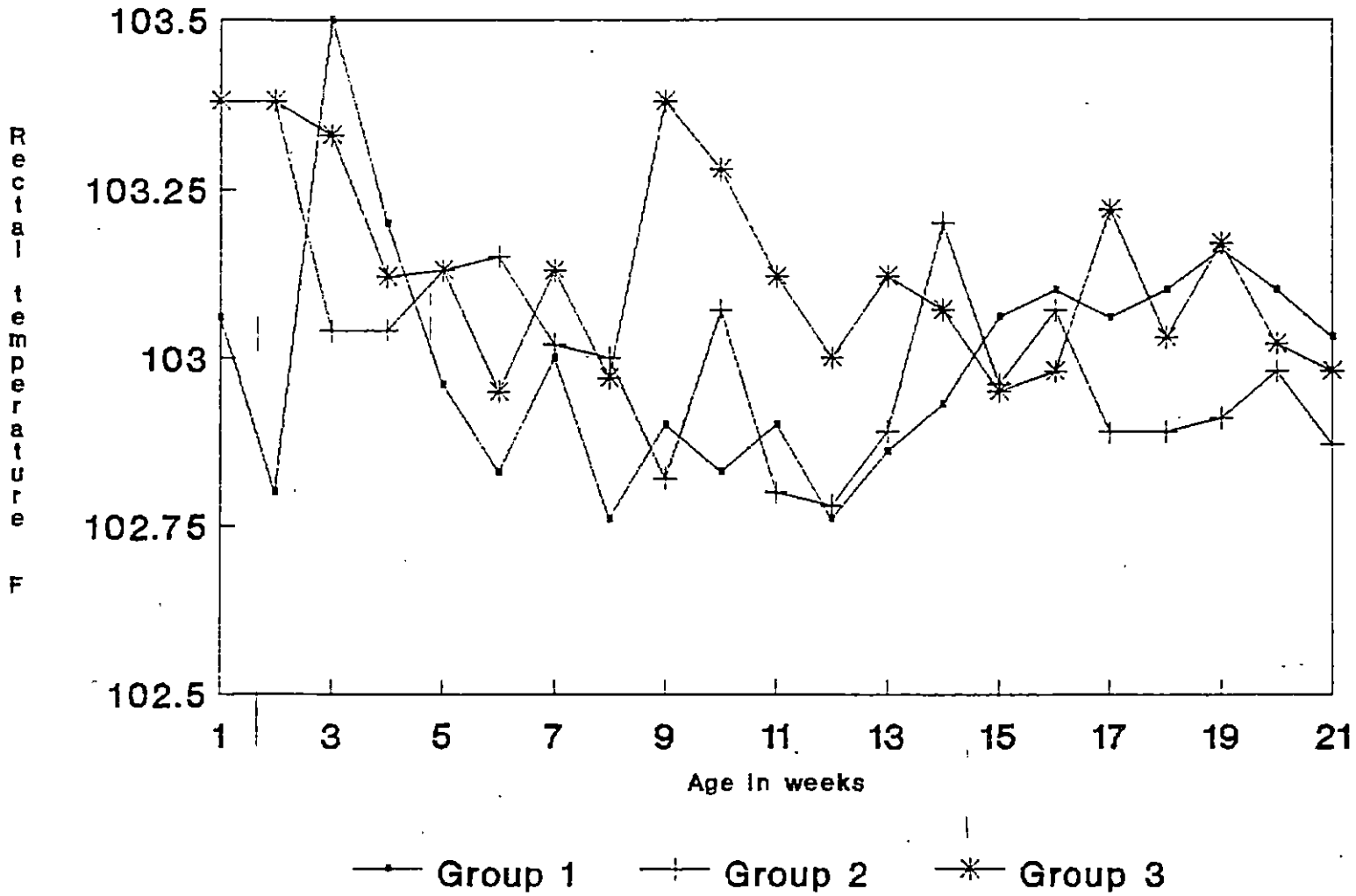


Table 40. Evening rectal temperatue (°F)

Weeks	group I ($1m^2$/pig)		group II ($0.75m^2$/pig)		group III ($0.5m^2$/pig)		Average	
	°F	°C	°F	°C	°F	°C	°F	°C
1	103.06	39.5	103.38	39.7	103.38	39.7	103.27	39.6
2	102.8	39.3	103.38	39.7	103.38	39.7	103.18	39.5
3	103.5	39.7	103.04	39.5	103.33	39.6	103.29	39.6
4	103.2	39.6	103.04	39.5	103.12	39.5	103.12	39.5
5	102.96	39.4	103.13	39.5	103.13	39.5	103.07	39.5
6	102.83	39.4	103.15	38.5	102.95	39.4	102.97	39.4
7	103.0	39.4	103.02	39.5	103.13	39.5	103.05	39.5
8	102.76	39.3	103.0	39.4	102.97	39.4	102.91	39.4
9	102.9	39.4	102.82	39.4	103.38	39.7	103.03	39.5
10	102.83	39.4	103.07	39.5	103.28	39.6	103.06	39.5
11	102.9	39.4	102.8	39.3	103.12	39.5	102.94	39.4
12	102.76	39.3	102.78	39.3	103.0	39.4	102.85	39.4
13	102.86	39.4	102.89	39.4	103.12	39.5	102.96	39.4
14	102.93	39.4	103.2	39.6	103.07	39.5	103.06	39.5
15	103.06	39.5	102.96	39.4	102.95	39.4	102.99	39.4
16	103.1	39.5	103.07	39.5	102.98	39.4	103.05	39.5
17	103.06	39.5	102.89	39.4	103.22	39.6	103.05	39.5
18	103.1	39.5	102.89	39.4	103.03	39.5	103.01	39.5
19	103.16	39.5	102.91	39.4	103.17	39.5	103.08	39.5
20	103.1	39.5	102.98	39.4	103.02	39.5	103.03	39.5
21	103.03	39.5	102.87	39.4	102.98	39.4	102.96	39.4
Average	102.995	39.4	103.012	39.5	103.129	39.5	103.05	39.5

FIGURE 22. EVENING RECTAL TEMPERATURE (F)



Discussion

DISCUSSION

Body weight

In livestock production growth is very important since it is the basis on which other forms of production like meat, milk etc., rest. Growth represented by an increase in size and weight with age and development, is thus of great economic significance.

The animals used in this study showed a progressively increasing weight from weaning to eleventh fortnight in all the groups. This nature of growth is in agreement with the pattern of growth reported by Brody (1945) and Maynard *et al*. (1979). They have reported an increase in body weight from birth in a way characteristic to the species.

Eventhough the initial weights of pigs were similar (8.5 kg) the final weights in the control group were higher (67.0±4.902 kg) than the group with 25 per cent less floor space (64.77±4.003 kg) and with 50 per cent less floor space (64.0±3.466 kg) (Table I and Fig. I).

The total gain in weight in the control group was 2.28 kg more (58.5 kg) than the second group (56.22 kg) and

3.04 kg more than the third group (55.46 kg). Those animals with less floor space gained only less weight than the one having more space. The lesser weight gain obtained in the pens with less space is in agreement with the findings of several workers (Heitman et al., 1961; Jensen et al., 1973; Benkov et al., 1985; Kornegay et al., 1985; Edwards et al., 1988; Spicer and Aherne, 1988; and McGlone et al., 1989). whereas the result obtained in the study is in consistent with the reports of Skoknic et al. (1969) Cornejo et al. (1971), Plumlee et al. (1976), Skoknik et al. (1979 a), Hunt et al. (1985 a) and Hunt (1988) who have reported no significant effect of weight gain on stocking density. Voloshchik et al. also reported that the body weights were higher at 100 days in pigs with less space allowance. Similar result was reported by Kornegay and Notter (1984).

Rate of growth

Hammond (1955) explained that the rate at which an animal grows is of greater importance for the livestock owner than its mature weight as only a few animals live long enough to reach mature weight. Fairly rapid growth is desirable in almost all kinds of animals. In females age at puberty is increased by retarded growth rate.

The average monthly rate of growth increased from the initial weight to the fourth month and thereafter showed a declining tendency in all groups. In the first group the animals recorded an increase in monthly rate of growth from 7.21 kg to 18.0 kg in the fourth month and then 9.58 kg in the fifth month. Similarly in second group, the average monthly rate of growth increased from 7.45 kg to 15.16 kg and then declined to 10.00 kg in the fifth month. In the third group the average monthly rate of growth increased from 7.33 kg in the first month to 15.37 kg in the fourth month and then declined to 10.17 kg in the fifth month (Table 2, Fig. 2). The result obtained in the present study is in agreement with that of Bartlet and Janeson (1932) in cattle. They have reported a progressively increasing weight upto sixth month and thereafter a progressive decline. This result is also in agreement with Brody (1945) in cattle. He has reported that the rate of growth was poor in the first month and then a sudden tendency for a quick increase to a maximum by the fifth month to seventh month. Thereafter growth rate declined as the age advanced. Morrison (1984) reported that growth rate increased gradually until the pigs reached a weight of about 225 lbs (102 kg) and then decreased slightly, but the results in this study is at variance with the above report.

Mitchel et al. (1983) and O'Grady (1985) observed that there was no significant difference in growth rate due to difference in stocking density. The result obtained in this study is not in agreement with the above reports. Randolph et al. (1981) reported that increased stocking rate tended to reduce the daily gain and this result is in agreement with the present study.

Absolute daily gain

The absolute daily gain in weight also showed a similar trend. In the first group absolute daily gain increased from 218 g in the first month to a peak of 600 g in the fourth month and then declining to 319 g in the fifth month. While in second group it was from 225 g in the first month to a peak gain of 505 g in the fourth month and declining to 333 g in the fifth month. Similarly in the third group the absolute daily gain in weight increased from 222 g in the first month to a peak of 512 g in the fourth month and then declining to 339 g in the fifth month (Table 4 Fig 3) Morrison (1984) reported that the daily gain increased gradually until the pigs reached a weight of about 102 kg (225 lbs) and the decreased slightly. If carried to heavier weights than 300 lbs., (136 kg) the rate of gain would be considerably less. The above mentioned pattern of daily

gains were not observed in this study. The result obtained in this study is agreeing with the reports of several workers (Heitman et al., 1961; Clawson, 1962; Gehlbach et al., 1966; Jenson et al., 1966; Puhac et al., 1967; Barenburg et al., 1969; Pickett et al., 1969; Devin, 1970; Spers et al., 1970; Jensen et al., 1973; Sinitsin, 1974; Krider et al., 1975; Schneider and Bronsch, 1975; Serebrennikov and Shurmukhin, 1975; Bublik and Gerasimove, 1976; Fritschen, 1976; Ross and Curtis, 1976; Andreov et al.,1977; Lindwall, 1981; Randolph et al., 1981; Zin, 1981; Lunen, 1983; Bark et al., 1985; Benkov et al., 1985; Moser, 1985; Moreira et al., 1986; Zin, 1987; Edwards et al., 1988; Spicer and Aherne, 1988; and Mc Glone et al., 1989).

Krasnodebski et al. (1982) and Kornegay and Notter (1984) noticed that pigs at high stocking density performed better in terms of daily gains. These reports are not in agreement with the results of the present study. The findings of the study are also at variance with the reports from Chile: Instituto De Investigaciones (1970), Ohlen and Nilsson(1977),Ford and Teague(1978), Skoknik et al. (1979a), Dinu and Pasculescu (1981), Kuhlers et al. (1981), Hisa and Lu (1985), Hunt et al. (1985 a, b), Kornegay et al. (1985), Paterson (1987) and Hunt (1988). They have reported non-significant effect of stocking density on daily gain.

Growth rate expressed as percentage of previous month's weight

Growth rate expressed as percentage of previous month's weight was maximum in the first month in all the three groups (Table 5, Fig. 4). It declined gradually to the fifth month in all the treatments.

The pattern of growth in all the groups of pigs was similar to that of other farm animals. The body weight has shown an increase from the initial to the final stage. Stocking density has no effect on the pattern and the nature of growth curve.

When taken into account of the rate of growth and absolute gain, there was increase to a peak in the fourth month in all the groups irrespective of the stocking density. This peak growth may be associated with the onset of puberty as only a few animals have shown signs of heat during the course of the experiment.

But the rate of growth and absolute gain when taken in terms of quantity it was seen affected by the stocking density. The absolute gain and rate of growth were maximum in the first group and less in those groups with lesser floor space.

Length

The average fortnightly increase in lengths of pigs had also shown a similar pattern like weight gain in all groups. This parameter in the first group showed a progressive increase from 52.33±2.01 cm to 87.33±2.46 cm with a gain in length of 35.00 cm. The same in the second group was from 51.33±1.64 cm to 87.11±2.01 cm with a gain of 35.78 cm in length. In group III the length increased from 53.16±1.42 cm to 82.83±1.74 cm, giving a gain of 29.67 cm. In all the groups the length showed a progressive increase from the initial to the final stage. Eventhough there was variation between the fortnights, it was not found to be significant except during the fifth fortnight where the variation was found to be significant (Table 6, Fig. 5).

The average monthly rate of gain in length has not shown any definite or regular pattern. It was found to be maximum in the second month in the first group (13.34 cm) followed by a decline (3.16 cm) and again an increase to 11.17 cm before declining to the fifth month (7.33 cm). Whereas in the second group the average monthly rate of gain in length increased from the second month (5.11 cm) to a peak of 11.22 cm in the fourth month and then declined to fifth month (8.78 cm). In the third group the maximum

rate of gain in length was observed in the third month (12.00 cm) before a gradual decline (Table 7, Fig. 6).

The absolute daily gain in length was found to be maximum in the second month (0.44 cm) in the first group followed by a decline (0.105 cm), an increase again to 0.372 cm and then a decline to 0.244 cm in the fifth month. In the second group it gradually increased from 0.170 cm in the second month to a peak of 0.374 cm in the fourth month and then a decline to the fifth month (0.293 cm). In the third group maximum absolute daily gain in length was noticed in the third month (0.40 cm) before a gradual decline to the fifth month (Table 8, Fig. 7).

The rate of gain in length expressed as percentage of previous month's length was showing an irregular trend. In the second and third group the percentage was maximum in the third month and then a gradual decline to the fifth month, whereas in the first group this parameter gradually increased to the fourth month and then declined to the fifth month (Table 9 and Fig. 8).

Similar reports about the growth in terms of length could not be traced in pigs. But growth rate in terms of length from the initial stage to the final stage was showing

a progressively increasing nature like that reported by Brody (1945) and Maynard et al. (1979). Growth rate when taken in terms of monthly rate of gain in length and absolute gain in length showed a difference in its nature from that of growth in terms of weight. In the case of growth in terms of weight, it increased from the initial stage to a peak in the fourth month and then a gradual decline whereas the growth in terms of length showed an irregular tendency but attained the peak between second and fourth month in all the groups. Since no comparison of this nature could be made with other reports, it is presumed that this variation is might be to the inherent nature of this parameter.

Height

In the first group, average monthly rate of gain in height of 8.83 cm was noticed in the third month before declining the fifth month. In the second group the average monthly rate of gain in height attained a peak in second month (7.67 cm) and also in the third month (7.11 cm) before the decline. In the third group the peak monthly rate of gain was noticed in second month (7.09 cm) before a gradual decline to fifth month (Table 11, fig. 10).

The absolute daily gain in height in the first group showed a maximum in the third month (0.29 cm). In second and third group the absolute daily gain in height was maximum in the second month (0.26 cm and 0.24 cm respectively) before a gradual decline to the fifth month (Table 12, Fig. 11). The rate of gain in height expressed as percentage of previous month's height was maximum in the third month (19.55 cm) in the first group and then a gradual decline to the fifth month. Whereas this parameter in pigs showed an increase of 26.67 cm in the first group with a range from 39.16±1.37 cm to 65.83±1.74 cm. The same in the second group was 27.23 cm with a range from 37.88±1.12 cm to 65.11±1.42 cm. In the third group a gain of 25.33 cm in fortnightly height of pigs was noticed with a range from 39.33±0.97 cm to 64.66±1.23 cm (Table 10, Fig. 9).

Similar to the other cumulative growth parameters the height of pigs also showed a progressively increasing trend from the initial stage to the final stage. Eventhough the height of pigs expressed variation between the groups between fortnights, this was found to be statistically non-significant.

The average monthly rate of gain in height showed an irregular trend during the period of the study. In the

first group a peak rate of gain in the second and third group was maximum in the second month itself (20.24 cm and 17.8 cm respectively) before a gradual decline to the fifth month (Table 13 and Fig. 12).

The cumulative growth in terms of the height was showing a progressively increasing trend when height is taken into consideration like that of weight and length. Whereas when the same is taken in terms of the monthly rate of gain or absolute daily gain the trend was irregular indicating a peak rate of growth between second and fourth month almost in line with that of growth in terms of length. The rate of gain in height expressed as percentage of previous month's height was observed to be progressively decreasing in all the groups except a mild variation in the first group, where an initial increase of this parameter was noticed from the second to third month before a decline.

Similar reports on the growth in terms of height in pigs could not be observed.

Girth

The gain in fortnightly front girth was found to be 39.34 cm (56.66±1.93 cm to 96.0±3.46 cm) in the first group,

39.66 cm (55.11±1.57 cm to 94.77±2.8 cm) in the second group and 37.92 cm (54.66±1.36 to 92.56±2.85) in the third group (Table 14, Fig.13).

The gain in fortnightly hind girth noted was 39.83 cm (58.33±2.86 cm to 98.16±4.14 cm) in the control group, 38.23 cm (54.88±2.34 cm to 93.11±3.38 cm) in the second group and 33.41 cm (59.92±2.02 cm to 93.33±2.93 cm) in the third group (Table 18, Fig. 17). The growth in terms of girth also showed a progressive increasing tendency from the initial to final stage in all the groups, both in front girth as well as hind girth. Analysis of variance of average fortnightly girth (both front and hind girth) revealed no significant difference between the group.

The average rate of gain in front girth showed a maximum in fourth month in all the groups (12.50 cm, 10.89 cm and 10.58 cm respectively for the first, second and third groups) (Table 15 and Fig. 14). Similarly, the absolute gain in front girth also was maximum in the fourth month in all the groups (0.42 cm, 0.36 cm, 0.35 cm respectively for first, second and third groups (Table 16 and Fig. 15). The average monthly rate of gain in hind girth was also showed maximum in the fourth month in all the groups (12.17, 13.22 and 12.58 cm respectively in group one, two and

three). (Table 19, Fig. 18). In the first group the rate of gain in hind girth also showed another peak growth rate in second month (12.84 cm). Similarly absolute daily gain in hind girth was observed to be maximum in the fourth month in all the groups (0.41, 0.44 and 0.42 cm respectively for the group I, II and III) (Table 20, Fig. 19). In the first group the rate of absolute daily gain in hind girth also showed a maximum of 0.43 cm in the second month.

The rate of gain expressed as percentage of previous month's front girth noted to be maximum in the second month progressively declining to the fifth month (Table 17, Fig. 16). This parameter for the hind girth was also showing a similar trend in all the groups except in the third group where the percentage was maximum in the fourth month and then declining to the fifth month (Table 21, Fig. 20).

The growth rate when taken in terms of the girth measurements was similar in nature to that of growth expressed in terms of weight, length and height. When compared in terms of the monthly rate of gain and absolute daily gain this parameter was similar to that of weight than that of length and height. The rate of growth in terms of girth tended to increase to a maximum in the fourth month

before declining further as age advanced. The rate of growth expressed as percentage of growth also showed a similar tendency like that of weight, in the front girth where maximum percentage of growth is recorded in the second month itself and then a progressive decline in the fifth month. Whereas in the case of this parameter for hind girth, it was found to be irregular like that of length and height. Similar reports on this line could not be traced in pigs. But agrees with that reported by Brody (1945).

Feed intake and feed conversion efficiency

The average daily feed intake when taken at fortnightly interval was found to increase gradually from the first to the eighth fortnight, followed by a reduction in the quantity of the feed consumed in the nineth fortnight and then increased to the 10th fortnight in all the groups (Table 22). The same was the trend when the feed intake was compared at monthly level (Table 24). Eventhough considerable variation was noticed in the daily feed intake between the groups it was not found to be significant (Table 23). The results obtained in this study are in agreement with several of earlier reports (Jenson et al., 1966; Handlin et al., 1969; Skoknic et al., 1969; Spers et al., 1970; Cornejo et al., 1971; Skoknik et al., 1971;

Sinitsin, 1974; Voloshchik et al., 1975; Ford and Teague, 1978; Skoknik et al., 1979 a; Hisa and Lu 1985; Hunt et al., 1985 a, 1985 b; Edwards et al., 1988; Hunt 1988; Walker, 1990). They have reported non-significant effect of stocking density on feed intake. Many authors have reported a significant reduction in feed intake at higher stocking density which is also not in agreement with the result of the study (Heitman et al., 1961; Gehlbach et al., 1966; Jensen et al., 1966; Puhac et al., 1967; Jensen et al., 1973; Moser et al., 1985; Spicer and Aherne, 1988; and McGlone et al., 1989).

Barenburg et al. (1969), Serebrennikov and Shurmukhin (1975) and Ross and Curtis (1976) have reported an increased feed intake at higher stocking density. The above reports are also not in agreement with the present study.

The reduction in the feed intake noted in the nineth fortnight in all groups is probably due to the change in the feed given to the experimental stock. When the farm stock of pigs reaches an age of five months from weaning the feed given to it (18 per cent Crude protein) was replaced by a feed containing 14 per cent crude protein. The pigs were seen adjusting to the new feed soon after the change in the nineth fortnight when the increased feed intake was noticed.

When the feed conversion efficiency was taken at monthly level it was found to increase from the first month to the second month and then gradually decreased to the fifth month. A highest feed conversion efficiency of 2.54, 2.13 and 2.38 was noticed in group I, II and III respectively (Table 26).

When the feed conversion ratio was taken as a whole for the experimental period it was found to be highest in group III (3.746±0.667 and lowest in Group I (3.96±0.864). The animals in group II were showing feed conversion ratio in between that of group I and II (3.798±0.744) (Table 28).

The average weight gain was more in control group (11.732±1.826 kg). The same was less in group II (11.244±1.267 kg) and least in group III (11.092±1.296 kg) (Table 28).

When the average feed intake was taken as a whole for the experimental period it was found to be highest in control group (45.738±9.875 kg) and lower in group II (42.854±8.969 kg) and lowest in group III (42.044±8.502 kg).

The coefficient of correlation between average weight gain and average feed intake when compared was found to be

non-significant between groups (Table 29). Same was the result between average weight gain and average feed conversion efficiency (Table 30).

The coefficient of correlation between average feed intake and average feed conversion efficiency was found to be non-significant in group I and significant in Group II and III (Table 31).

When compared monthwise a highest feed conversion efficiency was noticed in the second month in all the groups, eventhough the feed conversion efficiency when taken as a whole period was found to be highest in group III followed by group II and group I.

As stocking density increases the feed conversion efficiency was found to be increasing, highest being the group III where less amount of space was given. The finding of the study is in agreement with reports of Randolph et al. (1981) and Krasnodebskï et al. (1982). Many workers have reported a significant reduction in feed conversion efficiency at higher stocking density (Heitman et al., 1961; Nigul, 1968; Schneider and Bronsch 1975; Bublik and Gerasimove, 1976; Plumlee et al.,1976; Andreov et al., 1977; Moser et al., 1985; Moreira et al., 1986; Endwards et al., 1988; and Jakob et al., 1988).

As the space was restricted from one square meter to 0.75 and 0.5 m^2 per pigs, it gave only lesser space for the animal to move around and therefore less energy was utilized for body activity and hence increased feed conversion efficiency (Crampton, 1956; Morrison, 1984; McDonald et al., 1987; Gillespie, 1987).

The result of this study is not in agreement with that reported by Skoknic et al. (1969), reported from Chile: Instituto De investigaciones (1970) Cornejo et al. (1971); Skoknik et al. (1971), Jensen et al. (1973), Mullaney (1976), Ohlen and Nilsson (1977), Mitchel et al. (1983), O'Grady (1985), Hisa and Lu (1985), Hunt et al. (1985 a), Hunt et al. (1985 b), Paterson et al. (1987), Hunt (1988) and Walker (1990) who observed no relationship between stocking density and feed conversion efficiency.

Behaviour

There is considerable evidence to show that crowding has a stressful effect which can be measured in terms of physiological adaptation and behavioural alterations. In the present study the competition aggressive behaviour during feeding were measured by counting the number of threats, biting and pushing (Table 32 and 33). The results

showed significant difference in aggressive behaviour between the three stocking density groups (Table 34 and 35). Higher rate of competition aggression was noticed at higher stocking density. The result obtained in the study is in agreement with that of Bryant and Ewbank (1972), Ewbank and Bryant (1972), Ross abd Curtis (1972), Kelley et al. (1980) Randolph et al. (1981) and Hamilton (1984), whereas the result obtained in the study is not agreeing with the reports of Plumlee et al. (1976), Hunt et al. (1985 a) and Hunt (1988). They have reported no significant difference in aggressive behaviour between stocking density groups. Immediately after feeding the animals at lower stocking rate preferred to be relaxed while in the other groups, a few animals continued to be active chasing and teasing other animals. This result is agreeing with the reports of several workers (Heitman et al., 1961; Ross and Curtis, 1976; Hajek, 1984). Whereas Ross and Curtis (1976) observed that pigs at lower stocking rate moved around twice the distance as far as did those at higher stocking density. Pigs at lower stocking density spent more time in moving around than those kept at higher stocking density. Spicer and Aherne (1988) on the other hand reported that different stocking densities did not seem to influence the time spent by pigs resting, active and non-feeding. The result obtained in this study is not in agreement with the above reports.

A few incidence (33.3 per cent in control, 33.3 per cent in Group II and 50 per cent in group III) of tail-biting was also noticed during the first two months of experiment and it was absent afterwards. The increased incidence of tail-biting recorded in the pens with higher stocking density is in agreement with reports of Fritschen (1976) and Cornelius et al.(1981). Whereas it is at variance with the observations of Kelly et al. (1980). He did not find evidence to show that increasing stocking rate altered tail-biting behaviour.

Carcass characteristics

When the dressing percentage with head on was compared between groups according to stocking density, it was found that there was practically not much difference between the first and third group. The second group exhibited a lower dressing percentage with head (75.814, 68.064 and 74.189 respectively). Similarly the dressing percentage with head also showed no apparent difference between group I and III (67.825 per cent and 66.376 per cent for group I and III respectively). The decreased dressing percentage with head noticed in the second group (59.735) was due to the lower live weight of animals when slaughtered. While the dressing percentage with head is taken and compared with per unit

weight, no apparent difference was observed between the groups (1.096; 1.360 and 1.118 per cent respectively for group I, II and III). The result of the experiment clearly indicates that reduction in the floor space had no significant effect on the dressing percentage. Similar was the trend in half carcass weight, weight of the ham and carcass length. The eye muscle area was found to be less in group II and III (24.213 and 27.42 cm^2 respectively) than the control group I (31.623 cm^2). This parameter when considered on an average basis also shows no appreciable change (Table 36). The results are in agreement with the reports of Handlin et al. (1969); Skoknic et al. (1969), reports from Chile: Instituto De Investigaciones (1970) Cornejo et al. (1971), Skoknik et al. (1971) Ohlen and Nilsson (1977), Skoknik et al. (1979 b); Kuhlers et al. (1981) Moreira et al. (1986) and Walker (1990) whereas it is not in agreement with the reports of Lunen (1983), Augustini et al. (1984), Benkov et al. (1985), Zin et al. (1987) and Kirov et al. (1988).

The back fat thickness at first rib was found to be less in group II and III (1.833 and 3.166 cm) than first group (3.660 cm) whereas back fat thickness at last rib and last lumbar vertibrae were found to be greater in third group (1.866 cm and 2.133 cm respectively) than the control group (1.566 cm and 2.000 cm). This parameter was lowest

in second group (1.266 cm and 1.400 cm respectively). But when compared on an average basis, the back fat thickness was found to be similar in group I and III (2.410 cm and 2.388 cm respectively) and less in group II (1.499 cm) (Table 36).

The back fat thickness when considred on an average basis also exhibited no practical change as the stocking density increased. A lower value obtained in the second group is probably due to the lesser live weight of the animal slaughtered. The above finding is in agreement with the reports of Heitman et al. (1961), Skoknic et al. (1969), Kuhlers et al. (1981); Mitchell et al. (1983) and Walker (1990) whereas this result is not agreeing with Lunen (1983), Augustini et al.(1984), Benkov et al. (1985), Zin et al. (1987) and Edwards et al. (1988). The above workers have reported differences in back fat thickness at different stocking densities.

Rectal temperature

The average morning rectal temperature of the control group was found to be 102.2 ±0.56°F (39.0±0.034°C) (ranging from 101.5 to 102.4°F ie 38.6 to 39.1°C), 102.3±0.038°F (39.1±0.024) in the second group (with a range of 102.2 to 102.6°F ie 39.0 to 39.2°C) and in the third group

102.4±0.043°F (39.1±0.025°C) (with a range of 102.1 to 102.7°F ie 38.9 to 39.3°C) (Table 37, 39 and Fig. 21).

In the evening the control group showed an average rectal temperature of 102.9±0.038°F (39.4±0.021°C) (range was 102.7 to 103.5°F ie 39.3 to 39.7°C). The same in the second group was 103.0±0.037°F (39.5±0.023°C) (102.78 to 103.38°F ie 39.3 to 39.6°C) and in the third group 103.1±0.032 (39.5±0.022°C) (102.95 to 103.22°F ie. 39.4 to 39.6°C) (Table 37, 40 and Fig. 22).

Although slight variation existed in the morning temperature between the groups, it was not found to be significant (Table 38). Whereas highly significant difference in the evening rectal temperature was noticed between the group I and the group III and significant difference between group II and III was also observed. The rectal temperature of pigs recorded during morning and evening in the same group varied and was found to be highly significant. The temperature recorded in this study was within the normal range for pigs (Martin 1970; Campbell and Lasley, 1977; West, 1985; Mathur, 1990).

The lowest rectal temperature was noticed both in the morning and evening in group I and highest in group III

showing a significant influence of stocking density on the rectal temperature of pigs. As the number of animals increased in the pen or as the floor area is reduced the rectal temperature of the animals was found to increase. It was also noted that the rectal temperature of group II was in between group I and III, both in the morning as well as in the evening. (Findlay, 1953; Dukes, 1955; Sutherland, 1967; Martin, 1970; Sainsbury and Sainsbury 1979; Rechciyl, 1982 and Kotrabcek, 1985).

In the above reports the variation in rectal temperature is mostly due to high ambient temperature and relative humidity. Reports about the effect of stocking density on body temperature could not be traced in pigs. Close and Mount (1981) reported that very large groups of animals may create unfavourable social environments and that may increase their heat production. For this reason Sainsbury (1972) has recommended group size of 12-20 pigs per pen. The above reports are in agreement with present study where an increased temperature was noticed in groups with more pigs.

In the present study a clear variation also was observed between morning and evening temperature in all the groups. This finding is in accordance with report of West (1985).

Summary

SUMMARY

The modern breeds will not easily survive without good housing. Many of the pigs seen now are carefully bred hybrids which can be very profitable when kept in the ideal conditions created by relatively less expensive housing. For a pig farmer to provide the required amount of floor space per pig to maximise the pork produced from a given facility, he must know the relationship between the floor space per pig and performance. This experiment was designed to investiage the effect of floor space or stocking density on the performance of growing pigs.

Twenty seven large white yorkshire pigs after weaning were housed into three groups according to the floor space. One group consisting of six females were housed according to ISI specification having a floor space of $1m^2$ per pig. The second group was provided 25 per cent less floor space than the ISI specification giving only 0.75 m^2 per pig. Similarly the third group housed with a 50 per cent reduction in floor space than the ISI specification giving only $0.5m^2$ per pig. Pigs were maintained under the usual feeding and management conditions prevailing in the Kerala Agricultural University Pig Breeding Farm, Mannuthy. The growth performance in terms of weight, height, length and

girth was recorded once in a fortnight. Feed intake was recorded on three consecutive days in a fortnight. The behaviour pattern of the experimental pigs was studied for a total of two hours a day. The rectal temperature was recorded once in every week in the morning at 09.00 hours and at 14.00 hours. After five months of observation, three pigs from each of the groups were slaughtered to study the carcass characteristics.

Total weight gain of 58.5 kg, 56.22 kg and 55.46 kg were noticed in control group, group II ($0.75m^2$/pig) and group III ($0.5m^2$/pig) respectively. Variations of average fortnightly body weight of pigs due to stocking density were not found to be significant. The maximum growth rate was observed during the fourth month in all the groups (18.0, 15.16 and 15.37 kg for group I, II and III respectively). Minimum growth was noticed during the first month of experiment in all the three groups (7.21, 7.45 and 7.33 kg at $1m^2$, 0.75 and $0.5m^2$ of floor space per pig respectively). Peak absolute gain was noticed during the fourth month and minimum during the first month. The absolute daily gain varied from 218 to 600 g, 225 to 505 g and 222 to 512 g in group I, II and III respectively. Growth rate expressed as percentage of previous month's weight was maximum during the first month and it declined gradually with advance in age.

Average fortnightly length showed gain of 35.0; 35.78 and 29.67 cm in pigs at $1m^2$, $0.75m^2$ and $0.5m^2$ floor space. Average monthly rate of gain in length showed maximum in the second month in group I (13.34 cm). The rate of gain was maximum during fourth and second month in group II and III (11.22 and 12.0 cm). The absolute daily gain in length varied from 0.105 cm to 0.440 cm at $1m^2$/pig; 0.170 cm to 0.374 cm at $0.75m^2$/pig and 0.142 cm to 0.400 cm at 0.5 m^2/pig. The maximum values were observed during second, fourth and third months in group I, II and III respectively. The peak values of rate of gain in length expressed as percentage of previous month's length were noticed during fourth month in Group I (16.22) and during the third month in group II and III (18.9 and 20.09 respectively).

The total gain in height during experimental period were observed to be 26.67 cm; 27.23 cm and 25.33 cm in control group, group II and group III respectively. The maximum average monthly rate of gain in height was noticed during the third month in control group and during the second month in group II and III (8.83, 7.67 and 7.09 cm for group I, II and III respectively). Corresponding minimum values were 5.83, 5.55 and 5.58 cm and those were observed during the fourth month in all the groups. The absolute daily gain in height showed a tendency to decrease from the

second month to fourth month in all the groups. Highest percentage of rate of gain in height (19.55, 20.24 and 17.80 %) were noticed during third month in control group and second month for group II and III respectively.

The average fortnightly front girth showed an increase of 39.34, 39.66 and 37.92 cm in control group, group II and group III respectively. Similarly the average fortnightly hind girth showed a gain of 39.83, 38.23 and 33.41 cm in group one, two and three respectively. The maximum average monthly rate of gain in front girth were 12.5, 10.89 and 10.58 cm at $1m^2$, $0.75m^2$ and $0.5m^2$ floor space per pig. The corresponding value of hind girth were 12.84, 13.22 and 12.58 cm in control, group two and three respectively. These maximum values were noticed during fourth month in all the groups · Absolute gain in front girth showed an increasing tendency in all groups to the fourth month (0.42 cm, 0.36 cm and 0.35 cm respectively for group one, two and three). The same was the trend for absolute gain in hind girth (0.41, 0.44 and 0.42 cm for group I, II and III respectively). Rate of gain in front girth expressed as percentage of previous month's front girth was maximum during the second month in all the groups (21.17, 19.76 and 18.89 for group I, II and III respectively). The same data for hind girth were maximum during the second month in

control group and group II (22.01 and 23.64 %). In the third group maximum was recorded during the fourth month (16.65 %). There was no significant difference in growth parameters between the groups.

Average monthly feed conversion efficiency in all the groups increased from first month to second month and then gradually decreased to the fifth month. The highest feed conversion efficiency of 3.96±0.864; 3.798±0.744 and 3.746±0.667 was noticed in groups I, II and III respectively. When the feed intake was taken as a whole it was highest in control group (45.738±9.875 kg) and lower in group II (42.854 ± 8.969 kg) and lowest in group III (42.044±8.502 kg).

Aggressive behaviour was measured by counting the number of threats (10.24±0.706; 12.65±0.716 and 15.21±0.775 at $1m^2$, $0.75m^2$ and $0.5m^2$ floor space per pig) and number of ear-biting incidence (1±0; 1.2±0.133 and 2.1±0.211 in group I, II and III respectively).

Dressing percentage with head on and without head were maximum (75.814 per cent and 67.825 per cent) in animals at stocking rate of $1m^2$/pig and minimum (68.064 per cent and 59.735 per cent) in group II. In the third group the

dressing percentage with head on was 74.189 and dressing percentage without head was 66.376 per cent. Half carcass weight of pigs were 23.458, 15.083 and 22.00 kg at $1m^2$, $0.75m^2$ and $0.5m^2$ per pig respectively. Average carcass length was same in control group and group III (71.33 cm) and a lesser carcass length (64.66 cm) was noticed in the second group. Weight of the ham were 5.583, 3.573 and 5.403 kg in control group, group II and group III respectively. Average eye muscle areas were 31.623, 24.213 and 27.420 cm^2 were noticed in control group, group II and group III respectively. The average back fat thickness noticed were 2.410 cm, 1.499 cm and 2.388 cm at $1m^2$, $0.75m^2$ and $0.5m^2$ of floor space respectively.

Morning rectal temperature in control group showed a variation from 101.5 to 102.4°F (38.6 to 39.1°C) with an average of 102.2 $\pm$0.56°F (39.0$\pm$0.034°C). In group II the rectal temperature in the morning ranged from 102.2 to 102.6°F (39.0 to 39.2°C) with an average of 102.3$\pm$0.038°F (39.1$\pm$0.024°C). The same in the group III ranged from 102.1 to 102.7°F (38.9 to 39.3°C) with an average of 102.4$\pm$0.043°F (39.1$\pm$0.025°C). Average evening rectal temperature in the first group was 102.9$\pm$0.038°F (39.4$\pm$0.021°C)(range was 102.7 to 103.5°F ie. 39.3 to 39.7°C), in the second group 103.0$\pm$0.037°F (39.5$\pm$0.023°C) (range was 102.78 to 103.38°F

ie 39.3 to 39.6°C) and in the third group 103.1±0.032 (39.5±0.022°C) (102.95 to 103.22°F ie. 39.4 to 39.6°C).

Eventhough the feed intake and weight gain were more in the group with maximum floor space the variation in the growth rate was not found to be significant. Similarly maximum growth rate and absolute gain have also came to peak in the fourth month in all the groups. When the dressing percentage was considered group one and three were found to be comparable. Similarly in the case of the weight of the ham, where there was no significant difference between group I and III. Whereas when the feed conversion efficiency was considered it was found to be better in the third group.

From the experimental result no significant difference could be observed in the performance of those animals having a floor space as per ISI specification and the one where the floor space reduced to the extent of 50 percentage.

References

REFERENCES

Andreov, A., Apostolov, N. and Beremski, S. (1977). The effect of different stocking densities on the performance of commercially fattened pigs. Anim. Breed. Abstr. 45(9): 501.

Augustini C., Fischer, K. and Schon, L. (1984). Meat quality and housing allowing freedom of movement in pigs. Anim. Breed. Abstr. 52(5): 338.

Barenburg, A.D., Maslov, N.F. and Sevcenko, N.T. (1969). Management of pigs in multi-tiered cage batteries. Anim. Breed.Abstr. 37(4): 646.

Bark, L.J., English, P.R., Duncan, J. and Birine, M. (1985). Effect of floor space allowance and group size on growth of pigs from 11 to 35 kg live weight in 'second stage' weaner accommodation. Anim. Breed. Abstr. 53(11): 886.

Bartlet, S. and Janeson, J.L. (1932). Growth of dairy heifers. J. Dairy Res. 3: 310.

Benkov, M., Steffanova, S., Kirov, M. and Kolev, T. (1985). The effect of floor area on finishing performance, carcass quality, adaptation and behaviour of pigs. Anim. Breed. Abstr. 53(4):: 313.

Brody, S. (1945). Bioenergetic and growth, Reinhold Pub. Corp. New York, pp. 484.

Bryant, M.J. and Ewbank, R. (1972). Some effects of stocking rate and group size upon agonistic behaviour in groups of growing pigs. Brit. Vet. J. 128: 64-70.

Bublik, N. and Gerasimov, V. (1976). Group size, feeding space and stocking density of fattened pigs. Anim. Breed. Abstr. 44(12): 637.

Campbell, J.R. and Lasley, J.F. (1977). The Science of animals that serve man kind. McGraw-Hill Book Company, London, pp. 332.

Chile:Instituto De Investigaciones Agropecuarius. (1970). Effect of pen area on growth and fattening performance in pigs. Anim. Breed. Abstr. 38(1): 118.

Clawson, A.J. (1962). Effect of number of pigs per pen of equal floor space on performance. J. Anim. Sci. 21(2): 382.

Close, W.H. and Mount, L.E. (1981). The climatic requirements of the pigs. In: Environmental Aspects of Housing for Animal Production by Clark, J.A. Butterworths, London, pp.149-158.

Cornejo, V.S., Skoknic, K.A., Potocnjak, R.J. and Rosa, W.J.G. (1971). Effect of surface area of the pens on returns from growing and finishing pigs. 2. Autumn and Winter period. Anim. Breed. Abstr. 39(2): 316.

Cornelius, H.H., Bogner, H. and Peschke, W. (1981). Investigations on the behaviour of fattening pigs in different stall-housing systems in relation to tail and ear-biting. Anim. Breed. Abstr. 40(9):623.

Crampton, E.W.(1956). Applied Animal Nutrition. W.H.Freeman and Company, Sanfrancisco, pp. 140.

Devin, K.P. (1970). Maintenance of pigs in piggeries with mechanised feeding. Anim. Breed. Abstr. 38(3): 460.

Dinu, I. and Pasculescu, F.(1981). Behaviour of young pigs reared in battery cages. Anim. Breed. Abstr. 49(10): 683.

Dukes, H.H. (1955). Physiology of Domestic Animals. Bailliere Tindal and Cox, London, 7th ed. pp. 638-648.

Edwards, S.A., Armsby, A.W. and Spechter, H.H. (1988). Effect of floor area allowance on performance of growing pigs kept on fully slatted floors. Anim. Prod. 46(3): 453-461.

Ewbank, R. and Bryant, M.J. (1972). Aggressive behaviour amongst groups of domesticated pigs kept at various stocking rates. Anim. Beh. 20(1): 21-28.

Findlay, J.D. (1953). Farm animals and high temperatures. Br. Agric. Bull. 6(28): 301.

Ford, J.J. and Teague, H.S. (1978). Effect of floor space restriction on age at puberty in gilts and on performance of Barrows and gilts. J. Anim. Sci. 47(4): 828-832.

Fritschen, R.D. (1976). Effect of building arrangements and management on performance and behaviour of growing-finishing pigs. J. Anim. Sci. 42(5): 1334-1340.

Gehlbach, G.D., Becker, D.E., Cox, J.L., Harmon, B.G. and Jensen, A.H. (1966). Effect of floor space allowance and number per group on performance of growing finishing swine. J. Anim. Sci. 25(2): 386-391.

Gillespie, J.R. (1987). Animal Nutrition and Feeding. Delmar Publishing inc., U.S.A., pp. 106-107.

Hajek, J. (1984). The optimum stocking rate of slatted floor pens for finishing pigs. Anim. Breed. Abstr. 52(7): 517.

Hamilton, R. (1974). Don't crowd pigs when it's Hot. National Hog Farmer. 29(7): 30.

Hammond, J (1955). Progress in physiology of farm animals. Vol.2. Butterworth, London,pp. 395.

Handlin, D.L., Crook, L., Skelly, G.L., Ballington, D.A. and johnson, E.W. (1969). Confinement and ration effect on ulcers in swine. J. Anim. Sci. 28(1): 152.

Heitman, H., Hahn, L., Kelly, C.F. and Bond, T.E. (1961). Space allotment and performance of growing finishing swine raised in confinement.J. Anim. Sci. 20(3): 543-546.

Hisa, L.C. and Lu, G.H. (1985). The effect of slotted floor space and sex on the performance of growing-finishing pigs. World. Rev. Anim. Prod. 21(2): 31-34.

Hunt, K.A. (1988). The effect of stocking density on the performance and welfare of early weaned pigs. Anim. Breed. Abstr. 56(6): 503.

Hunt, K.A., English, P.R., Buckingham, J., Bampton, P.R. and McPherson, O. (1985 a). Effect of group size and stocking density on food intake, growth and food efficiency of pigs weaned at three weeks and fed ad libitum to eight weeks of age. Anim. Prod. 40(3): 548-549.

Hunt, K.A., English, P.R., Buckingham, j., Bampton, P.R., MacPherson, O. and Ingram, S. (1985 b). Effect of group size and stocking density on feed intake, growth, feed efficiency and apparent welfare of pigs weaned at 3 weeks and fed ad libitum to 8 weeks of age. Anim. Breed. Abstr. 53(11): 886.

I.S.I. (1966). Code of practice for pig housing, IS: 3916-1966. Indian Standards Institution, Manak Bhavan, New Delhi.

Jakob, M., Kersten, U., Klatt, G., and Wallenbrandt, H. (1988). Effect of different pen areas during the first stage of feeding and regrouping of animals on the performance of fattening pigs. Anim. Breed. Abstr. 56(6): 503.

Jensen, A.H., Becker, D.E. and Harmon, B.G. (1966). Management factors and young pig performance. J. Anim. Sci. 25(4): 1273.

Jensen, A.H., Backer, D.H., Harmon, B.G. and Woods, D.M. (1973). Response of growing-finishing male and female swine to floor space allowance on partially and totally slotted floors. J. Anim. Sci. 37(3): 629-631.

Kelley, K.W., McGlone, J.J. and Gaskins, C.T. (1980). Porcine aggression: measurement and effects of crowding and fasting. J. Anim. Sci. 50(2): 336-341.

Kirov, M., Benkov, M., Angelov, K. and Georgive, D. (1988). The effect of floor area on finishing performance of pigs in roofed pens. Anim. Breed. Abstr.56(9): 742.

Kornegay, E.T., Notter, D.R., Bartlett, H.S. and Lindemann, M.D. (1985). Variance of body weights and daily weight gains of weaner pigs housed at various stocking densities in confinement. Anim. Prod. 41(3): 369-373.

Kornegay, E.T. and Notter, D.R. (1984). Effects of floor space and number of pigs per pen on performance. Pig News and Information, 5(1): 23-33.

Kotrabcek, V. (1985). The effect of changes in the complexity defined thermal environment on body and skin temperature and energy metabolism in piglets. Pig News and Information 6(2): 213.

Krasnodebski, B., Zebrowski, Z., Olszak, A. and Jozefik, J. (1982). Rearing weaned pigs in batteries. Anim. Breed. Abstr. 50(7): 465.

Krider, J.L., Albright, J.L., Plumlee, M.P., Conrad, J.H., Sinclair, C.L., Underwood, L., Jones, R.G. and Harrington, R.B. (1975). Magnesium supplementation, space and docking effects on swine performance and behaviour. J. Anim. Sci. 40(6): 1027-1033.

Kuhlers, D.L., Jungst, S.D. and Chandler, J.D. (1981). Estimates of genetic pen density interactions in production traits of swine. J. Anim. Sci. 53(5): 1166-1173.

Lindwall, R.N. (1981). Effect of flooring material and number of pigs per pen on nursery pig performance. J. Anim. Sci. 53(4): 863-868.

Lunen, T.A. (1983). Effect of rearing weaner pigs at three stocking densities on raised decks or solid flooring. Can. J. Anim. Sci. 63(3): 731-734.

Martin, J.E. (1970). Physiology. In: Diseases of Swine, Editor Dunne, H.W. Iowa State University Press, Ames, USA, 3rd ed. pp. 88.

Mathur, A.C. (1990). Animal Management housing and hygiene. In: Hand book of animal husbandry. Edited by ICAR. Publications and Information Division of Indian Council of Agricultural Research, New Delhi. 2nd ed. pp. 241.

Maynard, L.A., Loosli, J.K., Hintz, H.F. and Warner, R.G. (1979). Animal Nutrition Tata Mc Graw-Hill Publishing Company Ltd., New Delhi, 7th ed. pp. 416-427.

McDonald, P., Edwards, R.A. and Geenhalgh, J.F.D. (1987). animal Nutrition. English Language Book Society/Longmann, England, 4th ed. pp. 291-292.

McGlone, J.J., Hurst, R.J. and Lomax, D.A. (1989). Space requirements for finishing pigs in confinement: behaviour and performance while group size and space vary. ADSASAS Abstracts. July: 96.

Mitchell, K.G., Keal, H.D. and Pittman, R.J. (1983). The effect of three stocking rates of pigs housed in identical sized pens on performance. Anim. Prod. 37(1): 41-43.

Moreira, I., Costa, P.M.A., Pereira, J.A.A., Mello, H.V.DE., Cardoso, R.M. and Gomes, S.T. (1986 a). Effect of housing density on the performance of growing pigs. Anim. Breed. Abstr. 54(7): 578.

Moreira, I., Costa, P.M.A., Pereira, J.A.A., Cardoso, R.M., Gomes, S.T. and Mello, H.V.DE. (1986 b). Effect of housing density on the performance of finishing pigs. Anim. Breed. Abstr. 54(7): 578.

Morrison, F.B. (1984). Feeds and Feeding CBS Publishers and Distributors, Delhi, 22nd ed. pp. 179-180. 936-939.

Moser,R.L., Cornelius, S.G., Pettigrew, J.E., Hanke, H.E. and Hagen, C.D. (1985). Responses of growing-finishing pigs to decreasing floor space allowance and (or) Virginamycin in diet. J. Anim. Sci. 61(2): 337-342.

Mullaney, P.D. (1976). Effects of number of pigs per pen on production. Anim. Breed. Abstr. 44(9): 489.

Nigul, L. (1968). Pig meat production in relation to management. Anim. Breed. Abstr.36(3): 462.

O'Grady, J.F. (1985). Effect of stocking rates and weight at allocation on weaner performance. Anim. Breed. Abstr. 53(8): 650.

Ohlen, P. and Nilsson, C. (1977). Experiments with varying housing density for pigs. Anim. Breed. Abstr.45(9): 502.

Paterson, L.M. (1987). The effect of stocking density on performance of pigs weaned at three weeks. Anim. Breed. Abstr.55(6): 463.

Pickett, R.A., Fugate, W.H., Harrington, R.B., Perry, T.W. and Curtin, T.M. (1969). Influence of feed preparation and number of pigs per pen on performance and occurrence of oesophago gastric ulcers in swine. J. Anim. Sci., 28(6): 837-841.

Plumlee, M.P., Cline, T.R., Krider, J.L. and Underwood, L.(1976). Space, protein and feeder type effects on finishing swine. J. Anim. Sci. 42(5): 1339.

Puhac, I., murgaski, S., Surducki, I. and Sevkovic. (1967). The effect of environment and density of population in a sty with a slatted floor on results of fattening and the quality of pig meat. Anim. Breed. Abstr.35(2): 282.

Randolph, J.H., Cromwell, G.L., Stahly, T.G. and Kratzer, D.D. (1981). Effects of group size and space allowance and behaviour of swine. J. Anim. Sci. 53(4): 922-927.

Rechciyl, M. (1982). C.R.C. Handbook of Agricultural Productivity. Vol. II - Animal Productivity. C.R.C. Press, Inc. Boca Raton, Florida, pp. 10.

Ross, M.C. and Curtis, S.E. (1976). Space allowance and pig behaviour. J. Anim. ci. 42(5): 1339.

Sainsbury, D.B. (1972). In pig production by Cole D.J.A. Butterworths. London. pp. 91-105.

Sainsbury, D. and Sainsbury, P. (1979). Livestock Health and Housing. Bailliere Tindal, London, 2nd ed. pp. 42-50.

Schneider, D. and Bronsch, K. (1975). Rearing early weaned piglets in cages or on the floor. Anim. Breed. Abstr. 43(8): 409.

Serebrennikov, V. and Shurmukhin, A. (1975). Housing pigs in battery cages. Anim. Breed. Abstr. 43(10): 541.

Sinitsin, I.A. (1974). Effectiveness of floor space utilisation in fattening pigs. Anim. Breed. Abstr. 42(9): 443.

Skoknic, A., Cornejo, S., Potocnjak, J., Davidovich, A., Rozas, J.G. and Cifuentes, M. (1969). Space allotment and performance of growing finishing swine. J. Anim. Sci. 29(1): 117.

Skoknik, A., Cornejo, S., Potocnjak, J., Davidovich, Z.A. and Cifuentes, C.M. (1971). Effect of surface area of the pens on returns from growing and finishing pigs. 1. Spring and summer. Anim. Breed. Abstr. 39(2): 320.

Skoknik, A., Cornejo, S. and Pokniak, J. (1979 a). Effects of floor space on the performance of growing-finishing pigs. The Winter-spring period. Anim. Breed. Abstr. 47(7): 404.

Skoknik, A., Cornejo, S. and Pokniak, J. (1979 b). Effects of floor space on the performance of growing-finishing pigs. 1. The Spring-summer period. Anim. Breed. Abstr. 47(7): 404.

Snedecor, G.L. and Cochran, W.G. (1967). Statistical Methods. Oxford and IBH Publishing Co., New Delhi, 6th ed. pp. 391-406.

Spers, A., Rodrigues, A.J. and Silveira, J.J.N. (1970). Space requirements for growing and finishing pigs raised in pens. Anim. Breed. Abstr. 38(3): 461.

Spicer, H.M. and Aherne, F.X. (1988). The effects of group size/stocking density on weanling pig performance and behaviour. Anim. Breed. Abstr. 56(10): 835.

Suther Land, J.A. (1967). Understanding Farm Animals. Angus and Robertson, Sydney, pp. 154-155.

Voloschchik, P.P., Dmitrieva, N.M. and Morozov, V.N. (1975). Stocking density of weaned piglets. Anim. Breed. Abstr. 43(7): 352.

Walker, N. (1990). The interactions of stocking density, form of diet and sex group of finishing pigs fed ad libitum. Anim. Breed. Abstr. 58(3): 227.

West,G.P. (1985). Black's Veterinary Dictionary. A and C Black, London. 15th ed. pp. 792-793.

Zin, M. (1981). The effect of group size and stocking density on fattening performance of pigs. Anim. Breed. Abstr. 49(3): 174-175.

Zin, M., Krupa, J. and Olszewski, A. (1987). The effect of housing in batteries on finishing performance and carcass quality of pigs. Anim. Breed. Abstr. 55(3): 195.

By

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ABSTRACT OF A THESIS

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ABSTRACT

The objectives of the study were, to find out the minimum floor space requirement without affecting performance in growing pigs, to assess change in the pattern of behaviour in pigs due to change in stocking rates and to find out whether there is any effect of reduction in floor space upon the growth and carcass quality of pigs.

Twenty seven large White Yorkshire weanling female pigs having an average body weight of 8.5 kg and 56 days of age were assigned at random to three treatment groups. In the first (control) group of six pigs, each received $1m^2$ of floor space (as per ISI specification) while in the second group there were nine pigs and in the third group 12 pigs received 0.75 m^2 and $0.5m^2$ of floor space per pig respectively. Animals were provided with concentrate and allowed to consume as much as they could within a period of one hour.

Total weight gain of 58.5 kg, 56.22 kg and 55.46 kg were noticed in control group, group two and group three respectively. Variations of average fortnightly body weight of pigs due to stocking density were not found to be significant. Similar trend were noticed in the case of height, length and girth.

When the feed conversion efficiency was taken as whole, it was found to be highest in group III (3.746±0.667) and lowest in group I (3.960±0.864). The animals of group II were showing feed conversion efficiency between group I and group III (3.798±0.744).

Aggressive behaviour was measured by counting the number of threats and number of ear-biting incidence. These parameters were found to be highest at higher stocking densities.

When the dressing percentage with head is taken and compared to per unit weight, no apparent difference was observed between the groups (1.096; 1.360 and 1.118 per cent respectively for group I, II and III). Similar was the trend in half carcass weight, weight of the ham, carcass length and eye muscle area. The back fat thickness was found to be similar in group I and III (2.41 cm and 2.388 cm respectively) and less in group II (1.499 cm).

From the experimental result no significant difference could be observed in the performance of those pigs having a floor space as per ISI specification and the one where the floor space reduced to the extent of 50 percentage.