EFFECT OF SEASON OF BIRTH AND ENERGY LEVELS OF FEED ON PRODUCTION PERFORMANCE OF PIGS

By

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THESIS

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DECLARATION

I hereby declare that the thesis entitled **EFFECT OF SEASON OF BIRTH AND ENERGY LEVELS OF FEED ON PRODUCTION PERFORMANCE OF 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.

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CERTIFICATE

Certified that the thesis entitled **EFFECT OF SEASON OF BIRTH AND ENERGY LEVELS OF FEED ON PRODUCTION PERFORMANCE OF PIGS** is a record of research work done independently by Sri. K.S. Sebastian under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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Introduction

INTRODUCTION

Livestock in India accounts for one fourth of the total animal population of the world. However the productivity of Indian animals is comparatively low.

Increased food production for human consumption is the prime objective of planning in the developing countries. The human population of India is increasing at a rapid rate of 3-4 millions per year and consequently the shortage of food has become a major problem. It is inadequately realised that animal products like milk, meat, egg and fish provide nutrients both in quality and quantity that can be efficiently utilized by human beings.

Acute scarcity of animal protein is reflected from the fact that the per capita consumption per day is only 5.6 g against the recommended daily allowance of 20 g (Borgstrom, 1973). The prejudice against beef and slow multiplication of sheep and goat to keep pace with the ever increasing demand for food had precipitated the need to find other sources to satisfy human requirements. Pigs as meat animals offer an immediate solution to this problem since they multiply rapidly at a low cost.

Hazel (1963) has stated that pig is an extremely versatile animal, able to adapt to a wide variety of circumstances imposed by man and yet retaining it's own peculiar individuality. Pigs thrive from arctic to tropical temperatures on highly concentrated or bulky feeds and produce high percentage of meat and fat.

In India pig rearing is still not in a satisfactory state and almost entirely in the hands of people with little resources who continue to follow the primitive methods of rearing. The common Indian pig is a scrub animal, slow grower, small sized and producer of small litters. Recognising the merits and potential of exotic breeds as a source of animal protein, the Government of India is paying considerable attention in the development of pig industry. A number of pig production centres have been established in several states and the farmers are being educated on scientific lines.

Pigs are ideal suppliers of good quality meat. Pigs excel all other meat producing animals except well kept broiler. Swine can effectively utilize agricultural byeproducts and industrial waste materials. Compared to other meat animals pigs yield higher dressing percentage. Pork has higher energy value than beef or mutton.

It is well known that the production of livestock in a country is influenced by its climatological and meteorological conditions. Pigs thrive very well in Indian conditions. The total population of pigs in India is 88.3 lakhs as per FAO Bulletin, 39. Imported animals thrive well in Kerala conditions. People of Kerala do not show much aversion to pork as those in other parts of India.

Swine husbandry is a profitable animal husbandry enterprise. There are several advantages in swine industry because hogs: (1) give quick returns (2) are prolific (3) require only moderate investment (4) are efficient converters of feed materials into edible products for human consumption (5) produce meat with several desirable characters and (6) labour requirement in raising hogs is low, the animal being adaptable to most type of farming.

The economy in swine production is influenced by such factors as (1) number of piglets farrowed per litter (2) weight of the litter at weaning (3) labour charges per 100 kg of meat produced (4) returns per amount of money spent and (5) cost per kg meat sold.

Efficiency of production depends on the successful interaction of several factors of these nutrition and climatic conditions prevailing in the region are by and large the most important.

Efficiency of feed utilization by swine is influenced by various factors such as nutrients, age, breed, sex and climatic variables. Energy requirement of pig is comparatively high, because they grow rapidly and cannot consume fibrous feeds. NRC recommends 3500 Kcal digestible energy per kg feed for younger ones and 3300 Kcal per kg feed later.

Without adding substantial proportion of maize or fat as such, it will be difficult to compute a ration having 3500 Kcal digestible energy as recommended by NRC. These are expensive ingredients in India. Besides the uniform 'slightly-above-thermo-neutral zone' ambient temperature condition of Kerala may help in reducing the energy requirement. On that premise and also considering the practical feasibility under the existing field conditions, the present study was taken up to see whether a 15 per cent reduction in energy from the NRC recommendation would significantly affect productivity and profitability.

Feed contributes 70-80 per cent of the total cost of pork production. Scientific feeding of pigs had contributed much to better growth rate, feed efficiency and carcass quality in pigs and had helped in reducing production costs and increasing profits.

Growth rate, feed efficiency and carcass quality are vital factors influencing the cost of fattner production in swine industry. These factors are related to live weight, age, quality and quantity of feed, genetic potential, environment and miscellaneous factors. Feed efficiency is maximum at the early stages of growth and it decreases with increasing age and live weight (Field et al., 1961; Kumar et al., 1974; Ranjhan et al., 1972).

Environment is having a profound influence on the animal's energy expenditure and this energy is derived from nutrients in the feed, the thermal effect of environment will have direct consequences for energy partition between that is retained for growth and that dessipated as heat. To maintain optimum production it is necessary to maintain optimum climatic conditions consistent with the requirement of the animal. Within the thermal neutral zone, energy available for growth is maximum (Mount, 1974).

The season in Kerala is classified into rainy season (May to November) and Dry season (December to April). The suitable season of birth of pigs for optimum production in Kerala is yet to be identified. A detailed investigation therefore, was taken up to study the effect of season of birth on growth rate, feed efficiency and carcass characteristics of fattening pigs maintained on two levels of energy intake upto a slaughter weight of 90 kg. The study is expected to identify the favourable season of birth in Yorkshire pigs for maximum economy of production. It is also aimed to investigate the feasibility of reducing the digestible energy content of grower swine ration by 15 per cent from the NRC standards to make suitable recommendations to farmers.

Review of Literature

REVIEW OF LITERATURE

Production performance of pigs as influenced by climatic changes and level of energy intake is well reviewed and reported by workers from temperate climate, where climatic conditions are not so hazardous to livestock production. Similarly, the extent to which the production performance and carcass characteristics are influenced by these characters are also reported extensively from western countries. But reports of such nature are scanty and scattered from tropical climates. The literature reviewed in this aspect is presented under the following heads.

Season of birth

Seasonal variation of climate produces effects that are far-reaching. This is apparent from a single meteorological record. The agelong action of weather in the nature and landscapes has built up a characteristic ecology in which climate and original geographic structure of the land have interacted to give a particular type of soil. This soil interacting with climate has allowed characteristic forms of plant life to flourish. Upon this plant life certain kinds of animals have come to depend for their food.

By it's food supply the climate of a region has profound influence on the animals living there. It is well known that the production of livestock in a country is influenced by it's climatological and meteorological conditions. Animal life is geared to this seasonal rhythm of plant growth. In addition to it's effect on food supplies, climate affects all production processes of living creatures directly through its control of heat exchanges through nervous, hormonal and seasonal mediations.

India renders a variety of meteorological conditions and features than any other country of similar size of the world (Calder, 1937). As climatic variables are changing with different seasons the effect of season of birth is significant on the performance of pigs. The climate of Indian sub continent is essentially tropical characterised by the occurrence of three distinct seasons viz; Winter (October to February), Summer (March to June) and rainy (July to September) (ICAR, 1977). But in South India especially in Kerala no distinct winter season prevails. Analysis of climatic data of Mannuthy revealed the occurrence of only two seasons viz; the rainy and dry season. The former extending from May to November and the latter from December to April. The cold winter season experienced in the northern parts of the country and in high altitudes does not appear in this part of Kerala since the ambient temperature never falls below 21°C (Somanathan 1980). There is also absence of seasonal rhythm and little variation in day length. Mean ambient temperature as high as 40°C used to be experienced during the months of March and April. The relative humidity is high throughout the year (Nair, 1973). Season influences its effects through ambient temperature, relative humidity, solar radiation, rain fall, light and atmospheric pressure.

Air temperature is the most important single bioclimatological factor in the animal's physical environment that affects it's production. As mean daily temperature fall out side the comfort zone, other climatic variables assume greater significance in the homeostasis of animals.

Brody (1945) has reported that such animals born younger than normal attain subsequent weight later than the normal animals. Animals which are under sized at birth are physiologically premature and also more subjected to neonatal mortality owing to their poor thermoregulatory mechanism and their inability to withstand stress in a new environment (Hafez and Dyer, 1969). Season's effect on birth weight has been reported in cattle (Juma and Kasir, 1967 and Dhillon et al., 1971).

McDowell (1972) has reported that young ones born in hot climate are usually lighter at birth than similar offsprings born in cool climates. Females born in summer months are five per cent lighter. He has further reported that birth weight of sindhi cattle in warm places was six per cent lesser than in colder places in spite of same feeding and managemental regime. He has also reported that the number of abnormally small pigs was higher in warm places. Tropical climate has an influence on physiological functions of the mother including level of endocrine secretion which in turn is expressed in the size of the offsprings.

Tomes and Neilson (1979) has reported that animals born in summer were lower in litter size and individual weight. Han and Kim (1982) has reported that even season of breeding itself significantly affected the litter size at birth. Goswami et al. (1983) reported that daily gain in weight is significantly affected by season of birth. Bardoloi and Raina (1984) reported that pigs born during December to

February was superior in growth than those born in other seasons. Rai and Desai (1987) reported significant effect of season of birth in birth weight of piglets. Piglets born in summer, monsoon and winter season weighed 1.21, 1.22 and 1.25 kg respectively at birth. They have further reported that the weaning weight of pigs born in summer, monsoon and winter as 9.54, 10.35 and 10.99 kg respectively.

Chung and Park (1990) reported that season of birth significantly affected the average daily gain, age at 90 kg body weight and back fat thickness. Pigs born in June and July had higher average daily gain and reached 90 kg body weight earlier. Pigs born in the month of March and April had lowest average daily gain.

McDowell (1972) demonstrated a retardation in growth rate in pigs at high temperature. He has reported an optimum temperature of 21-24°C for swine of 45 kg or larger while that for baby pigs as 27-29°C. The rate of gain for 49-60 kg pigs was reported to be 40-50 per cent at 4-5°C, 25 per cent at 27°C and 40 per cent at 30°C. An environmental temperature of 32°C is reported to decrease gain by 80 per cent. Level of relative humidity is also a critical factor in the growth rate in summer particularly at 27°C or above.

Rectal temperature

Homeothermic animals maintain a constant body temperature with little fluctuation. The body temperature of mammals is seen affected by the age. The foetus is having a higher body temperature which gradually declines after birth and through advancing age to attain the level characteristic to the species. Rectal temperature is usually taken as an index of body temperature.

Dukes (1955) noticed that rectal temperature of pigs begin to increase at an environmental temperature of 85-90°F (29.4-32.2°C). The pigs could not tolerate prolonged exposure (seven hours) to an environmental temperature of 95°F (35°C). Robinson and Klemm (1953) had reported that there is a noticable rise in rectal temperature above 95°F and rise in rectal temperature parallelled rise in humidity. Findlay (1957) reported that pigs were ill adapted to extremes of heat and cold. It is reported that there is an increase in rectal temperature of animals exposed to high environmental temperature both in climatic chamber and outside (Bianca, 1959 and Williams _et al_., 1960). Wrenn _et al_. (1961) reported that there is an elevation of rectal temperature of animals in the mid morning and afternoon which declines in early morning and evening. Findlay (1961) stated that for all practical purposes rectal temperature appeared to be a very good measure of the temperature of animals which was within 0.2-0.3°C of the mean circulating blood temperature provided the heat content of the animal remained constant or changing very slowly. Body temperature is elevated during feeding, exercise, oestrus and at the terminal phase of pregnancy and depressed during starvation and immediately after intake of large quantity of cold water.

Stress of ambient temperature causes marked behavioural and physiological responses in young pigs (Mount, 1960, Holmes, 1968). There is a diurinal fluctuation of rectal temperature of animals, having minimum in the early morning and maximum in the afternoon (Hafez, 1968). Sutherland (1967) observed that as ambient temperature rose above the upper critical temperature, the temperature of animals may begin to increase. Martin (1970) reported that rectal temperature of pigs began to show a sharp increase when the environmental temperature rose from 60-80°F (15.6-26.7°C). He had also reported that the body temperature of swine appears quite variable with a range of 101.5-104°F (38.6-40°C) Campbell and Lasley (1977) have reported the rectal temperature of swine as 102.5°F (39.20°C) Sainsbury and Sainsbury (1979) reported that critical temperature of piglets were 35°C at birth, 29°C upto 5 kg live weight and 24°C at 10 kg body weight. According to West (1985) pigs show a variation in body temperature between 100.9 to 104.0°F.

Respiration

Increased respiratory activity is an important means of heat dissipation in domestic animals at high temperature. Kibler et al. (1949) reported that the respiratory rate was increased with an increase in air temperature and humidity. Increased respiratory rate is usually the visible sign of response to heat stress and is placed third in the sequence of adaptive reaction as the unnoticed vasodilatation and sweating usually occurred earlier (McDowell, 1972). Increase in the rate of respiration causes an increased dissipation of heat in two ways; first by warming the inspired air and secondly by increasing the evaporation from the respiratory passage and lungs. The greater the volume of air that could be breathed in, warmed and humidified the greater the resultant heat loss. The reaction of breathing to heat stress fall in two phases. In the first phase respiratory rate is increased with shallow breathing. In the second phase opposite occurs and the air turnover is increased.

Energy intake

Cost of feed is the major factor affecting the cost of production in pigs which accounts for 75-80 per cent of the total cost of production (Emsminger, 1970). Feed intake and energy utilization is influenced by climatic variables, especially ambient temperature. McDowell (1972) reported that one of the first noticable response of most livestock to thermal stress is a decrease in feed intake and the extend of depression is directly related to the level of stress.

Next to ambient temperature, humidity imposes stress on animals and this results in low input output efficiency of feed energy for production purposes as compared to cooler climates (McDowell, 1972). Pigs maintained in high ambient temperature voluntarily reduce their feed consumption. Low temperature stimulate feed consumption but dipresses efficiency of feed utilization (Holmes and Close, 1977). Close et al. (1978) reported that less efficient energy utilization in winter is attributable to the increased energy expenditure to maintain body temperature. It is reported by Herz and Steinhauf (1978) that the amount of feed consumed is at least partly determined by the organism's ability to give off the heat produced by the food.

The effect of the amount of feed consumed on metabolic heat and heat tolerance depends partly on the quality of feed. A low crude protein ration results in increased heat tolerance. Seerly and Poley (1964) reported that energy efficiency decreases as the level of energy increases on a low protein diet. Hale _et al_. (1968) reported that as the energy concentration of the diet increases, feed intake decreases without affecting gain thereby resulting an improvement in feedefficiency. It is reported that feed efficiency was improved with fat addition as low as two per cent (Moser, 1977). It is observed that pigs receiving diets containing five per cent added fat gained faster and had a better feed efficiency than pigs fed diets without added fat (Keschall, 1983; Moser 1977; Rupnov _et al_.,1961). Inclusion of dietary fat increased metabolisable energy intake and improved growth rate and efficiency of energy utilization in pigs with low protein diets. Incorporation of lysine in the feed resulted in faster gain both in cold and warm environments (Stahly _et al_., 1979).

Stahly *et al*. (1979 a) reported that pigs allowed to consume *ad libitum* do not eat to satisfy their energy requirement when maintained in a hyper thermal environment (35°C). In an extensive experiment involving three winter and three summer feeding trials to determine the effect of season of the year and diet composition on the performance of pigs, Stahly *et al*. (1981) observed the pigs fed in the summer consumed less feed and gained more slowly but were more efficienct than those fed in winter. Group housed young growing pigs, given feed *ad libitum* were exposed to two temperatures; with in the thermal neutrality (25°C) and one around lower critical temperature (15°C). Pigs at 15°C had daily gain reduced by 57 g for six days after initial exposure. Feed intake was significantly increased after six days at 15°C but not at 25°C. Maintenance requirement was increased by 58 K J/kg $M^{0.75}$ and energy retained as protein was decreased by 49 K J/Kg $M^{0.75}$ for the first six days after exposure to treatment of 15°C and thereafter both became equivalent to those of pigs at 25°C. It is concluded that animals were acclamatized after six days exposure (Verhagen *et al*., 1987).

Nichols *et al*. (1982) reported that pigs maintained at 0°C had smaller average daily gain than those reared at 10, 15, 20 and 25°C and had greater feed gain ratio. At a constant level of feed intake, pigs reared under 28-22°C and 32-20°C temperature ranges had higher average daily gain than pigs raised under 24-18°C, temperature ranges and had greater feed:gain ratio. The pigs in the hoter environment had higher daily gain and protein and fat deposition (Dividich et al., 1982).

John et al. (1987) used 480 crossbred pigs to study the effect of heat and social stressors and their interaction on pig performance. In heat stressed group feed intake and weight gain were significantly reduced. The interaction of social and thermal stress was significant for gain:feed ratio. Regrouping dipressed feed gain ratio in heat stressed animals only. It was concluded that re-grouping did not impair weanling pig's performance which are held in natural temperature. However during heat stress, re-grouping should be avoided. In an extensive study with 798 crossbred white American pigs grown from 26 to 108 kg body weight, in a temperature range of 4-28°C Smith et al. (1988) observed that the pigs consumed at the rate of approximately 0.12 of the metabolic body weight ($LW^{0.75}$). The influence of temperature was expressed by the following equation;

daily feed intake (kg) per live weight (kg) =

$$0.0465\ (\pm 0.00031) - 0.00066\ (\pm 0.00004)\ (T-TC)$$

where T is the environmental temperature and TC is the lower critical temperature (TC) is calculated as TC = 24-(0.15 LW) and the residual standard deviation (rsd) is 0.0077. The regression value of the equation was 0.54. For each °C above critical temperature, feed intake would be reduced by 0.66 g/kg live weight. Experiments conducted by McGlone _et al_. (1988) concluded that weanling performance will not be influenced by re-grouping when pigs are held in thermally neutral zone. However, during heat stress, regrouping should be avoided.

In controlled environmental studies Mahn _et al_. (1990) observed that maximum growth rate and most efficient feed conversion were achieved at a temperature of 60.4°F and 67.5°F respectively. Acceptance of a performance loss of 1, 2, 3 or 5 per cent for these traits would permit the use of temperature ranges of 63.9-64.4, 62.4-66, 61.3-67.1, 59-68.9°F respectively. Within the normal temperature ranges daily fluctuation of 5-8°F had no effect on the performance of healthy pigs. Tobinskova (1990) made observation on piglets housed in groups at 15, 18, 21, 24 and 27°C. Daily gain from 6 to 8 kg averaged 369, 397, 406, 354 and 347 g respectively. Daily gain from 18-30 kg averaged 527, 528, 580 and 490 g respectively. The between group differences in feed conversion were not significant The lowest rearing cost was obtained at 21°C.

Growth

Brody (1945) defined growth as a constructive or assimilatory synthesis of one substance at the expense of other (nutrient) which undergo dissimilation. Growth is a complex set of metabolic events which are environmentally and genetically controlled (Hafez, 1968).

Maynard *et al*. (1969) had estimated the average percentage of gross energy in the feed eaten by various kinds of animals and converted into human food as follows; pork 20 per cent milk (dairy cow) 15 per cent; egg seven per cent; poultry five per cent and beef and lamb four per cent. Morrison (1984) reported that well maintained and well fed pigs make more than twice weight gain per 100 lb body weight as compared with fattening calves and three times as compared with fattening lambs.

Environment is having a profound influence on the animals energy expenditure and as this energy is derived from nutrients in the feed, thermal effect of the environment will have direct consequences for energy partition. Energy intake of animal is partitioned into energy that is retained as growth and that is dissipated as heat and lost to production. Sorensen (1962) suggested an approximate temperature of 12.1 to 12.9°C as the bounding zone of highest growth rate. Low temperature stimulate feed consumption and dipresses efficiency of feed utilization, because more heat production is required to maintain body temperature. Lubbrandt (1975), Campbell (1976) and Kornegay et al. (1974 and 1979) concluded that low feed intake is one of the factors responsible for poor post weaning performance of weaned pigs. To maintain optimum production it is necessary to maintain optimum climatic conditions consistant with the requirement of the animal (Clark, 1981). The primary influence of environment on the productivity of animals is by way of their heat exchange. This is regulated so that heat produced in the body is equal to heat lost from the body enabling the body temperature to be maintained within the relatively narrow limits. Within the thermally neutral zone energy available for growth is maximum.

Air temperature is the most important microclimate affecting growth. High humidity and high temperature lead to heat stress, impaired apetite and growth. Kaezmarezyk et al. (1981) and Bresk (1984) reported that in pigs housed at 12-15°C, 15-18°C and 18-21°C during finishing, daily weight gain averaged 516, 556 and 547g respectively. Deoe (1983) reported that weekly weight gain was not significantly affected by heat stress. Dividich et al. (1988) observed that digestible energy intake and the amount of digestible energy required per unit of body weight gain increased quadratically as environmental temperature decreased. The additional digestible energy required to compensate 1°C drop in temperature range between 28°C-20°C and between 20°C-12°C was 0.20 and 0.44 MJ/day respectively. Feenstra (1982) had reported that environment had no significant effect on average daily gain or feed conversion ratio. Ashton et al. (1955), Kropf et al. (1959), Kurvival (1962) and Wanger et al. (1963) reported that increasing the protein content in the diet improves rate and efficiency of gain as well as leanness of carcass. Bowland et al. (1959) reported that increasing protein content of the diet improves rate and efficiency of growth as well as carcass leanness. Pigs fed high levels of proteins from three weeks of age to market weight grew significantly faster (Seymour et al., 1964). Stevenson et al. (1960) and Scherer (1962) reported that pigs on high protein diet generally have faster rate of gain, higher feed conversion efficiency and leaner carcass than animals on low protein diet. Wilson et al. (1963) reported that pigs on high protein diets generally have faster rate of gain, higher feed efficiency and leaner carcass than animals on low protein diet. Wyllie et al. (1966) and Bunch et al. (1967) had stated that there is depression of gain per pound of feed consumed on feeding low protein diets to young pigs. Pigs fed low protein diets gained slower and fatter than pigs fed 14 per cent protein diet (Cunningham et al., 1973). Inadequate protein supplement decreased overall growth performance upto slaughter weight by about 3 per cent.

Brooks (1972) reported that mixed soybean oil, tallow or mixed fat were equally effective in improving feed efficiency. McDonald et al. (1976) observed improved feed efficiency by adding tallow, rape seed oil and soybean in swine feeds. Holmes et al. (1977) stated that reduced feed or energy intake results in dipressed growth rate and minimal change in efficiency of feed utilization. Three experiments were conducted with pigs of three weeks to five weeks age to compare the utilization of fat calories versus carbohydrate calories using either soy flour or non fat milk solids as a source of dietary protein. The pigs were fed six different diets that contained 12-74 per cent of non protein calories as fat. It was observed that pigs fed soy flour diet that contained 18, 25 and 43 per cent of non protein calories as fat averaged 375, 410 and 403 g per day gain. Pigs fed non fat milk solids containing 43, 58 and 74 per cent non protein calories as fat gained 374, 349 and 368 g per day respectively. The data revealed that young piglets can utilize high levels of fat to the same extend as glucose or lactose calories (Cline et al. 1977). Seerely et al. (1978) concluded that animal fat and poultry fat are equally effeetive in feed conversion.

Seerely et al. (1978) reported that in pigs housed at 12-15°C, 15-18°C and 18-21°C during finishing daily weight gain averaged 516, 556 and 547g respectively. Dece (1983) reported that weekly weight gain was not significantly affected by heat stress.

Seerely et al. (1978) had reported that average daily gain was not affected by energy level with combined data from warm and cool season trials. Pigs fed low levels of supplemental fat in their ration gained faster and required less amount of metabolizable energy per unit gain (Waterman et al., 1973).

Studies conducted in 17 boars, 12 gilts and 30 barrows by Henkel et al. (1984) revealed that the utilization of feed energy for weight gain was best in boars and poorest in gilts. Studies with 36 boars with three levels of energy intake (Ad libitum 1.64 and 1.38 kg energy intake per day) revealed that energy intake resulted in linear increase in growth rate and protein and fat acretion, but had no effect on the feed gain ratio (Campbell et al., 1988). In an extensive study involving 7850 Duroc, Hampshire Landrace and Yorkshire boars and gilts, Chung and Park (1990) observed that daily gain averaged 0.78±0.004 kg and age at 90 kg body weight as 155.6±0.03 days and back fat thickness 1.68±0.008 inches. Males had higher average daily gain and back fat thickness and were younger at 90 kg body weight than females. Year and month of birth affect all three traits.

Junkin (1990) conluded that growth performance and carcass composition of growing animals are largely determined by relations between protein and energy intake and protein deposition. As weight increases these relations are increasingly modified by sex and genotype. In the case of finisher pigs particularly accurate prediction of responses to dietary and feeding level changes requires use of separate relations for pigs of different sex and strain. The general principle for evaluating pig potential and responses to various lean growth across a range of intake firstly of protein and then of energy should be more widely adopted in research and commercial practices.

Carcass characteristics

Carcass characteristics are determined by body size, energy intake and environmental conditions. Sorensen (1962) reported that pigs maintained in temperature below 15°C produced fatter carcass than comparable animals gaining at a similar rate in warm climate. Several workers have reported that there is a definite effect of environmental and seasonal factors on the level of performance and carcass characteristics (Seymour et al., 1964; Bruner and Swiger, 1968; Hale and Johnson, 1968 and Hays, 1968).

Fuller (1965) reported that cold stress decrease nitrogen retention in pigs. Combined data from warm and cool season indicated that nine per cent fat supplement resulted three per cent increase in feed efficiency, slightly increased dressing percentage and back fat thickness and a decrease in loin eye area, and percentage of primal cuts. (Seerely et al., 1978).

Steopen (1982) from studies with 33 Landrace boars, concluded that boars maintained intensively had body length 7.4 cm longer and trunk length was 5.7 cm larger than that were maintained extensively. All body measurements of pigs reared intensively were higher than that were reared extensively.

Tamate and Ohtaka (1983) reported that significant differences were found in the iron content among pig muscle and significant difference between year and season. Duncey <u>et al</u>. (1983) reported that, for pigs kept at 35°C most of the energy was stored in superficial tissues with muscle as the second highest store. Pigs kept at 10°C stored most of their energy in muscle. Total amount of fat stored in the body was grater for pigs kept at 35°C than those kept at 10°C and increased with increased feed intake. But there is no interaction between these.

Tamate (1987) reported that there were significant year x season and season x breed interaction in the chloride content of pig muscle. But in this, season, breed and sex had no significant effect. He had also reported that phosphorous content in muscle is influenced by breed, season and year. Sex and muscle type had no significant effect on phosphorous content. There was significant season x breed, season x sex and year x breed interaction.

Dividich et al. (1988) concluded that there was no temperature and dietary energy interaction for any of the thirteen carcass traits studied. The environmental temperature did not affect total carcass percentage. However back fat per cent and thickness were higher in pigs maintained at 12°C (13.6 per cent and 23.6 mm respectively). Leaf fat percentage was higher in pigs at 28°C than those at 12°C (1.96 versus 1.39).

Body measurements indicate body weight which is having definite effect on carcass characteristics. Studies by Christian et al (1980) in 288 pigs for the effect of sex breed cross, dietary protein level and their slaughter weight and their first order interaction on performance and carcass traits noted that barrows grew faster than gilts but had low percentage of ham and loin, shorter carcass, shorter loin eye area and more back fat. Lean cross pigs had higher average daily gain, lower marbling and colour scores, less back fat, longer carcass, longer loin eye area and higher ham and loin percentage. Compared with 12 per cent protein diet 16 per cent protein diet decreased marbling scores and increased feed efficiency. Pigs slaughtered at 113.5 kg body weight was faster in gain but less efficient when compared to pigs of 98.5 kg body weight. High weight animals produced carcass with less ham and loin percentage, more back fat and increased carcass length. It is further concluded that there was no difference between gilts and barrows to high protein diets and there is no need of feeding gilts and barrows separately.

Data on 286 market pigs slaughtered between 72.5 and 140 kg live weight (Sather et al., 1980) indicated a linear increase of feed lot days, back fat measurements, carcass weight and dressing percentage as market weight increased. Average daily gain remained constant relative to market weight. Non linear effects for these traits did not substantially contribute multiple correlation coefficient. Furthermore these non linear effects were attributed to puberty of gilts. Barrows had superior growth effects with inferior fat measurements in comparison with gilts. Dressing percentage was equal in both sexes. Gilts excelled in carcass index at 78 kg body weight. In general the data support the marketing of pigs at 100-110 kg to produce 78-86 kg carcass. It was reported that dressing percentage was equal in both sexes. It was reported that dressing percentage increased from 77.18 at 45 kg body weight to 80.78 at 90 kg and was significantly lower for males (79.7) than females (80.67) (Gibs et al., 1980).

Cerna et al. (1982) reported that effect of breed of dam, breed of sire, parity, litter size, sex, duration of fattening, body weight at slaugher, back fat thickness, carcass weight during gain and during finishing and feed conversion are the factors which will affect significantly the finishing performance and carcass characteristics in pigs. It is also reported that as body weight increased from 65.4 to 109.4 kg dressing percentage increases from 68.7 to 76.4, back fat thickness from 2.07 to 3.57 cm. The lean meat percentage decreased from 71.2 to 67.2. The percentage yield for butt, picnic, loin, bacon and ham were 10.73, 20.73, 16.10, 17.23 and 31.28 respectively (Cheong et al., 1982).

Ramaswami et al. (1984) reported that carcass length and loin eye area were significantly higher in gilts than barrows at all weights. There was significant sex difference for dressing percentage and carcass weight. Values for all increased with increase in body weight. Differences between different slaughter weight groups were significant.

In a study with Landrace pigs slaughtered at 65 to 74 kg, 75-84 kg and 85-94 kg body weight it was reported that the dressing percentage averaged 70.44, 71.87 and 71.31 ($P < 0.05$) respectively and weight of trimmed ham 12.03, 13.70 and 15.02 kg ($P < 0.01$) respectively. Back fat thickness were 1.95, 2.42 and 2.53 cm ($P<0.01$) respectively. Carcass lengths were 74.57, 76.64 and 80.74 ($P < 0.01$) respectively and loin eye area 25.34, 27.82 and 29.32 cm^2 ($P < 0.01$) respectively (Anjaneyulu et al., 1984).

Ramaswamy et al., (1985) reported that increase in slaughter weight was associated with significant increase in dressing percentage (77.93 ± 0.29 to 81.18 ± 0.26) and back fat thickness from 2.87 ± 0.05 cm to 4.11 ± 0.07 cm). There was significant decrease in carcass lean percentage. The total weight of lean cuts and the weight of lean cuts as percentage of carcass weight did not differ significantly between slaughter weight groups.

Grady (1966) Havorka et al. (1974) and Wajda (1975) had reported that because of decreasing percentage of lean content an optimum slaughter weight of 90 kg was indicated. Delate and Babu (1990) stated that chest circumference accounted for 79-96.5 per cent and chest circumference and body length 87.5 to 98.5 per cent of variation in body weight.

Pigs fed high levels of protein from three weeks of age yielded carcass containing higher percentage of leaner cuts and significantly less back fat than pigs fed diets containing low protein (Seymour et al., 1964). It was reported that high protein level in the diet improves growth rate and feed conversion efficiency during growing phase as also carcass quality in terms of lean content of the carcass eye muscle area and body length (Robinsen et al., 1964). It is well established that dietary protein and energy levels affects performance of pigs and rate of fat to lean in the carcass. Allee (1976) reported that when diets were formulated on a caloric protein basis, the loin eye area is increased and back fat decreased compared with pigs receiving diets that were not adjusted for increased energy concentration. Cunningham (1973) stated that carcass from pigs fed low protein diet, had more back fat, less percentage of ham and loin and smaller loin eye area.

Rapnov et al. (1961), Hale et al. (1976), Moser (1977) and Keaschall et al. (1983) had reported that smaller amount of fat (upto 5 per cent) can be added to growing and finishing swine diets without adversely affecting carcass composition. Neither protein nor fat level significantly influenced loin eye area. There was no significant effect on difference in colour, firmness or marbling scores due to main effects of fat or protein. Waterman et al. (1973) reported that carcass composition was not adversely affected by addition of fat at three per cent level.

Allee et al., (1971); Mersman et al. (1976); Klain et al. (1977) and Steffen et al. (1978 a) reported that the lipid synthetic capacity of swine adipose tissue is affected by various dietary regimes such as level and type of fat. Swine with same energy intake gained an equal amount of weight regardless the fat content of the diet. But adipocyte size tended to be greater with isocaloric amount of high fat diet (Steffen, 1978).

In pigs major differentiation in muscle development appeared to take place prior to 23 kg live weight (Richmond et al., 1982). Henkel et al. (1984) reported that lowest carcass percentage was in boars on low feeding diet. It is well established that major fatty acids of dietary fat will be reflected in the body fat of non ruminants (Channon et al., 1987). The carcass fat content and carcass fat measurements also increased with energy intake, whereas carcass protein and water content decreased on feeding three levels of single diet (Ad libitum, 1.64, 1.38 kg energy intake per day) (Campbell et al.,1988).

Fat characteristics are influenced by the nature of food. Fatty acids with a high proportion of low molecular weight and unsaturated fatty acids will have a low melting point. subcutaneous fat contain higher proportion of unsaturated fatty acids and so are softer than deep body fat (Maynard et al., 1969). Melting point gives a useful measure of hardness of fat and indirectly reflects the degree of unsaturation. Lard is having melting point in the range of 36-45°C, Iodin value in the range of 40-70 and saponification value in the range of 193-200 (Carton, 1965). Maynard et al. (1969), Sebastian (1972) and Ramachandran (1977) also reported similar values in melting point saponification value and iodine value. Feeding experiments conducted by Yatsenko (1987) in pigs fed with standard ration with 10 per cent and 15 per cent less protein reported an average of 53-63 for iodine value. Close et al. (1978) reported that fat retention increases with increase in metabolisable energy intake. Energy retention in the body takes place at the rate that is dependant in the interaction beween the level of intake of metabolisable energy on one hand and the animals need for maintenance and thermo regulation on the other (Blaxter, 1977). Dividich _et al._ (1982) reported that pigs in the hoter environment had higher daily gain and protein and fat deposition. Tokoro (1984) reported that melting point of fat was significantly higher in pigs finished in winter than in summer. Recently health concerns have increasingly influenced consumer feed choices (NRC, 1988 a).

Materials and Methods

MATERIALS AND METHODS

Location

The Kerala Agricultural University Pig Breeding Farm, Mannuthy Trichur District, Kerala State is the location of the present study. Mannuthy is geographically situated

at longitude 76, 16" E

at latitude 10, 32" N and

at an altitude of 22.25 meters above MSL.

Meteorological data

The meteorological data over a period of two years from 1990 to 1991 obtained from the meteorological observatory unit attached to College of Horticulture, Vellanikkara were utilised. Monthly average maximum temperature (°C) relative humidity (%) Monthly averages of bright sun shine (hours per day), wind velocity (Km/hour) and monthly total rain fall for the period were collected to study the macro climate of the locality.

Since ambient temperature and humidity are the important bioclimatological factors which causes stress on animals and rain fall which affects indirectly through influencing feed supply is considered as the basis of classification of the climatic environment.

The seasonal classification is done as per Somanathan (1980). Season I consists of mainly rainy season (May to November). This is further classified into cold and wet (June to August) and warm and wet (May and September to October). Season II mainly consists of dry season (December to April). It is further classified into warm and dry (December to January) and hot and dry (February to April).

The experimental animals taken in the season I were born in the warm and wet season (September) where the average ambient temperature showed a variation from 27-29.5°C, a relative humidity of 75-80 per cent and a rainfall between 70-320 mm.

Animals born in season II were belonging to warm and dry season of December and January. The ambient temperature of this season was between 27-28.5°C, relative humidity 55-65 per cent. There was practically no rainfal (9 mm).

Experimental animals

Sixteen Large White Yorkshire weaned piglets born during wet season (season I) and 16 born during the dry season (season II) were selected. Males and females were selected in equal numbers. Animals for the study were selected as uniform as possible with regard to age and body weight.

Feeding

In the first treatment animals were maintained on rations containing crude protein and digestible energy as per NRC recommendations. In the second treatment animals received rations containing 15 per cent less energy than NRC recommendation but the level of crude protein was maintained identical.

NRC recommendations

	Crude protein (%)	Digestible energy (K cal/kg)
10-20 kg body weight	18	3500
20-35 kg body weight	16	3300
35-60 kg body weight	14	3300
60-100 kg body weight	13	3300

The ingredient composition of the ration computed was as follows:

	NRC level (%)	15 % less NRC level (%)
Body weight 10-20 kg		
Ground nut cake	17	17
Fish	10	10
Maize	50	45
Wheatbran	19	27
Tallow	3	-
Mineral mixture	1	1
Body weight 20-35 kg		
Ground nut cake	13	13
Fish	10	10
Maize	50	45
Wheatbran	23	31
Tallow	3	-
Mineral mixture	1	1

Body weight 35-60 kg

Ground nut cake	8	8
Fish	10	10
Maize	55	50
Wheatbran	24	31
Tallow	2	-
Mineral mixture	1	1

Body weight 60-100 kg

Ground nut cake	8	8
Fish	8	8
Maize	55	50
Wheatbran	27	33
Tallow	1	-
Mineral mixture	1	1

Animals were housed individually and fed *ad libitum*. Water was given *ad libitum* and feed was given at two times, morning and evening.

Observations

Rectal temperature, pulse rate and respiratory rate were recorded weekly on every monday and Tuesday of the week throughout the experimental period (Figs. 1 to 21 and Tables 23 to 25). This was recorded by 7 am and 2 pm. Fortnightly feed intake, average daily gain, weight gain and body measurements were recorded.

Animals were slaughtered on attaining a body weight of 90 kg. Live body weight at slaughter, dressed weight with head, dressed weight without head, half carcass weight were recorded. Carcass length was measured from the anterior aspect of first rib to the anterior aspect of aitch bone.

Average back fat thickness was measured at first rib, last rib and last lumbar vertibrae.

Eye muscle area was calculated by making impressions at the region of tenth rib.

Weight of ham was recorded after cutting at a point two and a half inches from the most anterior part of the aitch bone by sowing through the sacral virtibrae and shaft of ileum.

Dressing percentage with head and without head were calculated.

Saponification value, iodine number and melting point of lard were estimated as per the method specified in A.O.A.C (1965).

Data were analysed as suggested by Snedecor and Cochran (1967).

Results

RESULTS

1. Body weight

The fortnightly weights of pigs born in wet and dry seasons in the NRC and 15 per cent less NRC groups are presented from weaning till 90 kg body weight (Table 1).

The average weaning weight on NRC males, NRC females, 15 per cent less NRC males and females of wet season were noted to be 9 kg, 9.1 kg, 7.8 kg and 10 kg respectively. The animals attained the target weight of 90 kg in 19 fortnights, 18 fortnights, 18 fortnights and 18 fortnights respectively.

In the case of animals born in dry season, the weaning weight of NRC males, NRC females, 15 per cent less NRC males and 15 per cent less NRC females were 11.8 kg, 12.5 kg, 10 kg and 12 kg respectively. These animals attained the target weight of 90 kg in 14 fortnights, 12 fortnights, 14 fortnights and 14 fortnights respectively.

2. Rate of gain in weight

The fortnightly rate of growth of pigs born in wet and dry seasons of NRC group and 15 per cent less than NRC group are presented (Table 2 and 3).

Table 1. Fortnightly body weight of pigs (kg)

Age in fortnights	SEASON I				SEASON II			
	NRC		15% less NRC		NRC		15% less NRC	
	Males	Females	Males	Females	Males	Females	Males	Females
Initial	9.0	9.1	7.8	10.0	11.8	12.5	10.0	12.0
1	10.2	12.1	10.2	12.9	15.0	16.0	14.0	15.0
2	12.5	15.4	13.4	16.4	19.0	20.0	18.0	20.0
3	14.0	17.1	15.6	18.9	23.0	25.0	23.0	23.0
4	13.5	18.9	18.3	21.3	31.0	32.0	29.0	29.0
5	14.2	19.6	19.6	22.4	39.0	41.0	34.0	37.0
6	16.0	20.8	20.6	24.5	45.0	51.0	37.0	41.0
7	21.3	23.2	23.2	27.0	51.0	60.0	42.0	47.0
8	23.7	25.4	25.0	31.0	68.0	68.0	47.0	52.0
9	26.2	28.8	28.0	33.8	66.0	75.0	53.0	57.0
10	29.3	33.3	32.2	37.6	72.0	81.0	60.0	65.0
11	35.0	41.2	39.0	45.5	79.0	88.0	68.0	73.0
12	41.8	51.4	43.0	52.5	86.0	92.0	74.0	79.0
13	48.3	57.9	49.7	58.5	84.0		85.0	87.0
14	57.0	67.6	56.7	63.8	91.0		91.0	91.0
15	65.7	74.5	61.3	69.3				
16	74.7	82.3	65.3	74.0				
17	79.0	87.0	71.3	81.0				
18	82.0	91.0	86.7	89.5				
19	90.5							
Time taken to reach target weight	19	18	18	18	14	12	14	14

Table 2. Fortnigtly rate of gain in weight (kg).

Age in fort-nights	SEASON I				SEASON II			
	NRC		Less NRC		NRC		Less NRC	
	Males	Females	Males	Females	Males	Females	Males	Females
1	1.2	3.0	2.4	2.9	3.2	3.5	4.0	3.0
2	2.3	3.3	3.2	3.5	4.0	4.0	4.0	4.0
3	1.5	1.7	2.2	2.5	4.0	5.0	5.0	4.0
4	1.5	1.8	2.7	2.4	8.0	7.0	6.0	6.0
5	0.7	0.7	1.3	1.1	8.0	9.0	5.0	8.0
6	1.8	1.2	1.0	2.1	6.0	10.0	3.0	4.0
7	5.3	2.4	2.6	2.5	6.0	9.0	5.0	6.0
8	2.4	2.2	1.8	4.0	7.0	8.0	5.0	5.0
9	2.5	3.4	3.0	2.8	8.0	7.0	6.0	5.0
10	3.1	4.5	4.2	3.8	6.0	6.0	7.0	8.0
11	5.7	7.9	6.8	7.9	4.0	7.0	8.0	8.0
12	6.8	10.2	4.0	7.0	7.0	4.0	6.0	6.0
13	6.5	6.5	6.7	6.0	3.0		10.0	8.0
14	8.7	9.7	7.0	5.3	5.0		6.0	4.0
15	8.7	6.9	4.6	5.5	2.0		1.0	5.0
16	9.0	7.8	4.0	4.7	4.0			
17	4.3	4.7	6.0	5.5				
18	3.0	4.0	9.4	4.7				
19	8.5	-	-	7.0				
Average sex wise	4.39 ±0.64	4.55 ±0.68	4.05 ±0.53	4.27 ±0.42	5.33 ±0.46	6.63 ±0.63	5.06 ±0.55	5.31 ±0.48
Average treatment wise	4.47 ±0.66		4.22 ±0.48		5.88 ±0.36		5.19 ±0.37	
Average Season wise	4.34 ±0.28				5.52 ±0.27			

Table 3. Test of significance of rate of gain in weight.

Sl No.	Groups	Means		t value	Remark
1.	NRC Males Vs NRC Females	4.39	4.55	-0.1618	NS
2.	NRC Males Vs 15% less NRC Males	4.39	4.05	0.3997	NS
3.	NRC Females Vs 15% less NRC Females	4.55	4.27	0.3413	NS
4.	15% less NRC Males Vs 15% less NRC Females	4.05	4.27	-0.3233	NS
5.	S_2 NRC Males Vs S_2 NRC Females	5.33	6.63	-1.6694	NS
6.	S_2 15% less NRC Males Vs S_2 15% less NRC Females	5.06	5.31	-1.0215	NS
7.	NRC Males Vs 15% less NRC Females	4.39	4.27	-0.2963	NS
8.	NRC Females Vs 15% less NRC Males	4.55	4.05	0.5682	NS
9.	S_2 NRC Females Vs S_2 15% less NRC Females	5.33	5.31	0.0178	NS
10.	S_2 NRC Females Vs S_2 15% less NRC Males	6.63	5.06	2.5192	*
11.	S_2 NRC Females Vs S_2 15% less Females	6.63	5.31	1.6486	NS
12.	NRC Males Vs S_2 NRC Males	4.39	5.33	-1.0937	NS
13.	NRC Females Vs S_2 NRC Females	4.55	6.63	-2.0906	*
14.	15% less NRC Males Vs S_2 15% less NRC Males	4.05	5.06	-0.6717	NS
15.	15% less NRC Females Vs S_2 15% NRC Females	4.27	5.31	-1.5642	NS
16.	S_2 NRC Males Vs S_2 15% less NRC Males	5.33	5.06	1.0587	NS

* Significant at 5% level
NS Non-significant
S_1 Season I
S_2 Season II

Average rate of growth of NRC males of season I varied from 0.7 to 9 kg with an average of 4.39±0.64 kg. In the case of females of NRC group of season I varied from 0.7 kg to 10.2 kg with an average of 4.55±0.68 kg.

In the case of male pigs of less than 15 per cent NRC group season one the growth rate showed a variation of 1 kg to 9.4 kg, with an average of 4.05±0.53 kg per fortnight. In the case of female of the same group the variation in growth rate noted was 1.1 kg to 7.9 kg with an average of 4.27±0.42 kg per fortnight.

In the case of animals born in the second season the growth rate in NRC males varied from 2kg to 8 kg with an average of 5.33±0.46 kg and the females within the same group showed a variation of 3.5 kg to 10 kg with an average of 6.63±0.63.

In the case of animals of 15 per cent less than NRC in the second season the males showed a variation from 1 kg to 10 kg with an average of 5.06±0.55 kg. The same in the case of females was 5.31±0.48 kg with a variation of 1 kg to 8 kg.

The average rate of growth of animals born in season one was noted to be 4.34±0.28 and in season II was 5.52±0.27.

3. Rate of gain in body length

The fortnightly gain in body length of animals born in dry and wet season of NRC and 15 per cent less NRC group is presented (Table 4).

Average gain in body length of animals born in the wet season in the group of NRC male, NRC female, males in less than 15 per cent NRC and females in less than 15 per cent NRC group were 3.53 cm, 3.72 cm, 3.11 cm and 2.89 cm respectively.

In the case of NRC males, NRC females, 15 per cent less NRC males and 15 per cent less NRC females belonging to dry season were 3.81 cm, 4.28 cm, 3.03 cm and 3.04 cm respectively.

The mean rate of body length gain of NRC group of wet season was 3.65 cm against 3.0 cm in the 15 per cent less NRC group of the same season. The mean rate of gain in body

Table 4. Fortnightly gain in body length (cm).

Age in fort-nights	SEASON I				SEASON II			
	NRC		Less NRC		NRC		Less NRC	
	Males	Females	Males	Females	Males	Females	Males	Females
1	4.5	5.3	3.5	3.8	2.8	1.5	3.0	3.3
2	2.8	2.2	2.5	2.7	3.5	2.5	2.5	3.0
3	3.2	3.3	1.8	1.0	4.2	4.5	4.3	3.2
4	4.8	3.7	5.2	8.5	6.3	4.0	5.5	3.8
5	3.0	4.3	2.5	0.5	3.7	8.5	4.0	2.7
6	4.0	1.0	5.3	5.3	3.5	2.5	1.0	1.3
7	0.4	0.7	0.2	0.7	3.5	5.3	1.5	3.7
8	3.0	1.5	2.0	3.0	3.5	5.3	1.5	3.7
9	0.3	1.5	3.8	0.3	3.5	5.2	2.7	5.3
10	2.7	1.5	1.0	3.0	5.5	6.5	5.0	4.7
11	2.6	0.8	1.5	2.0	2.3	1.0	2.8	4.0
12	7.0	11.5	9.7	5.2	3.0	4.0	4.7	5.0
13	2.0	7.2	3.8	2.8	1.5	5.8	4.8	3.8
14	5.7	3.0	2.2	2.5	5.7		3.7	2.0
15	7.3	6.8	2.7	7.5	9.5		1.0	1.9
16	7.0	4.5	3.3	2.2	1.5		1.0	0.5
17	4.7	1.5	2.0	3.3	1.0		1.0	0.5
18	1.0	6.7	6.0	0.5				
19	1.0			0.5				
Average sex wise	3.53 $\pm$0.49	3.72 $\pm$0.68	3.11 $\pm$0.53	2.89 $\pm$0.53	3.81 $\pm$0.53	4.28 $\pm$0.62	3.03 $\pm$0.39	3.04 $\pm$0.36
Average treatment wise	3.65 $\pm$0.41		3.0 $\pm$0.37		4.01 $\pm$0.40		3.04 $\pm$0.25	
Average season wise	3.32 $\pm$0.37				3.49 $\pm$0.23			

length of NRC group of dry season and 15 per cent less NRC of the same season were 4.01 and 3.04 cm respectively.

Season means when taken the mean rate of gain of body length of animals born in wet season was found to be 3.32 against 3.49 in the dry season.

The average values obtained in rate of gain in body length were analysed statistically and the results are presented (Table 5).

The mean values when tested were found to be non-significant ($P > 0.05$) in all groups and season.

4. Carcass characteristics

a. Live weight of pigs at slaughter

Live weight of pigs at slaughter are presented treatment-wise and season-wise (Table 6).

The weight at slaughter of NRC males, NRC females, 15 per cent less NRC males and 15 per cent less NRC females were 88.0 kg, 88.0 kg, 90.0 kg and 90.0 kg respectively. In

Table 5. Test of significance of average gain in body length

Sl No.	Groups	Means		t value	Remark
1.	NRC Males Vs NRC Females	3.53	3.72	-0.2336	NS
2.	NRC Females Vs 15% less NRC Males	3.72	3.11	0.7040	NS
3.	NRC Males Vs 15% less NRC Males	3.53	3.11	0.5667	NS
4.	NRC Males Vs 15% less NRC Females	3.53	2.89	0.8399	NS
5.	NRC Males Vs NRC Males S_2	3.53	3.81	-0.3913	NS
6.	NRC Females Vs 15% less NRC Females	3.72	2.89	-0.9409	NS
7.	NRC Females Vs NRC Females S_2	3.72	4.28	-0.5632	NS
8.	15% less NRC males Vs 15% NRC Females	3.11	2.89	0.2639	NS
9.	15% less NRC Males Vs 15% less NRC Males S_2	3.11	3.03	0.1169	NS
10.	15% less NRC Females Vs 15% less NRC Females S_2	2.89	3.04	-0.1869	NS
11.	NRC Males S_2 Vs NRC Females S_2	3.81	4.28	-0.5636	NS
12.	NRC Male S_2 Vs 15% less NRC Male S_2	3.81	3.03	1.1098	NS
13.	NRC Female S_2 Vs 15% less NRC Male	4.28	3.03	1.7492	NS
14.	NRC Females S_2 Vs 15% less NRC Females S_2	4.28	3.04	1.6514	NS
15.	15% to less NRC S_2 Vs 15% less less	3.03	3.04	-0.0210	NS
16.	NRC males S_2 Vs 15% less NRC males S_2	3.81	3.03	1.1742	NS

NS Non-significant

Table 6. Live weight of pigs at slaughter (kg)

Treatment	Season I	Season II
NRC Males	88.0	97.0
NRC Females	88.0	99.0
15% less NRC Males	90.0	96.0
15% less NRC Females	90.0	97.0
Average	89.0	97.3

ANOVA TABLE

Source	DF	MS	F
Season	1	450.6719	72.1075 **
Treat	1	0.6719	0.1075 NS
Sex	1	4.1719	0.6675 NS
Season x Treat	1	20.1719	3.2275 NS
Season x Sex	1	0.6719	0.1075 NS
Treat x Sex	1	6.0000	0.9600 NS
3 Factor Inter	1	8.1406	1.3025 NS
Error	16	6.2500	

** Significant at 1% level
NS Non-significant

season II the live weight of pigs at the time of slaughter in NRC males, NRC females, 15 per cent less NRC males and 15 per cent less NRC females were 97.0 kg, 99.0 kg, 96.0 kg and 97.0 kg respectively. The average slaughter weight of pigs born in season I was 89.0 kg, whereas the live weight of pigs born in season II recorded 97.3 kg.

The analysis of variance of live weight of pigs at slaughter showed a highly significant ($P < 0.01$) difference between the animals born in the wet and dry seasons.

b. Dressed weight with head

The dressed weight of pigs with head recorded in the experiment according to season, is presented (Table 7).

The dressed weight of pigs with head of NRC males, NRC females, 15 per cent less NRC males and 15 per cent less NRC females born in season I recorded 65.80 kg, 68.10 kg, 67.97 kg and 70.87 kg respectively.

The dressed weight with head of pigs born in season II were found 78.16 kg, 80.35 kg, 78.11 kg and 79.00 kg in NRC males, NRC females, 15 per cent less NRC males and 15 per cent less NRC females respectively.

Table 7. Dressed weight with head of pigs (kg)

Treatment	Season I	Season II
NRC Males	65.80	78.16
NRC Females	68.10	80.35
15% less NRC Males	67.97	78.11
15% less NRC Females	70.87	79.00
Average	68.85	78.91

ANOVA TABLE

Source	DF	SS	MSS	F
Season	1	698.2422	698.2422	75.2830 **
Treat	1	3.5078	3.5078	0.3782 NS
Sex	1	10.2266	10.2266	1.1026 NS
Season x Treat	1	17.7266	17.7266	1.9112 NS
Season x Sex	1	9.7969	9.7969	1.0563 NS
Treat x Sex	1	11.5313	11.5313	1.2433 NS
3 Factor Inter	1	17.4531	17.4531	1.8818 NS
Error	16	148.3984	9.2749	

** Significant at 1% level
NS Non-significant

The average dressed weight with head of pigs born in wet season was 68.85. The same in those animals born in dry season recorded an average weight of 78.91 kg. These differences when tested were found to be non-significant between sex whereas the difference noted between the seasons were found to be highly significant ($P<0.01$).

c. Dressed weight of pigs without head

The dressed weight of pigs without head of NRC and 15 per cent less NRC groups, sexwise and seasonwise are presented (Table 8).

In the NRC group of season I the males recorded 59.83 kg dressed weight without head and females recorded a weight of 62.63. In the case of males and females of NRC group in season II the dressed weight without head was found to be 71.38 kg and 73.75 kg respectively.

In the 15 per cent less NRC group of season I the males recorded a dressed weight without head of 62.00 kg and females recorded a dressed weight without head of 61.86 kg. In season II the males and females of 15 per cent less than NRC group showed a dressed weight without head of 71.50 kg and 72.88 kg respectively.

Table 8. Dressed weight of pigs with out head (kg)

Treatment	Season I	Season II
NRC Males	59.83	71.38
NRC Females	62.63	73.75
15% less NRC Males	62.00	71.50
15% less NRC Females	61.86	72.88
Average	61.58	72.38

ANOVA TABLE

Source	DF	SS	MSS	F
Season	1	605.0078	605.0078	74.9444 **
Treat	1	3.6078	3.6078	0.3726 NS
Sex	1	19.2578	19.2578	1.7671 NS
Season x Treat	1	14.2656	14.2656	1.7671 NS
Season x Sex	1	10.0156	10.0156	1.2406 NS
Treat x Sex	1	12.7656	12.7656	1.5813 NS
3 Factor Inter	1	14.2578	14.2578	1.7662 NS
Error	16	129.1641	8.0728	

** Significant at 1% level
NS Non-significant

The average dressed weight without head noted in pigs of season I was 61.58 kg. The same in season II was 72.38 kg.

The analysis of variance showed a highly significant difference (P<0.01) in dressed weight without head of pigs between seasons. The result was non-significant between sex and treatment.

d. Half carcass weight

The half carcass weight of pigs observed in the study is presented according to season (Table 9).

The half carcass weight of pigs 29.92 kg, 31.31 kg, 31.00 kg, 32.50 kg were observed in NRC males, NRC females 15 per cent less than NRC males and 15 per cent less than NRC females respectively. The same in season II were found to be 35.69 kg, 36.94 kg, 35.75 kg and 36.44 kg respectively in NRC males, NRC females, 15 per cent less NRC males and 15 per cent less NRC females.

The average half carcass weight recorded in pigs born in season I was found to be 31.18 kg against 36.21 kg in

Table 9. Half carcass weight of pigs (kg)

Treatment	Season I	Season II
NRC Males	29.92	35.69
NRC Females	31.31	36.94
15% less NRC Males	31.00	35.75
15% less NRC Females	32.50	36.44
Average	31.18	36.21

ANOVA TABLE

Source	DF	SS	MSS	F
Season	1	151.2520	151.2520	74.9444 **
Treat	1	0.7520	0.7520	0.3726 NS
Sex	1	4.8145	4.8145	2.3855 NS
Season x Treat	1	3.5664	3.5664	1.7671 NS
Season x Sex	1	2.5039	2.5039	1.2407 NS
Treat x Sex	1	3.1914	3.1914	1.5813 NS
3 Factor Inter	1	3.5645	3.5645	1.7662 NS
Error	16	32.2910	2.0182	

** Significant at 1% level
NS Non-significant

season II. The differences noted in the half carcass weight of pigs were tested and found to be highly significant (P<0.01) between seasons and non significant between sex and treatment.

e. Carcass length

Carcass length of pigs born during season I and season II is presented (Table 10).

The carcass length of NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females were found to be 78.6 cm, 78.8 cm, 75 cm and 77 cm respectively. The carcass length of pigs of NRC males, NRC females, 15 per cent less than NRC males, 15 per cent less than NRC females born in season II were found to be 82 cm, 80 cm, 81 cm and 81 cm respectively.

The mean carcass length of pigs born in season I was found to be 77.4 cm against 81.0 cm in season II.

The average carcass length of pigs born in different seasons when statistically analysed were found to be non-significant between treatments and between sex. But the

Table 10. Carcass length of pigs (cm)

Treatment	Season I	Season II
NRC Males	78.6	82.0
NRC Females	78.8	80.0
15% less NRC Males	75.0	81.0
15% less NRC Females	77.0	81.0
Average	77.4	81.0

ANOVA TABLE

Source	DF	SS	MSS	F
Season	1	117.0469	117.0469	19.7815 **
Treat	1	2.0469	2.0469	0.3459 NS
Sex	1	1.0469	1.0469	0.1769 NS
Season x Treat	1	26.0313	26.0313	4.3994 NS
Season x Sex	1	12.0313	12.0313	2.0333 NS
Treat x Sex	1	2.0313	2.0313	0.3433 NS
3 Factor Inter	1	1.0469	1.0469	0.1769 NS
Error	16	94.6719	5.9170	

** Significant at 1% level
NS Non-significant

difference noted between the seasons were found to be highly significant ($P < 0.01$).

f. Back fat thickness

The average back fat thickness observed in the study in pigs born in season I and II is presented (Table 11).

Average back fat thickness of 2.5 cm, 3.0 cm, 3.0 cm and 2.7 cm were observed in NRC male, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females respectively. In the case of NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females born in season II average back fat thickness recorded were 3.2 cm, 3.80 cm, 2.70 cm and 2.80 cm.

An overall back fat thickness of 2.8 cm was no ted in the animals born in season I against 3.3 cm in season II.

The results when examined were found to be highly significant ($P<0.01$) between seasons and season into treatment. The interaction between treatment and sex was also found to be significant ($P < 0.05$) whereas it was non-significant in all other groups.

Table 11. Back fat thickness of pig (cm)

Treatment	Season I	Season II
NRC Males	2.5	3.2
NRC Females	3.0	3.8
15% less NRC Males	3.0	2.7
15% less NRC Females	2.7	2.8
Average	2.8	3.3

ANOVA TABLE

Source	DF	SS	MSS	F
Season	1	1.0005	1.0005	7.5035 **
Treat	1	0.5704	0.5704	4.2788 NS
Sex	1	7.0465	7.0465	0.5285 NS
Season x Treat	1	1.1704	1.1704	8.7780 **
Season x Sex	1	0.0104	0.0104	0.0777 NS
Treat x Sex	1	0.7004	0.7004	5.2530 *
3 Factor Inter	1	0.0038	0.0038	0.0284 NS
Error	16	2.1333	0.1333	

* Significant at 5% level
** Significant at 1% level
NS Non-significant

g. Eye muscle area

Eye muscle area of pigs born in season I and season II are presented (Table 12).

The NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females recorded an eye muscle area of 35.2 cm^2, 40.5 cm^2. 36.3 cm^2 and 34.3 cm^2 respectively. The same in pigs born in season II was observed to be 37.3 cm^2, 41.2 cm^2, 39.1 cm^2 and 41.9 cm^2 respectively in NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females.

An average of 36.6 cm^2 of eye muscle area was noticed in pigs born in season I as against 39.9 cm^2 in those pigs born in season II.

The eye muscle area noticed between treatments and between sex were found to be non-significant statistically. But the eye muscle area observed in pigs between seasons were found to be highly significant ($P<0.01$).

h. Weight of ham

The details showing weight of ham of pigs according to season, sex and treatment is presented (Table 13).

Table 12. Eye muscle area of pigs (cm^2)

Treatment	Season I	Season II
NRC Males	35.2	37.3
NRC Females	40.5	41.2
15% less NRC Males	36.3	39.1
15% less NRC Females	34.3	41.9
Average	36.6	39.9

ANOVA TABLE

Source	DF	SS	MSS	F
Season	1	182.6016	182.6016	10.2927 **
Treat	1	0.1992	0.1992	0.0123 NS
Sex	1	22.4258	22.4258	1.2641 NS
Season x Treat	1	29.0430	29.0430	1.6371 NS
Season x Sex	1	8.3984	8.3984	0.4784 NS
Treat x Sex	1	19.0820	19.0820	1.0756 NS
3 Factor Inter	1	17.3438	17.3438	0.9776 NS
Error	16	283.8555	17.7410	

** Significant at 1% level
NS Non-significant

Table 13. Weight of ham of pigs (kg)

Treatment	Season I	Season II
NRC Males	7.53	8.21
NRC Females	7.35	7.89
15% less NRC Males	7.35	7.89
15% less NRC Females	8.53	7.94
Average	7.72	7.98

ANOVA TABLE

Source	DF	SS	MSS	F
Season	1	2.0031	2.0131	9.4548 **
Treat	1	0.2714	0.2714	1.2745 NS
Sex	1	0.2303	0.2303	1.0819 NS
Season x Treat	1	2.8353	2.8353	13.3168 **
Season x Sex	1	0.6497	0.6497	3.0513 NS
Treat x Sex	1	3.7109	3.7109	0.1743 NS
3 Factor Inter	1	2.0331	2.0331	9.4554 **
Error	16	3.4066	0.2129	

** Significant at 1% level
NS Non-significant

Weight of ham of pigs of NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females were found to be 7.53 kg, 7.35 kg, 7.35 kg and 8.53 kg respectively. The same in season II were found to be 8.21 kg, 7.89 kg, 7.89 kg and 7.94 kg respectively for NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females.

An average of 7.72 kg was noticed in the weight of ham of pigs born in wet season. The same in dry season was found to be 7.98 kg.

The weight of the ham of pigs between season was found to be highly significant ($P < 0.01$). Similarly the interaction of this parameter between season and treatment was also found to be highly significant ($P < 0.01$).

i. Melting point

Melting point of the fat of pigs born in wet and dry seasons are presented (Table 14).

The melting point observed in the fat of NRC males, NRC females, 15 per cent less than NRC males and 15 per cent

Table 14. Melting point of fat

Treatement	Season I	Season II
NRC Males	39.0°C	43.0°C
NRC Females	45.0°C	43.0°C
15% less NRC Males	43.0°C	44.0°C
15% less NRC Females	44.0°C	39.0°C
Average	43.0°C	42.0°C

ANOVA TABLE

Source	DF	SS	MSS	F
Season	1	0.3750	0.3750	0.0267 NS
Treat	1	2.0430	2.0430	0.1235 NS
Sex	1	4.2969	4.2969	0.0026 NS
Season x Treat	1	3.3750	3.3750	0.2040 NS
Season x Sex	1	77.0430	77.0430	4.6575 *
Treat x Sex	1	51.0371	51.0371	3.0855 NS
3 Factor Inter	1	0.3711	0.3711	0.0224 NS
Error	16	264.6680	16.5418	

* Significant at 5% level
NS Non-significant

less than NRC females were found to be 39°C, 45°C, 43°C and 44°C in the pigs born in season I. The pigs born in season II the melting point of fat were found to be 43°C, 43°C, 44°C and 39°C respectively in NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females.

An overall average of 43°C was found to be the melting point of fat of pigs born in season I against 42°C in the melting point of fat of pigs born in season II.

The differences in the melting point of fat obtained in the experiment was found to be non-significant A significant difference ($P < 0.05$) was noticed between sex and season.

j. Iodine value

The iodine value of fat of pigs born in the wet and dry seasons are presented (Table 15).

An iodine value of 68, 69, 69 and 70 could be observed in the NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females born in wet season respectively. In season II an iodine value of 71,

Table 15. Iodine value of fat

Treatment	Season I	Season II
NRC Males	68	71
NRC Females	69	68
15% less NRC Males	69	73
15% less NRC Females	70	73
Average	69	71

ANOVA TABLE

Source	DF	SS	MSS	F
Season	1	2.6641	2.6641	1.0314 NS
Treat	1	10.6641	10.6641	4.1285 NS
Sex	1	4.1641	4.6141	1.6121 NS
Season x Treat	1	2.6719	2.6719	1.0344 NS
Season x Sex	1	13.5078	13.5078	5.2295 *
Treat x Sex	1	4.1719	4.1719	1.6151 NS
3 Factor Inter	1	4.1641	4.1641	1.6121 NS
Error	16	41.3281	2.5830	

* Significant at 5% level
NS Non-significant

68, 73 and 73 were noticed in NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females respectively.

When these values were compared between seasons, an iodine value of 69 was observed in the fat of animals born in season I against 71 in season II.

The differences when statistically analysed were found to be non-significant between seasons, between treatments and between sex. The difference noted in the iodine value when compared between season and sex it was found to be significant ($P < 0.05$).

k. Saponification value of fat of pigs

Saponification value of fat of pigs are presented (Table 16).

The saponification value observed in the NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females were found to be 193, 190, 190 and 195 respectively in those pigs born in dry season. In the case of pigs born in wet season the saponification value of fat

Table 16. Saponification value of fat

Treatment	Season I	Season II
NRC Males	193	188
NRC Females	190	192
15% less NRC Males	190	189
15% less NRC Females	195	190
Average	192	190

ANOVA TABLE

Source	DF	SS	MSS	F
Season	1	30.4375	30.4375	3.2753 NS
Treat	1	1.1250	1.1250	0.1211 NS
Sex	1	18.4375	18.4375	1.9840 NS
Season x Treat	1	5.0000	5.0000	0.5380 NS
Season x Sex	1	1.0000	1.0000	0.1076 NS
Treat x Sex	1	7.0000	7.0000	0.7533 NS
3 Factor Inter	1	63.3125	63.3125	6.8129 *
Error	16	148.6875	7.2930	

* Significant at 5% level
NS Non-significant

of NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females were found to be 188, 192, 189 and 190 respectively.

The average saponification value of fat of pigs born in season I was found to be 192 against 190 in the fat of pigs born in season II.

The differences noted in the saponification value of fat when analysed statistically was found to be non-significant.

1. Dressing percentage with head

The details of dressing percentage with head observed in the NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females born in season I were 75.1 per cent, 77 per cent, 75.6 per cent and 78.5 per cent respectively.

In those pigs born in season II a dressing percentage of 80.8 per cent, 81.3 per cent, 81.5 per cent and 81.9 per cent were observed in the NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females respectively.

The overall dressing percentage in season I was found to be 76.6 per cent against 81.4 per cent in season II.

The dressing percentage when analysed statistically was found to be highly significant (P> 0.01) between season and non-significant between treatment, between sex and all interactions (Table 17).

m. Dressing percentage without head

The details of the dressing percentage without head obtained for NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females were 68.3 per cent, 71.3 per cent, 69.1 per cent and 72.1 per cent respectively (Table 18).

In the case of season II NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females recorded a dressing percentage of 73.6 per cent, 74.4 per cent, 74.6 per cent and 75.5 per cent respectively.

The overall dressing percentage of pigs born in season I was 70.1 per cent. In the case of season II the overall dressing percentage was 74.50 per cent.

Table 17. Dressing percentage with head

Treatment	Season I	Season II
NRC Males	75.1	80.8
NRC Females	77.0	81.3
15% less NRC Males	75.6	81.5
15% less NRC Females	78.5	81.9
Average	76.6	81.4

ANOVA TABLE

Source	DF	SS	MSS	F
Season	1	114.4063	114.4063	25.9091 **
Treat	1	0.7569	0.7569	0.1811 NS
Sex	1	4.6788	4.6788	1.0519 NS
Season x Treat	1	1.9531	1.9531	0.4432 NS
Season x Sex	1	15.7188	15.7188	3.5731 NS
Treat x Sex	1	2.2969	2.2969	0.5220 NS
3 Factor Inter	1	3.9531	3.9531	0.8987 NS
Error	16	90.0781	5.6299	

** Significant at 1% level
NS Non-significant

Table 18. Dressing percentage without head

Treatment	Season I	Season II
NRC Males	68.3	73.6
NRC Females	71.3	74.4
15% less NRC Males	69.1	74.6
15% less NRC Females	72.1	75.5
Average	70.1	74.5

ANOVA TABLE

Source	DF	SS	MSS	F
Season	1	99.5703	99.5703	11.6860 **
Treat	1	0.2858	0.2858	0.0472 NS
Sex	1	11.3828	11.3828	2.0219 NS
Season x Treat	1	0.3359	0.3359	0.0597 NS
Season x Sex	1	11.8359	11.8359	2.1023 NS
Treat x Sex	1	3.5547	3.5547	0.6314 NS
3 Factor Inter	1	0.6797	0.6797	0.1207 NS
Error	16	90.0781	5.6299	

** Significant at 1% level
NS Non-significant

The differences noted in the dressing percentage when statistically analysed were found to be non-significant for all of the parameters except between season where it was found to be highly significant ($P < 0.01$).

5. Average daily gain

Average gain observed in the study for pigs born in season I and II, sex wise and treatment wise are presented (Table 19).

In the case of pigs born in season I a daily gain of 333 g and 357 g were noted in NRC males and females respectively. In the case of 15 per cent less than NRC males and females, the daily gain observed were 312 and 325 g respectively.

In the case of season II the daily gain observed in NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females were 478 g, 489 g, 450 g and 440 g respectively.

The differences in the daily gain observed when compared was found to be significant ($P < 0.05$) between

Table 19. Average daily gain of pigs (g)

Age in fort-nights	SEASON I				SEASON II			
	NRC		15% less NRC		NRC		15% less NRC	
	Males	Females	Males	Females	Males	Females	Males	Females
1	120	209	173	230	232	215	268	214
2	163	229	232	250	268	286	268	304
3	93	134	175	179	322	375	356	286
4	83	125	188	170	464	536	420	455
5	52	54	131	81	646	643	375	554
6	126	80	60	152	518	714	241	286
7	381	170	179	232	429	607	304	402
8	167	159	131	223	482	573	375	411
9	179	241	262	205	518	482	447	422
10	230	322	322	277	482	429	518	589
11	405	589	417	563	482	500	554	607
12	488	705	357	500	482	501	447	393
13	464	464	405	429	482	500	750	554
14	607	697	500	375	536	-	715	595
15	614	491	333	393	714	-	657	536
16	643	592	286	412	571	-	500	429
17	333	524	429	500	500			
18	372	643	633	524				
19	607	-	714	371				
Average	333	357	312	325	478	489	450	440

males of 15 per cent less than NRC group born in season II and season I and between females of 15 per cent less NRC of season II and season I. This difference was found significant ($P < 0.05$) between seasons in NRC male group (Table 20).

6. Feed efficiency

An average feed efficiency of 3.62 ± 0.20 and 3.60 ± 0.25 were observed in the NRC male and female pigs born in season I. The feed efficiency of 15 per cent less than NRC males and females born in season I were observed to be 4.80 ± 0.24 and 4.82 ± 0.33 respectively (Table 21).

In the case of season II the average feed efficiency of NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females were found to be 3.68 ± 0.33, 3.41 ± 0.43, 4.53 ± 0.41 and 4.52 ± 0.46 respectively.

When feed efficiency was observed treatment wise it was found that the NRC animals of season I were found to record an average feed efficiency of 3.61 ± 0.15 and those animals with 15 per cent less than NRC of the same season recorded a feed efficiency of 4.81 ± 0.18. In the case of season II the

Table 20. Test of significance of average gain in body weight

Sl No.	Groups	Means		t value	Remark
1.	NRC Males Vs NRC Females	333	357	-0.3333	NS
2.	15% less NRC Males Vs 15% less Females	312	325	-0.2391	NS
3.	S_2 NRC Male Vs S_2 NRC Female	478	489	-0.2340	NS
4.	S_2 15% less Male Vs 15% less NRC Female	450	440	0.1967	NS
5.	NRC Male Vs 15% less NRC Males	333	312	0.3345	NS
6.	NRC Females Vs 15% less NRC Females	357	325	0.5170	NS
7.	S_2 NRC Males Vs 15% less NRC Males S_2	478	450	0.5617	NS
8.	S_2 NRC Females Vs S_2 15% less NRC Females	489	440	1.0130	NS
9.	NRC Males Vs S_2 NRC Males	333	478	-2.5109	*
10.	NRC Females Vs S_2 NRC Females	357	489	-1.8524	NS
11.	15% less NRC males Vs S_2 15% less NRC Males	312	450	-2.4326	*
12.	15% less NRC Females VS S_2 15% less NRc Females	325	440	-2.4540	*
13.	NRC Males Vs 15% less NRC Females	333	325	0.1424	NS
14.	NRC Females Vs 15% less NRC Males	357	312	0.6794	NS
15.	S_2 NRC Males Vs S_2 15% less NRC Females	478	440	0.8668	NS
16.	S_2 NRC Females Vs S_2 15% less NRC Males	489	450	0.7094	NS

* Significant at 5% level
NS Non-significant

Table 21. Feed efficiency of pigs

Age in fort-nights	SEASON I				SEASON II			
	NRC		15% less NRC		NRC		15% less NRC	
	Males	Females	Males	Females	Males	Females	Males	Females
Average feed efficiency sex wise	3.62 ±0.20	3.60 ±0.25	4.80 ±0.24	4.82 ±0.33	3.68 ±0.33	3.41 ±0.43	4.53 ±0.41	4.52 ±0.46
Average feed efficiency treatment wise	3.61 ±0.15		4.81 ±0.18		3.50 ±0.26		4.52 ±0.30	
Average feed efficiency season wise	4.22 ±0.14				4.06 ±0.21			

NRC animals recorded a feed efficiency of 3.50 ± 0.26 and those with 15 per cent less than NRC recorded a feed efficiency of 4.52 ± 0.30 respectively.

The overall feed efficiency of animals born in season I was found to be 4.22 ± 0.14 against 4.06 ± 0.21 in season II.

The feed efficiency when analysed statistically found to be significant ($P < 0.05$) between season in the first fortnight and highly significant ($P < 0.01$) from second to fifth fortnight. There after the feed efficiency was found to be non-significant ($P > 0.05$) upto eleventh fortnight. The feed efficiency was found to be highly significant ($P < 0.01$) between seasons in the twelth fortnight (Table 22).

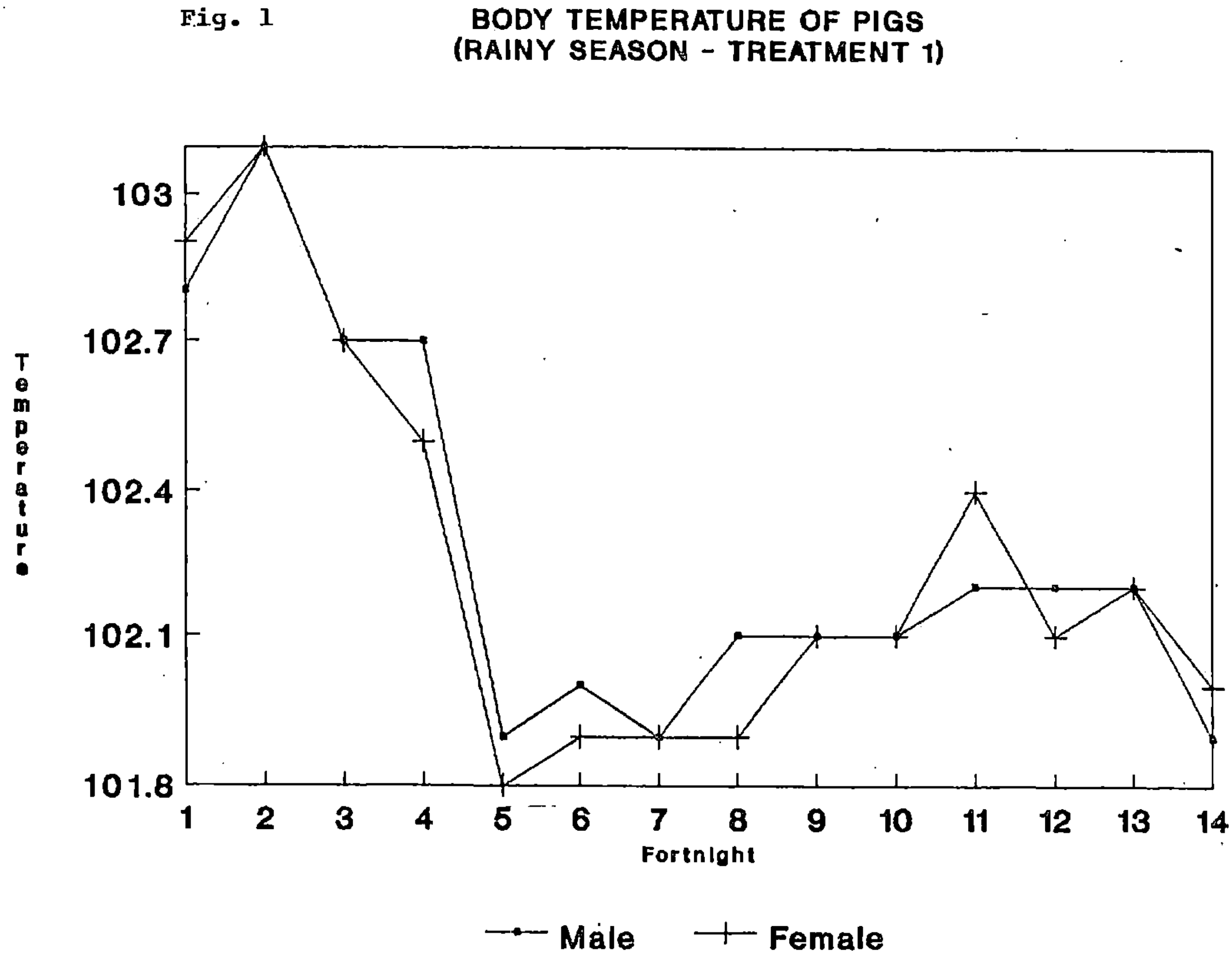
Between treatments when it was examined it was found to be non-significant ($P > 0.05$) from first to fifth fortnight. The parameter was found to be significant ($P < 0.05$) from sixth to eighth fortnight. Eventhough the feed efficiency was found to be non-significant from nineth to eleventh fortnight it was found to be highly significant ($P < 0.01$) in the twelth fortnight.

Table 22. Test of significance of absolute gain

Fortnight	F value			Error
	Season	Treatment	interaction	
1.	P < 0.05	P > 0.05	P > 0.05	20
2.	P < 0.01	P > 0.05	P > 0.05	20
3.	P < 0.01	P > 0.05	P > 0.05	20
4.	P < 0.01	P > 0.05	P > 0.05	20
5.	P < 0.01	P > 0.05	P > 0.05	20
6.	P > 0.05	P < 0.01	P > 0.05	20
7.	P > 0.05	P < 0.05	P < 0.05	20
8.	P > 0.05	P < 0.05	P < 0.05	20
9.	P > 0.05	P > 0.05	P > 0.05	20
10.	P > 0.05	P > 0.05	P < 0.05	20
11.	P > 0.05	P > 0.05	P < 0.01	20
12.	P < 0.01	P < 0.01	P > 0.05	20

(P < 0.01) - Highly significant
(P < 0.05) - Significant
(P > 0.05) - Non significant

Fig. 1



BODY TEMPERATURE OF PIGS
(RAINY SEASON - TREATMENT 1)
103
102.7
102.4
102.1
101.8
Temperature
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Fortnight
Male
Female

Fig. 2

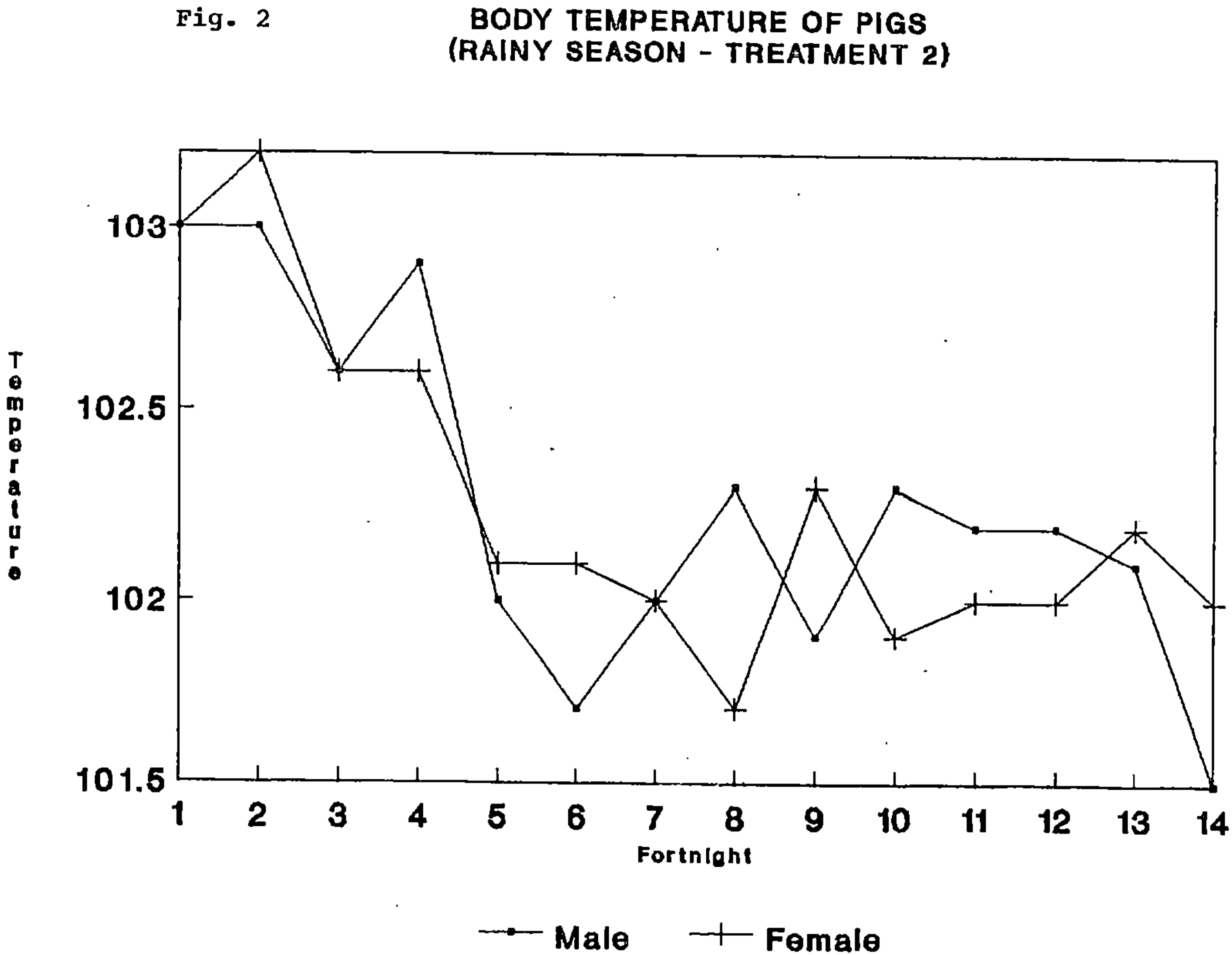

BODY TEMPERATURE OF PIGS
(RAINY SEASON - TREATMENT 2)
Temperature
103
102.5
102
101.5
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Fortnight
Male
Female

Fig. 3

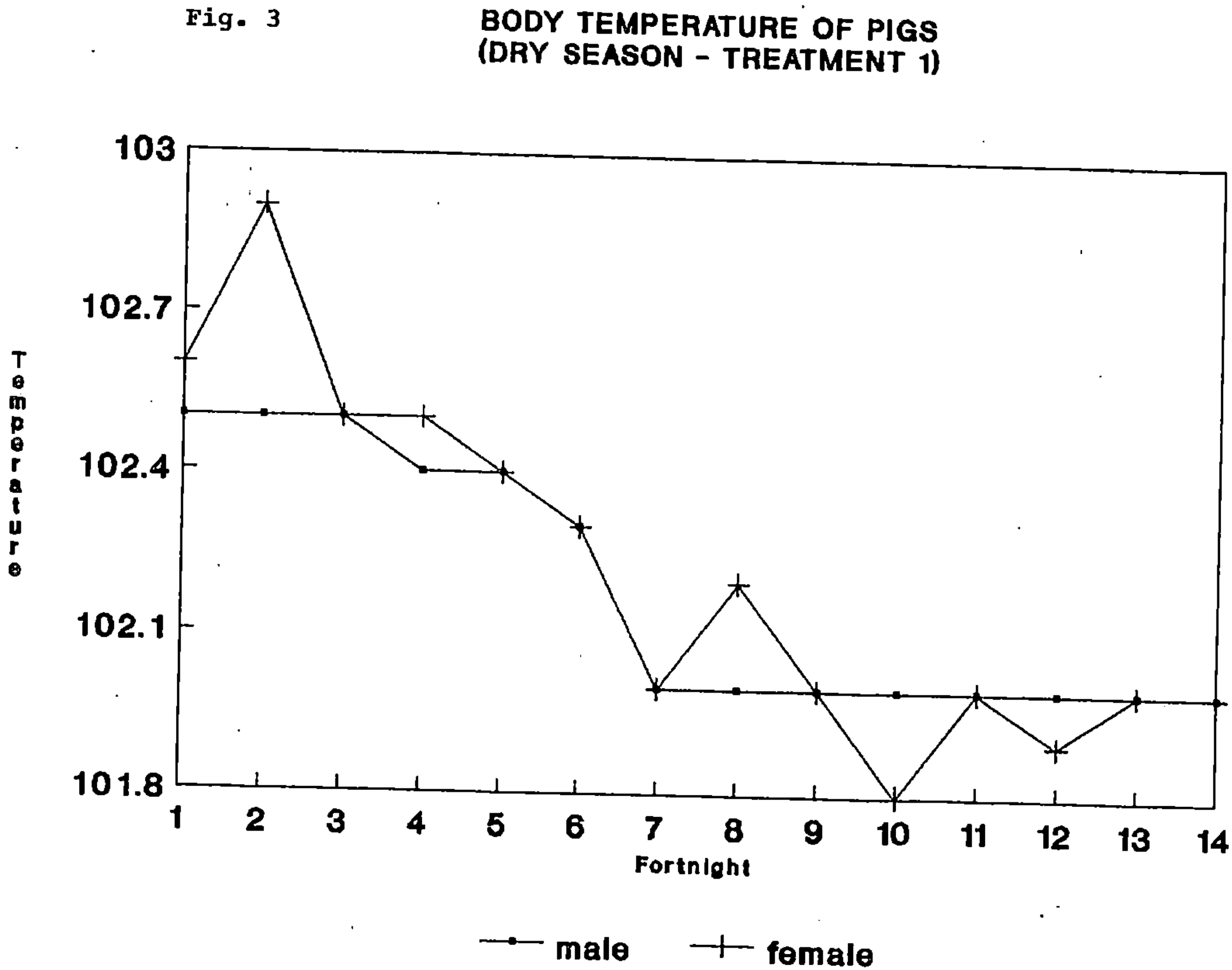

BODY TEMPERATURE OF PIGS
(DRY SEASON - TREATMENT 1)
103
102.7
102.4
102.1
101.8
Temperature
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Fortnight
male
female

Fig. 4

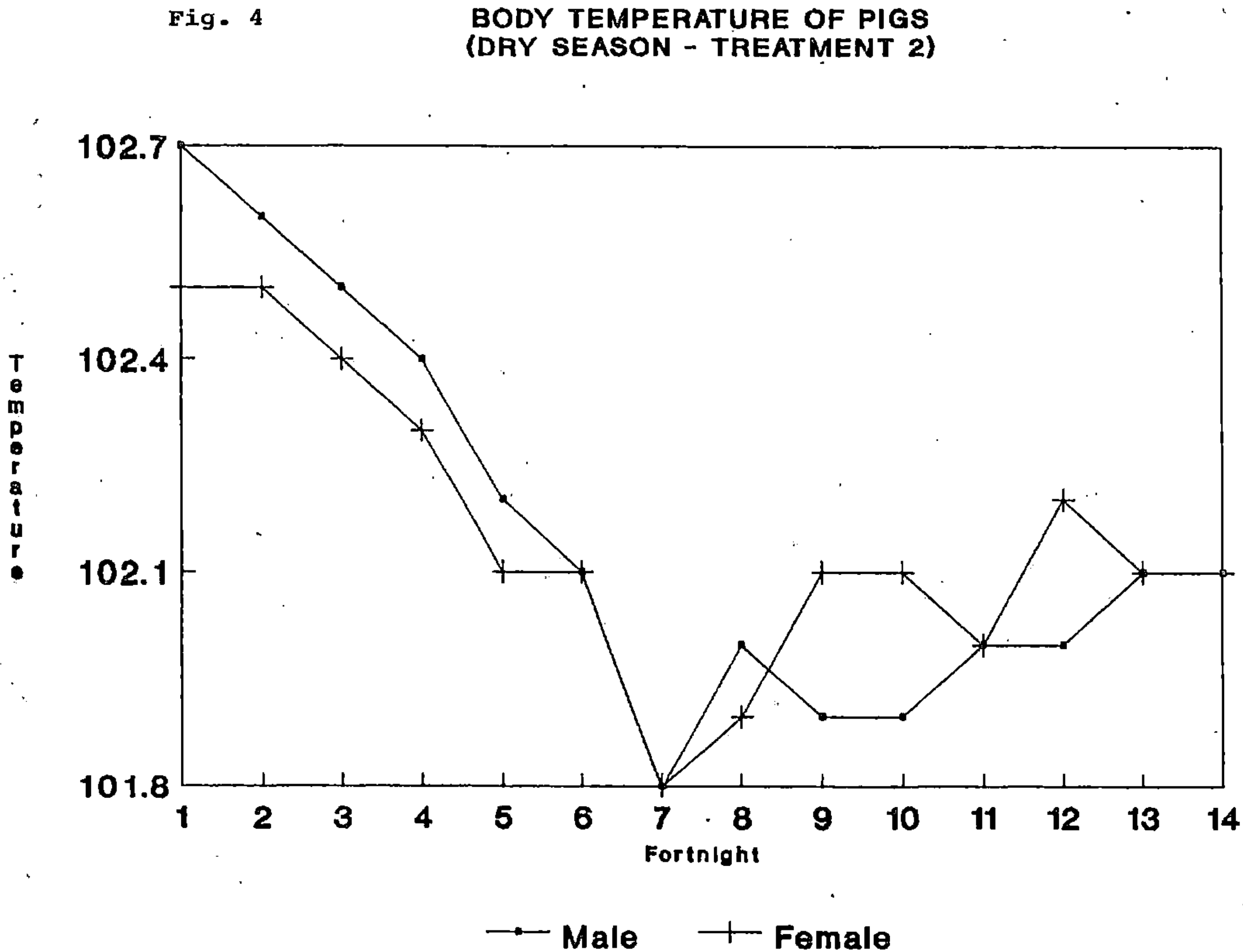

BODY TEMPERATURE OF PIGS
(DRY SEASON - TREATMENT 2)
Temperature
102.7
102.4
102.1
101.8
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Fortnight
Male
Female

Fig. 5

BODY TEMPERATURE OF PIGS
(RAINY SEASON - TREATMENT 1 & 2)

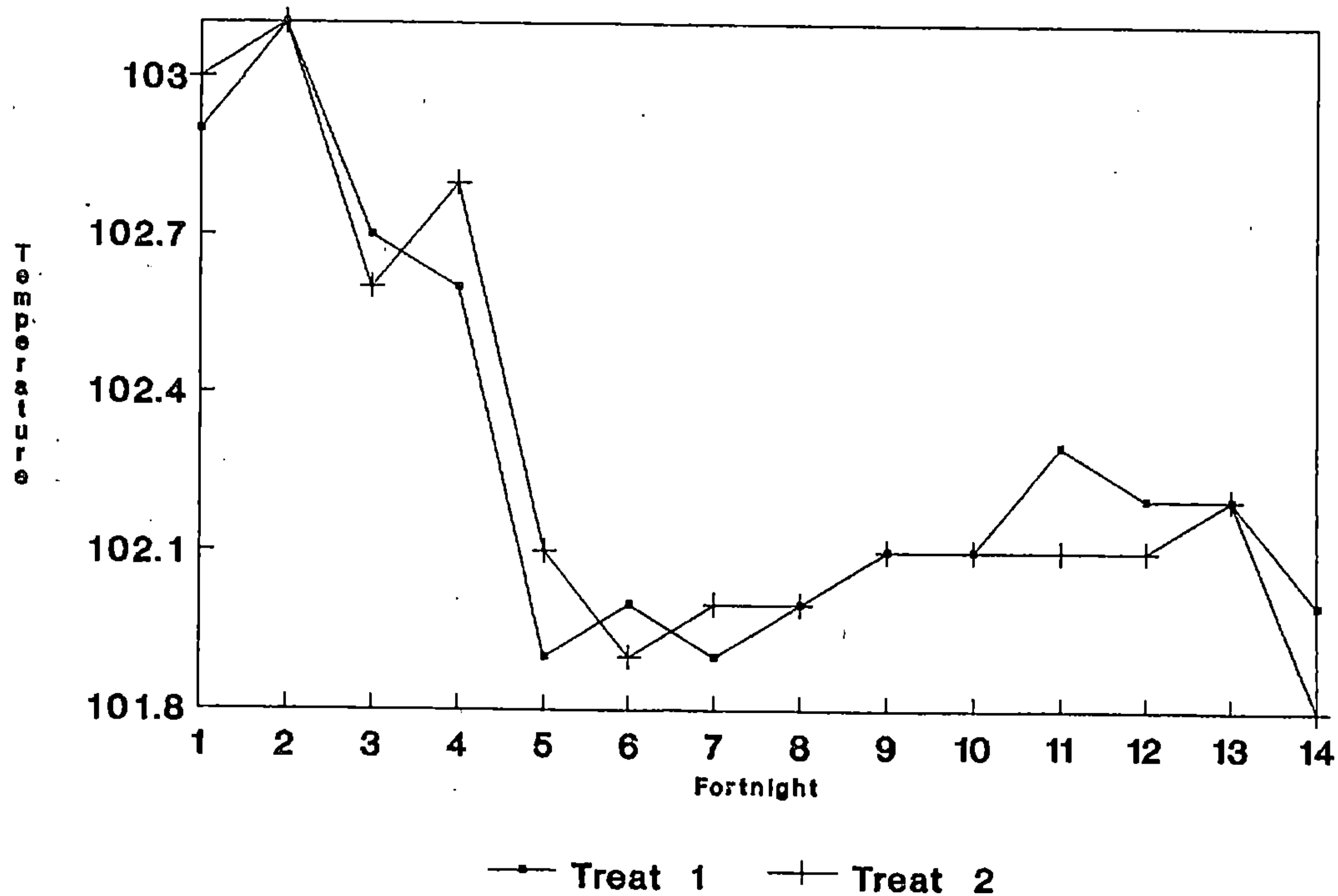


Fig. 6

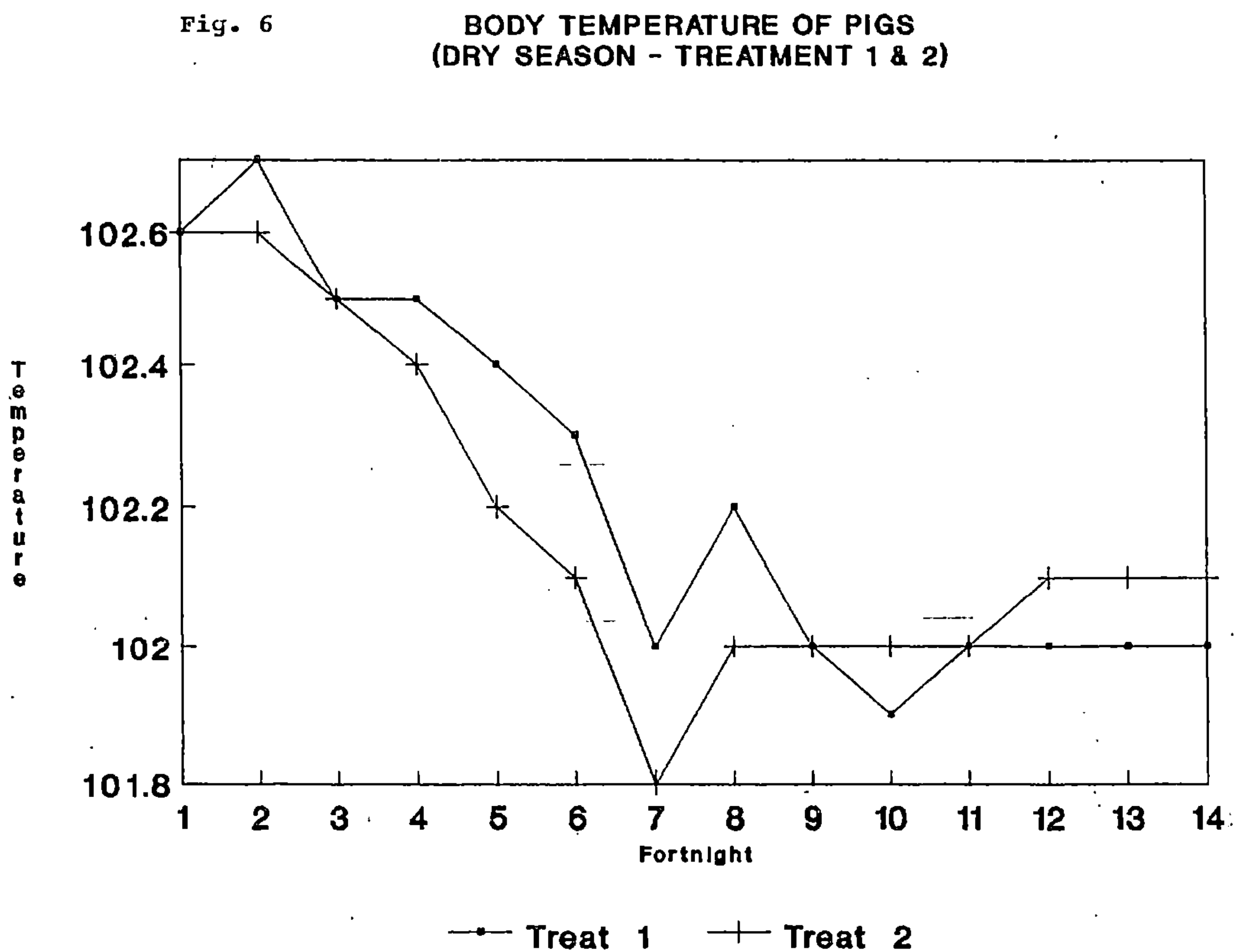
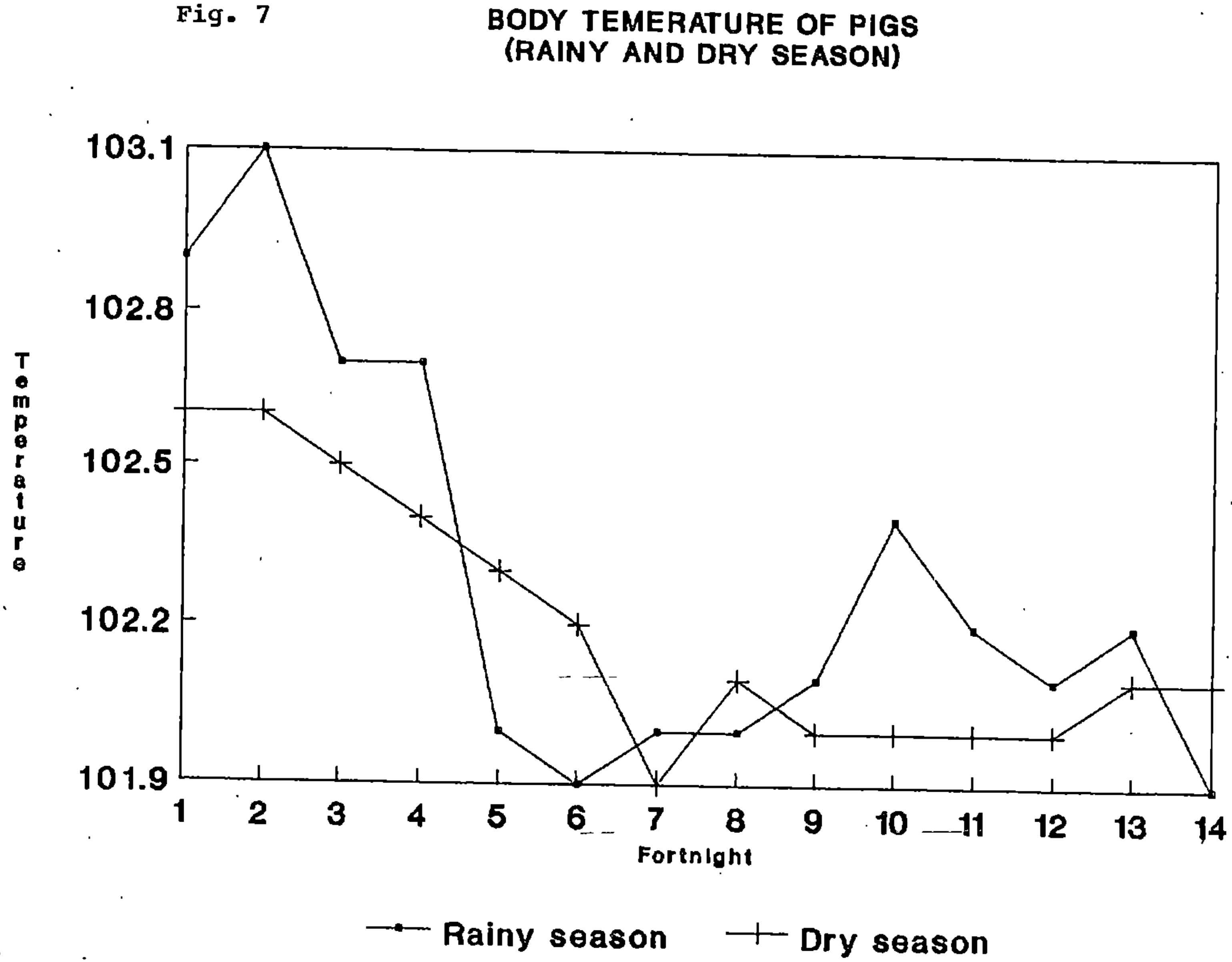

BODY TEMPERATURE OF PIGS
(DRY SEASON - TREATMENT 1 & 2)
Temperature
102.6
102.4
102.2
102
101.8
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Fortnight
Treat 1
Treat 2

Fig. 7



BODY TEMERATURE OF PIGS
(RAINY AND DRY SEASON)
103.1
102.8
102.5
102.2
101.9
Temperature
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Fortnight
Rainy season
Dry season

Fig. 8

RESPIRATORY RATE OF PIGS
(RAINY SEASON - TREATMENT 1)

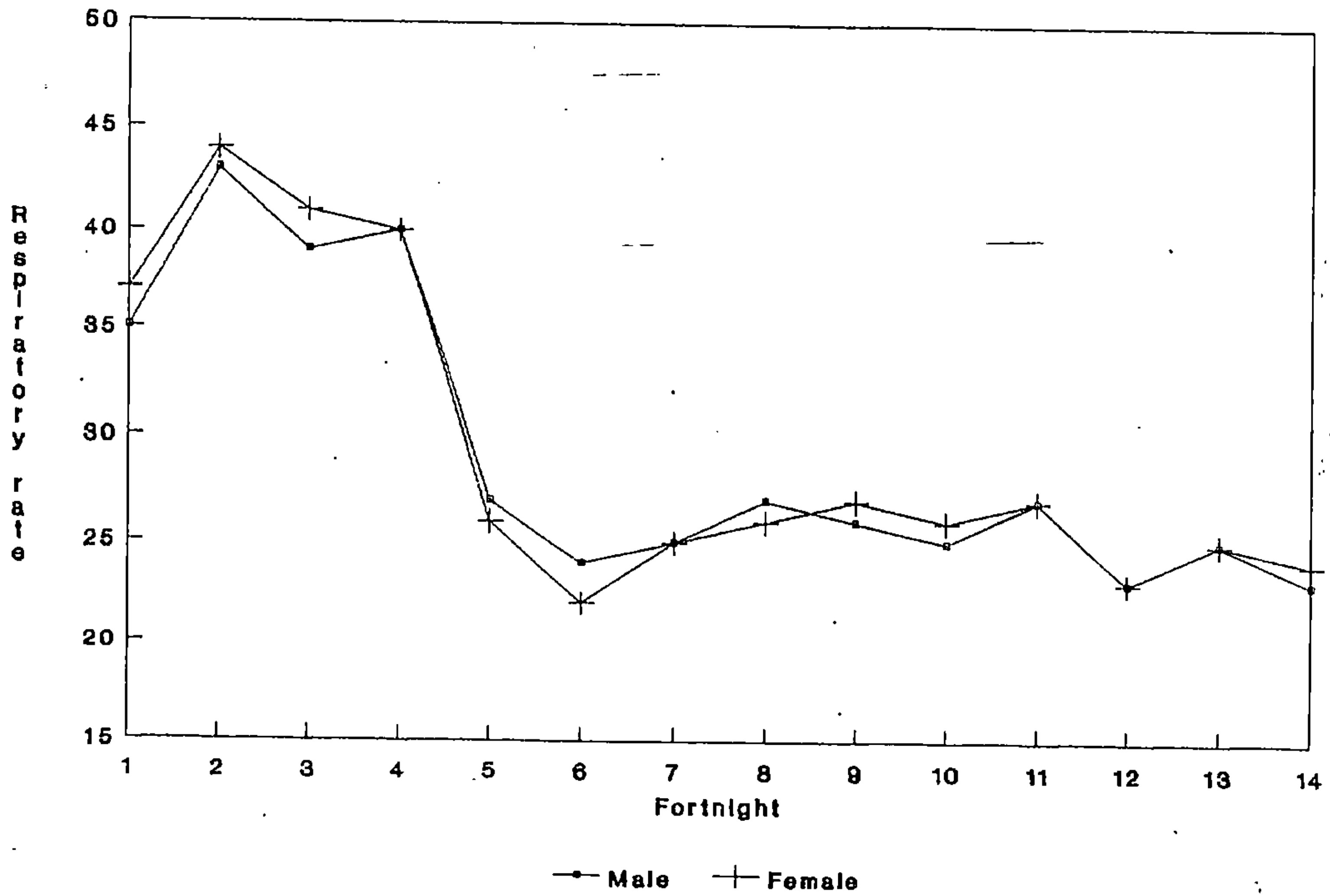


Fig. 9

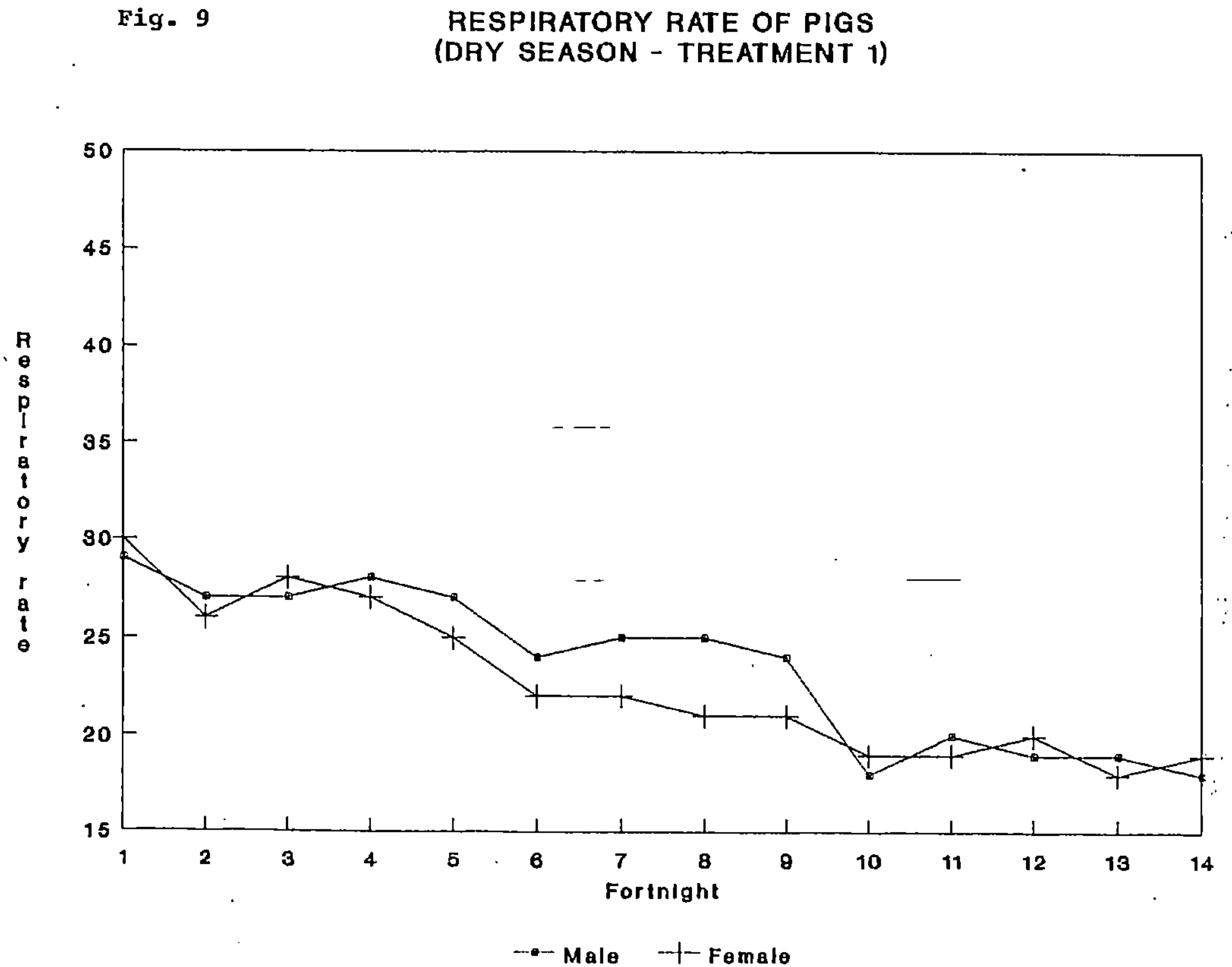
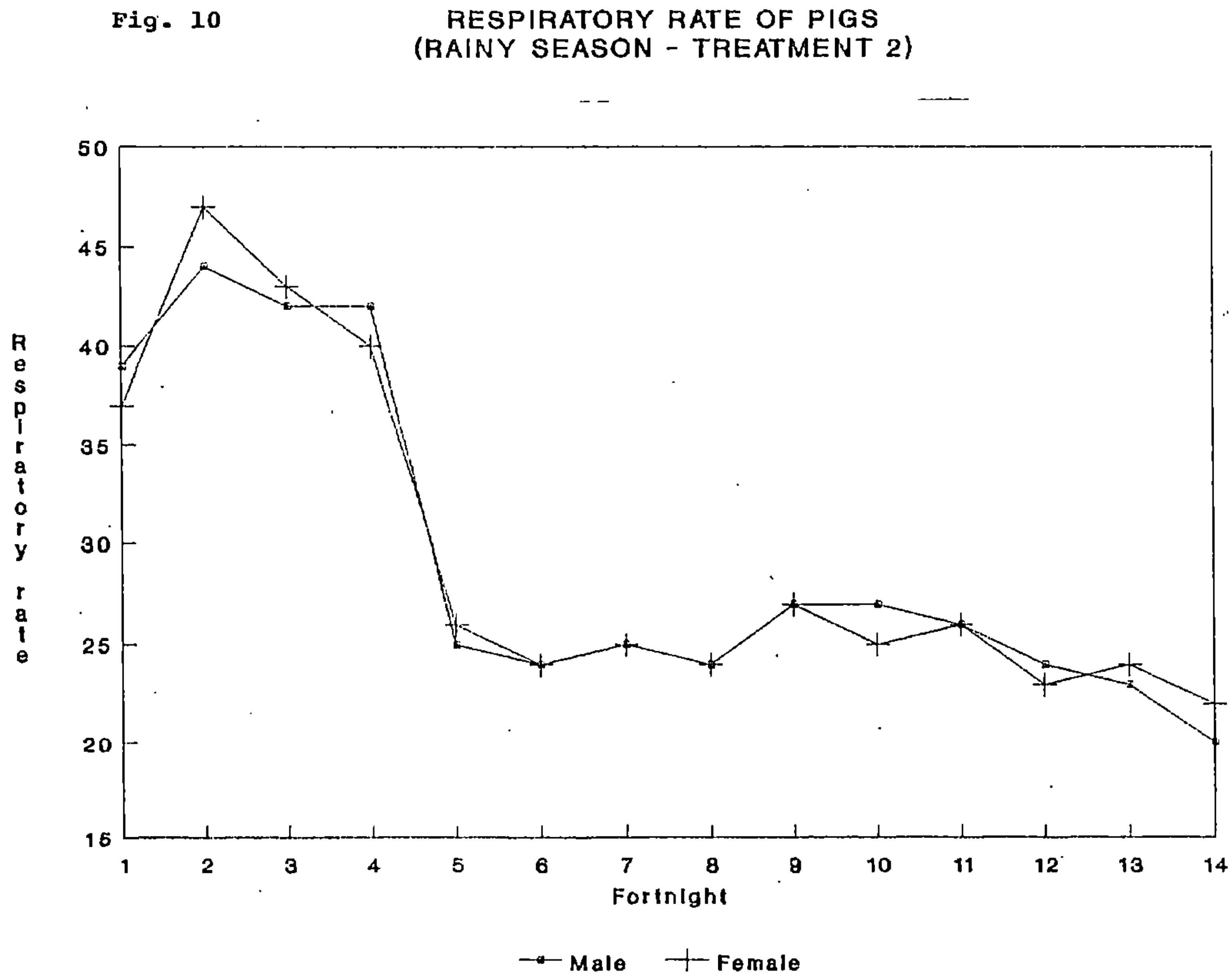

RESPIRATORY RATE OF PIGS
(DRY SEASON - TREATMENT 1)
Respiratory rate
50
45
40
35
30
25
20
15
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Fortnight
Male
Female

Fig. 10



RESPIRATORY RATE OF PIGS
(RAINY SEASON - TREATMENT 2)
Respiratory rate
50
45
40
35
30
25
20
15
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Fortnight
Male
Female

Fig. 11

RESPIRATORY RATE OF PIGS
(DRY SEASON - TREATEMENT 2)

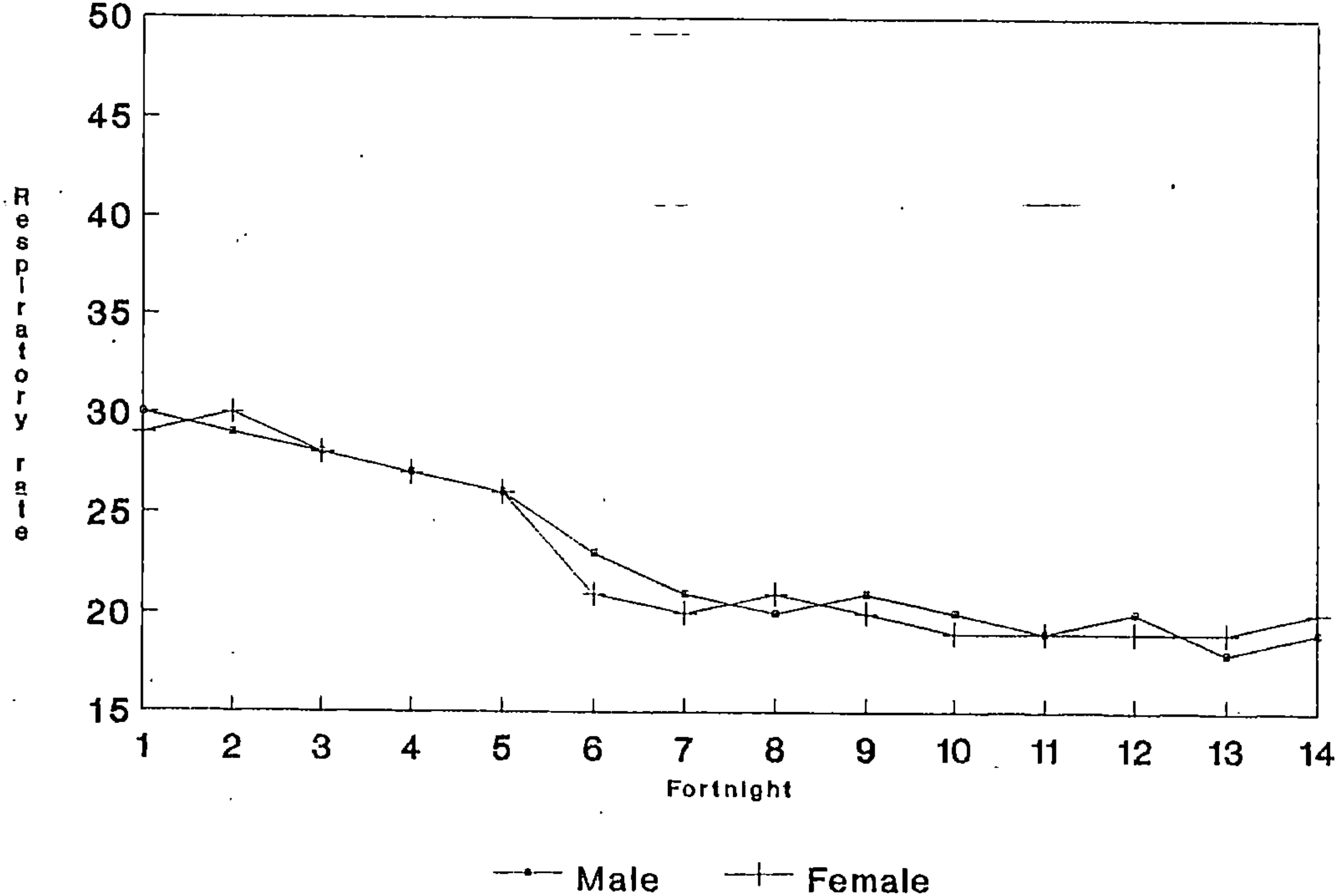


Fig. 12

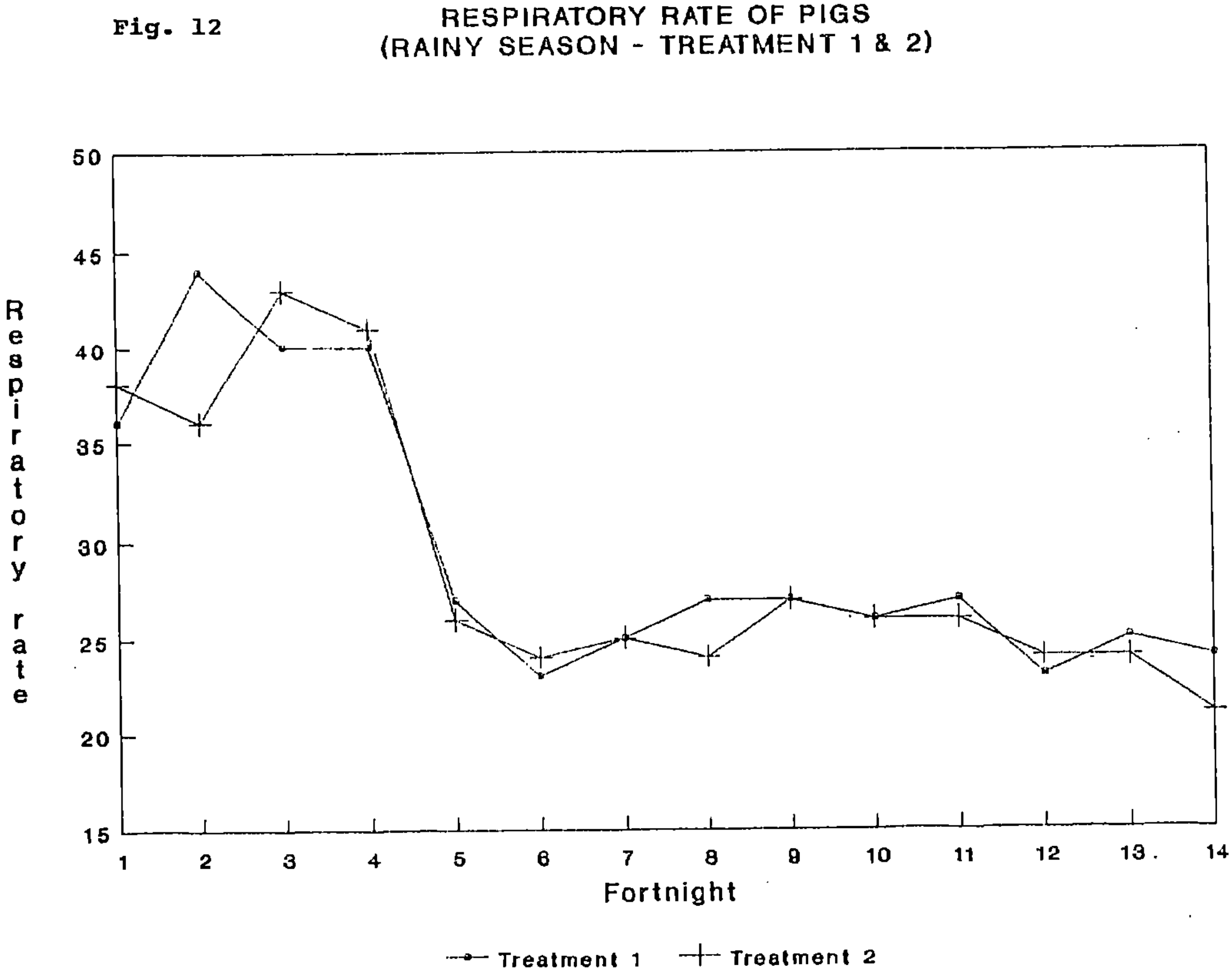

RESPIRATORY RATE OF PIGS
(RAINY SEASON - TREATMENT 1 & 2)
50
45
40
35
30
25
20
15
Respiratory rate
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Fortnight
Treatment 1
Treatment 2

Fig. 13

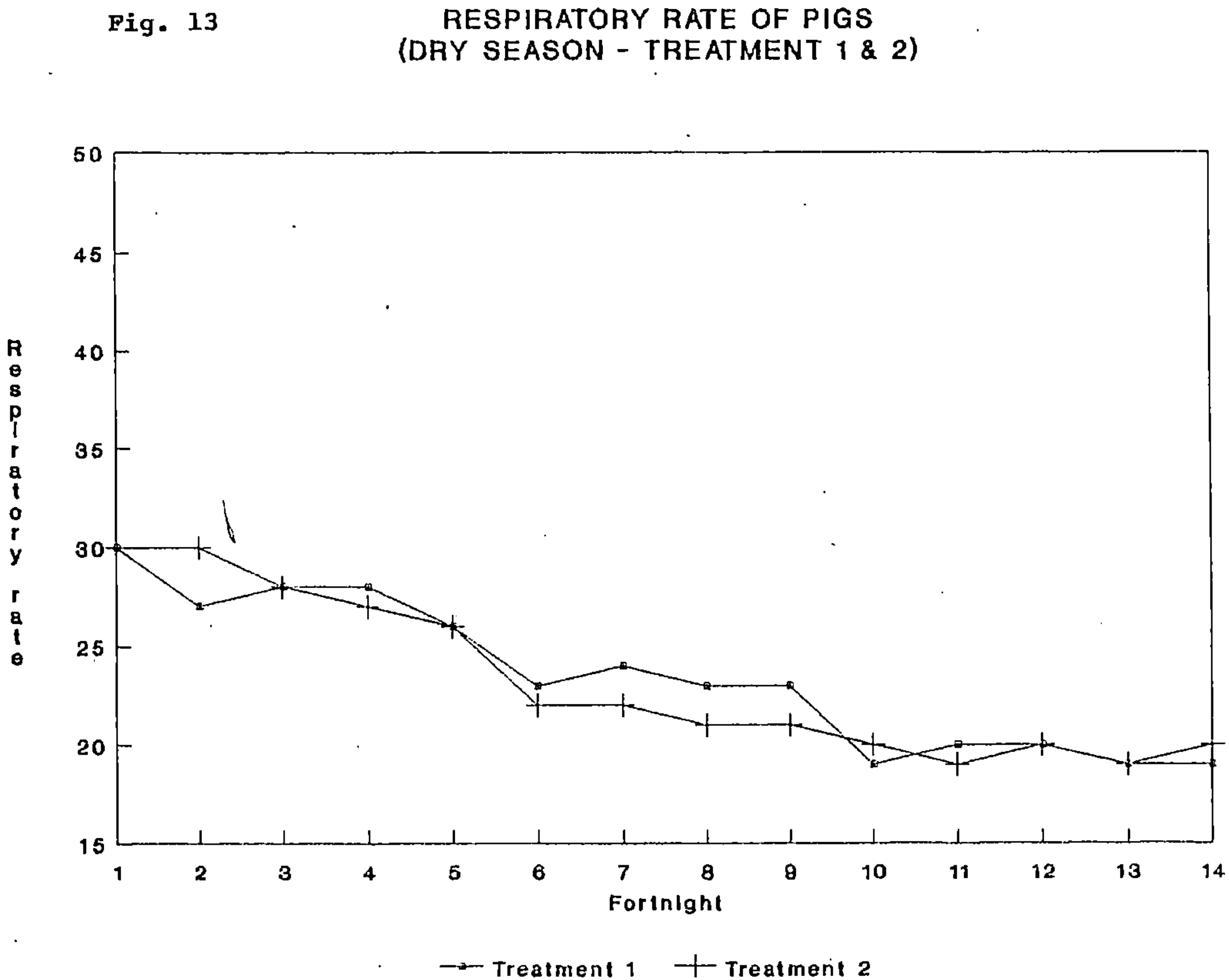

RESPIRATORY RATE OF PIGS
(DRY SEASON - TREATMENT 1 & 2)
Respiratory rate
50
45
40
35
30
25
20
15
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Fortnight
Treatment 1
Treatment 2

Fig. 14

RESPIRATRY RATE OF PIGS
(RAINY & DRY SEASONS)

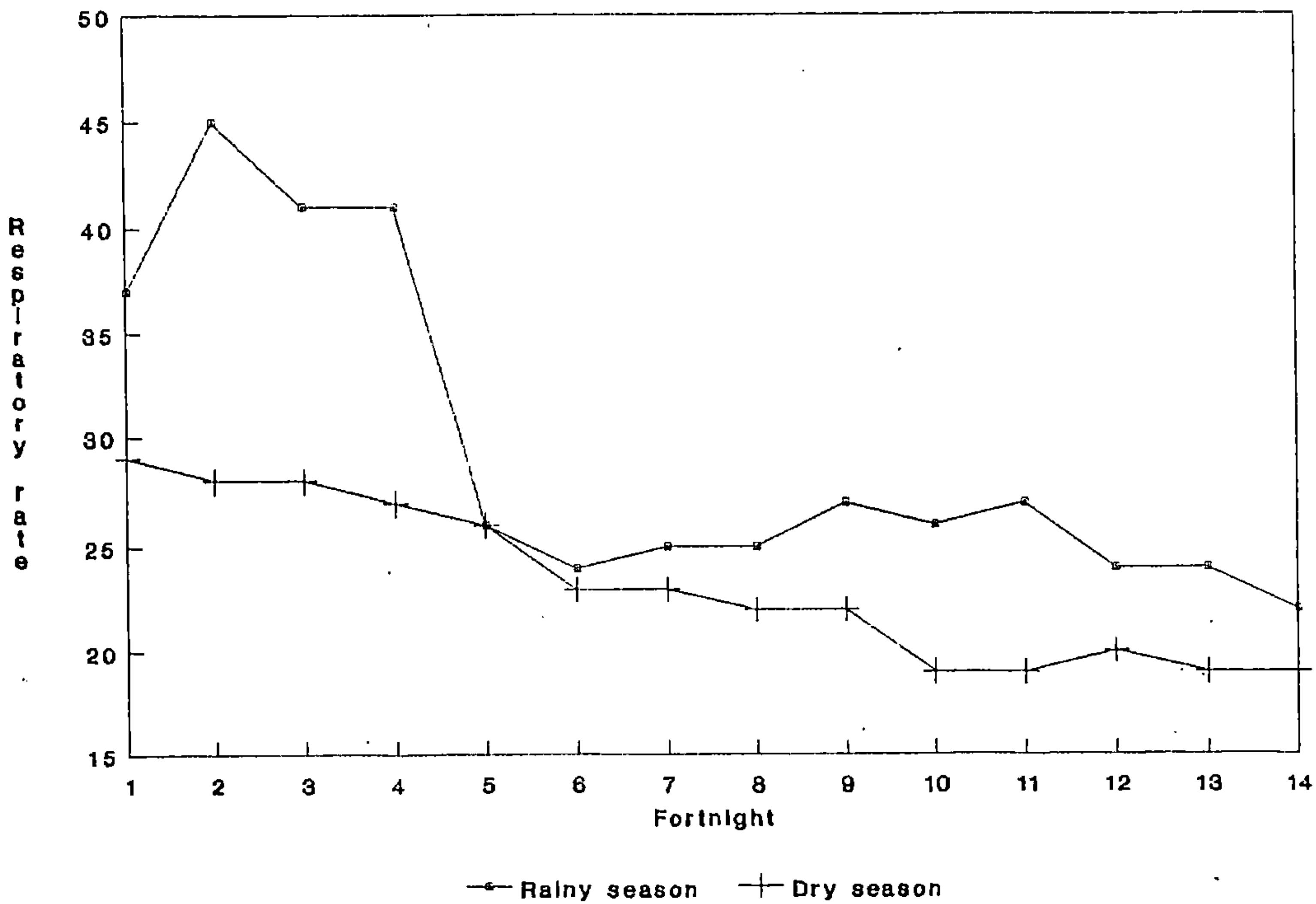


Fig. 15

PULSE RATE OF PIGS
(RAINY SEASON - TREATMENT 1)

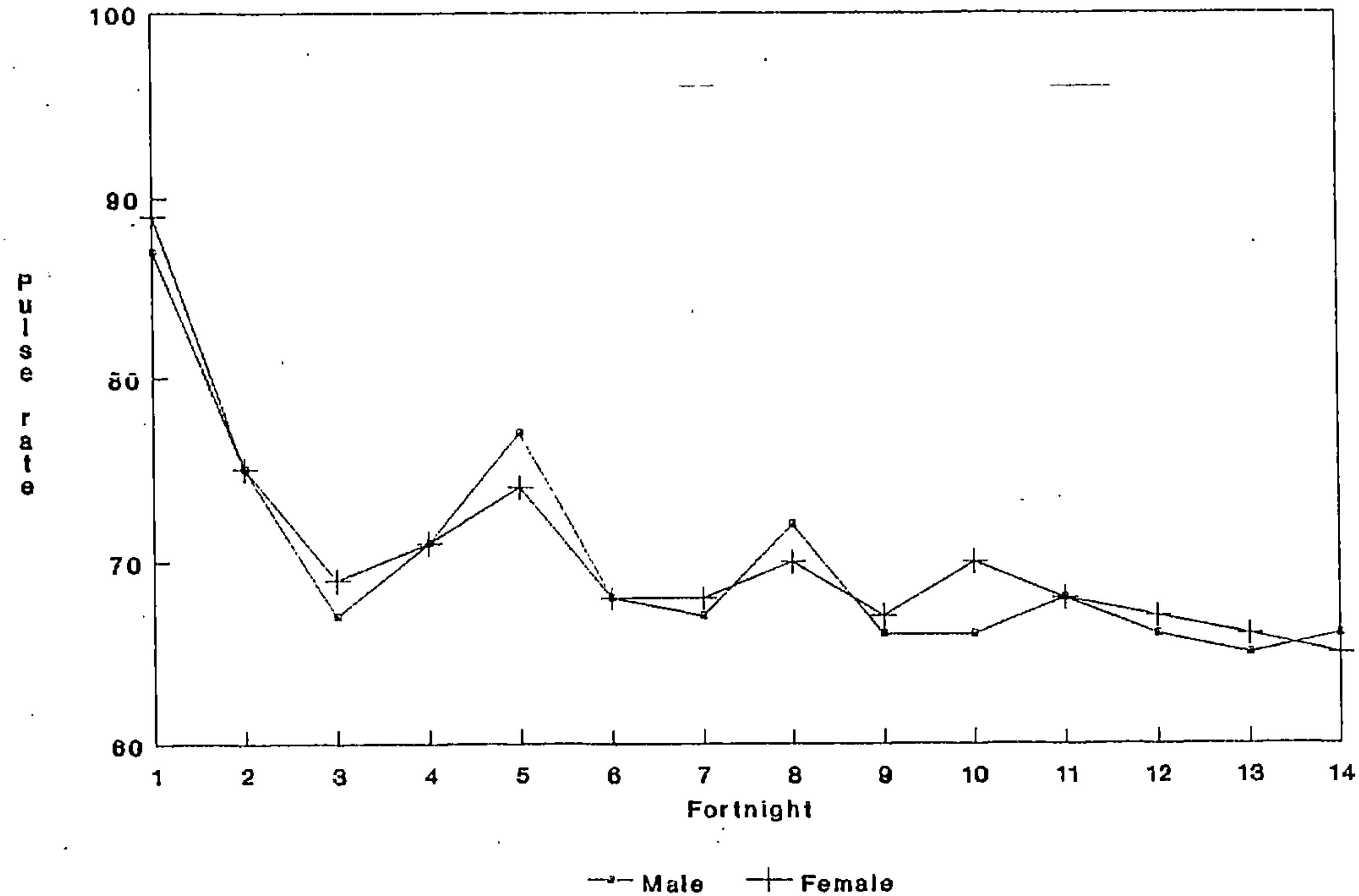


Fig. 16

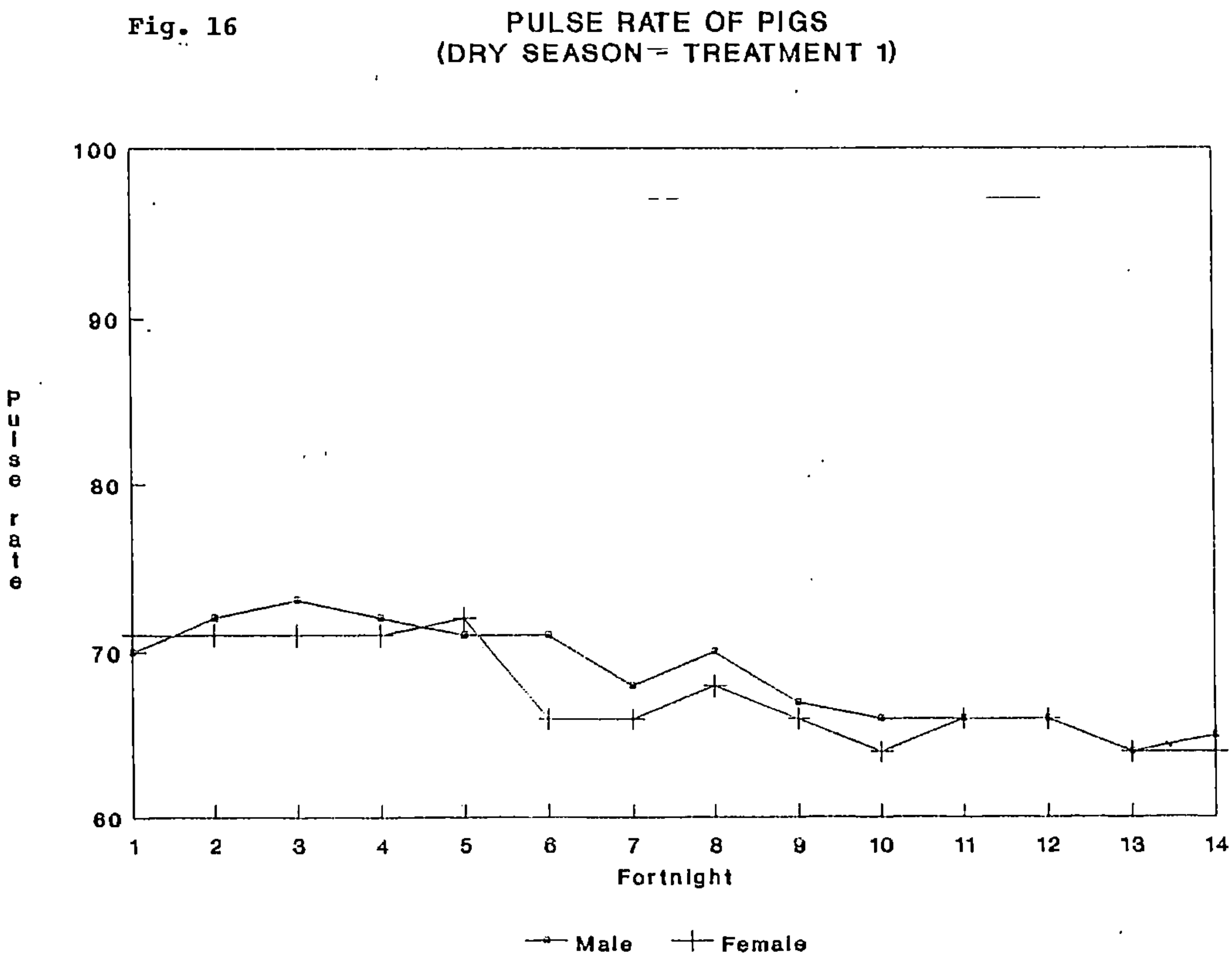

PULSE RATE OF PIGS
(DRY SEASON – TREATMENT 1)
Pulse rate
100
90
80
70
60
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Fortnight
Male
Female

Fig. 17

PULSE RATE OF PIGS
(RAINY SEASON - TREATMENT 2)

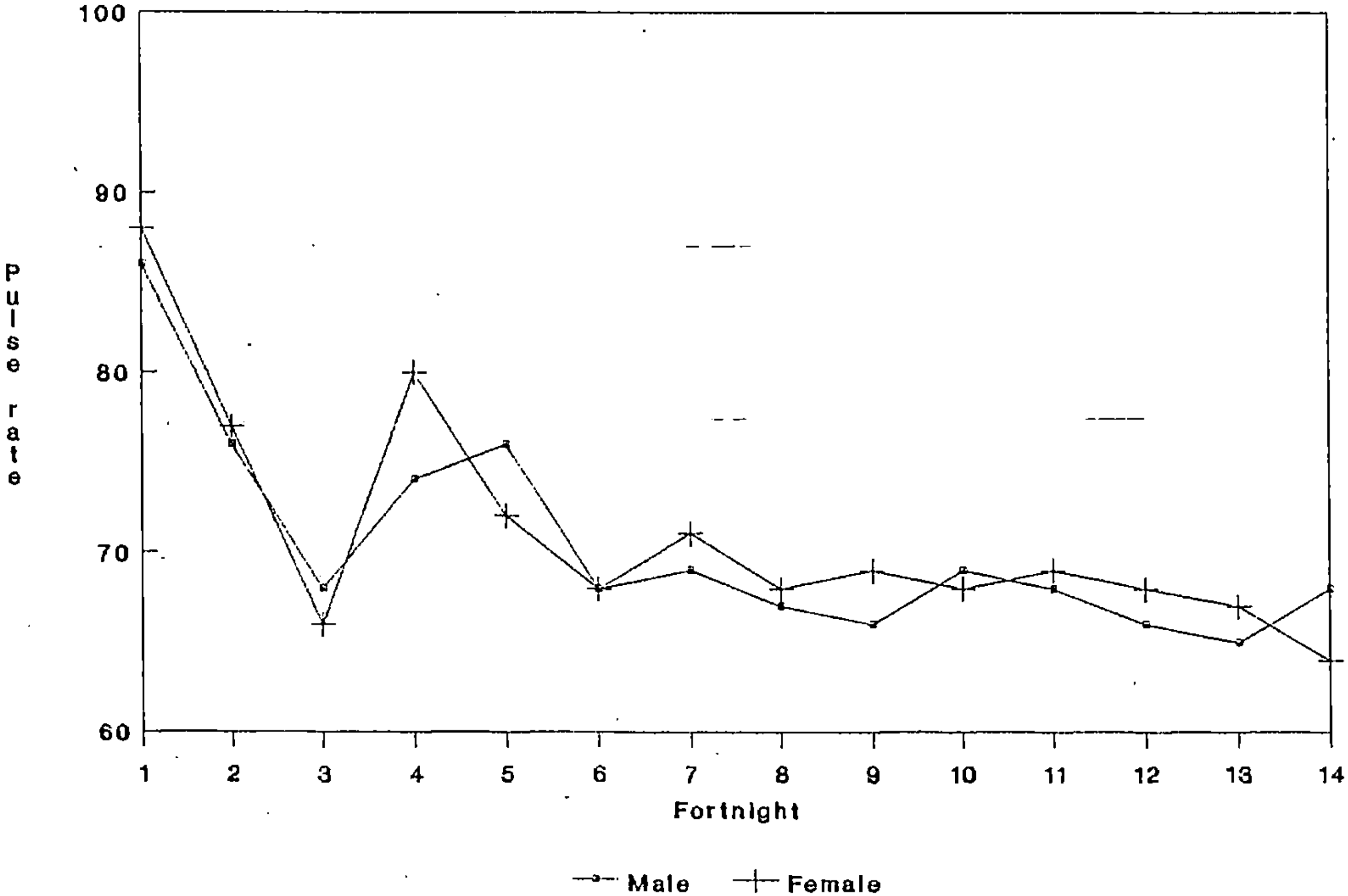


Fig. 18

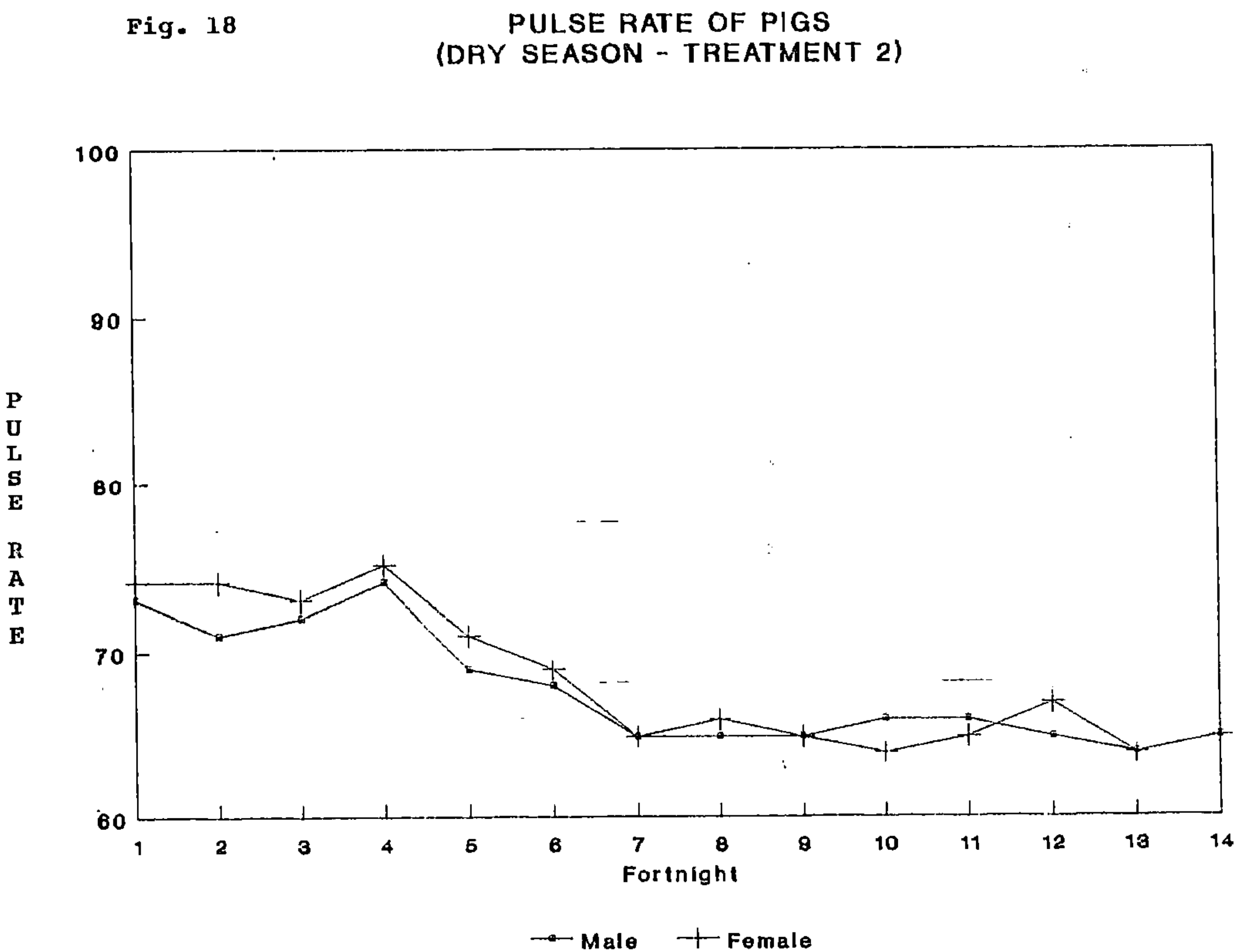

PULSE RATE OF PIGS
(DRY SEASON - TREATMENT 2)
100
90
80
70
60
PULSE RATE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Fortnight
Male
Female

Fig. 19 PULSE RATE OF PIGS
(RAINY SEASON - TREATMENT 1&2)

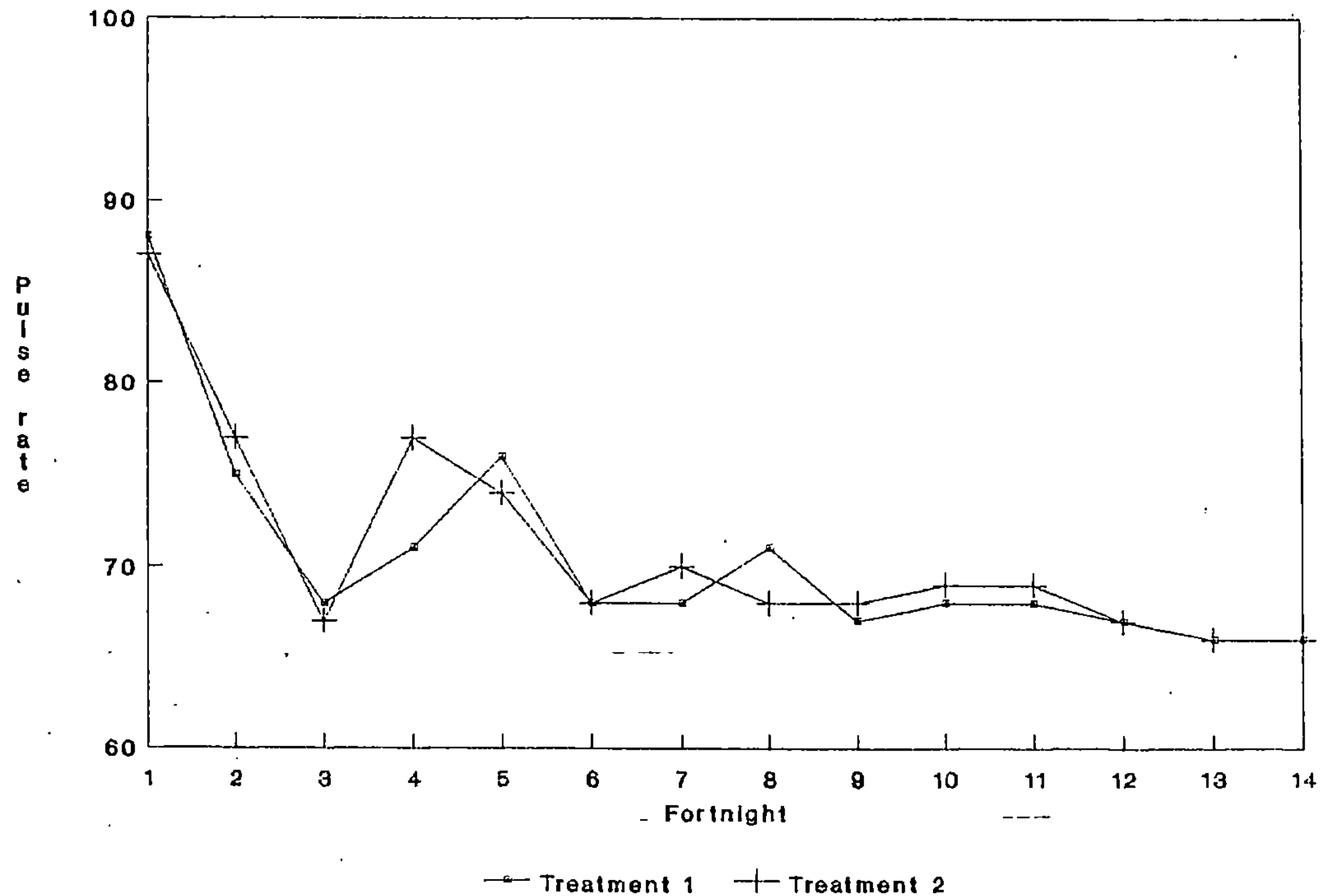


Fig. 20

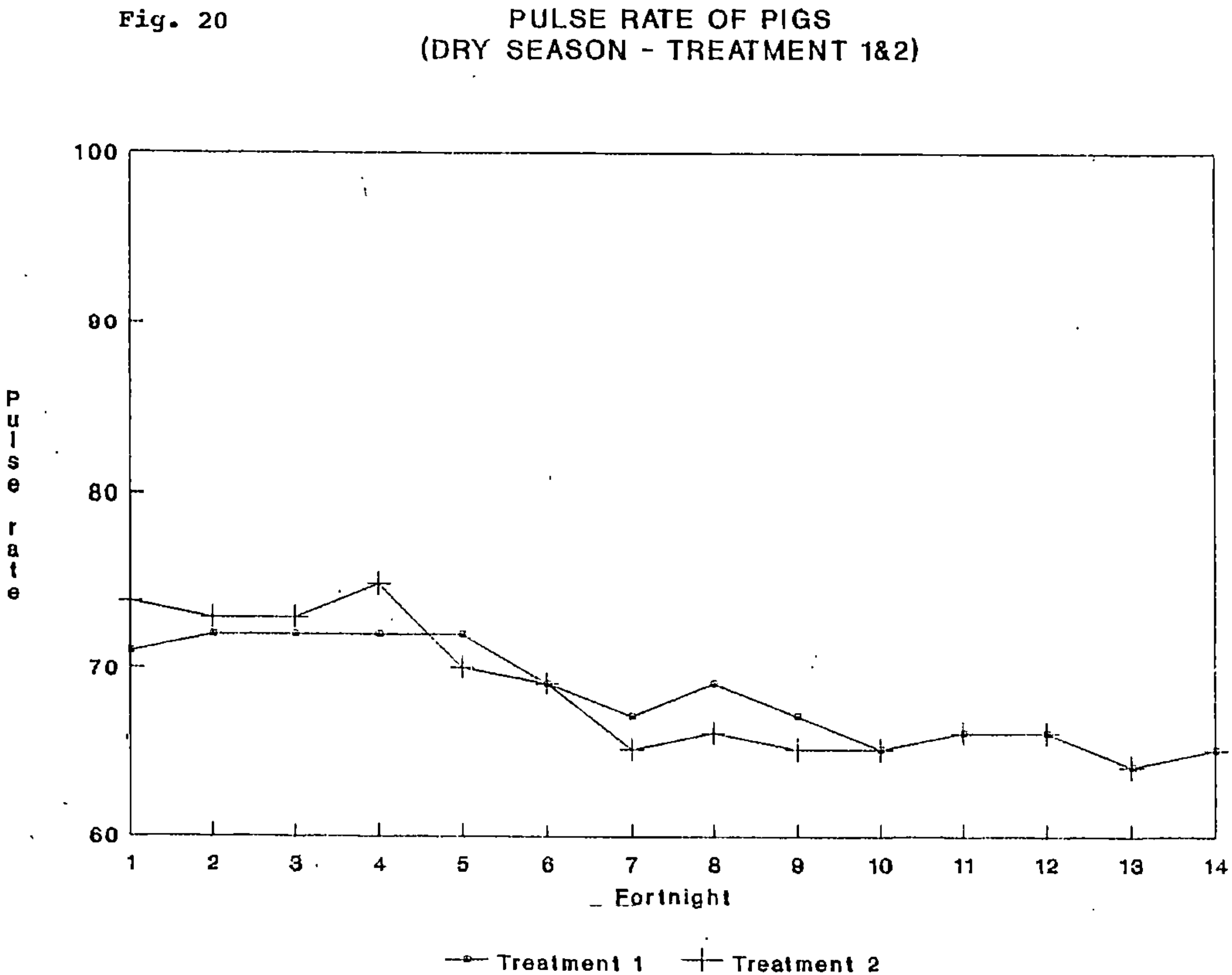

PULSE RATE OF PIGS
(DRY SEASON - TREATMENT 1&2)
100
90
80
70
60
Pulse rate
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Fortnight
Treatment 1
Treatment 2

Fig.21

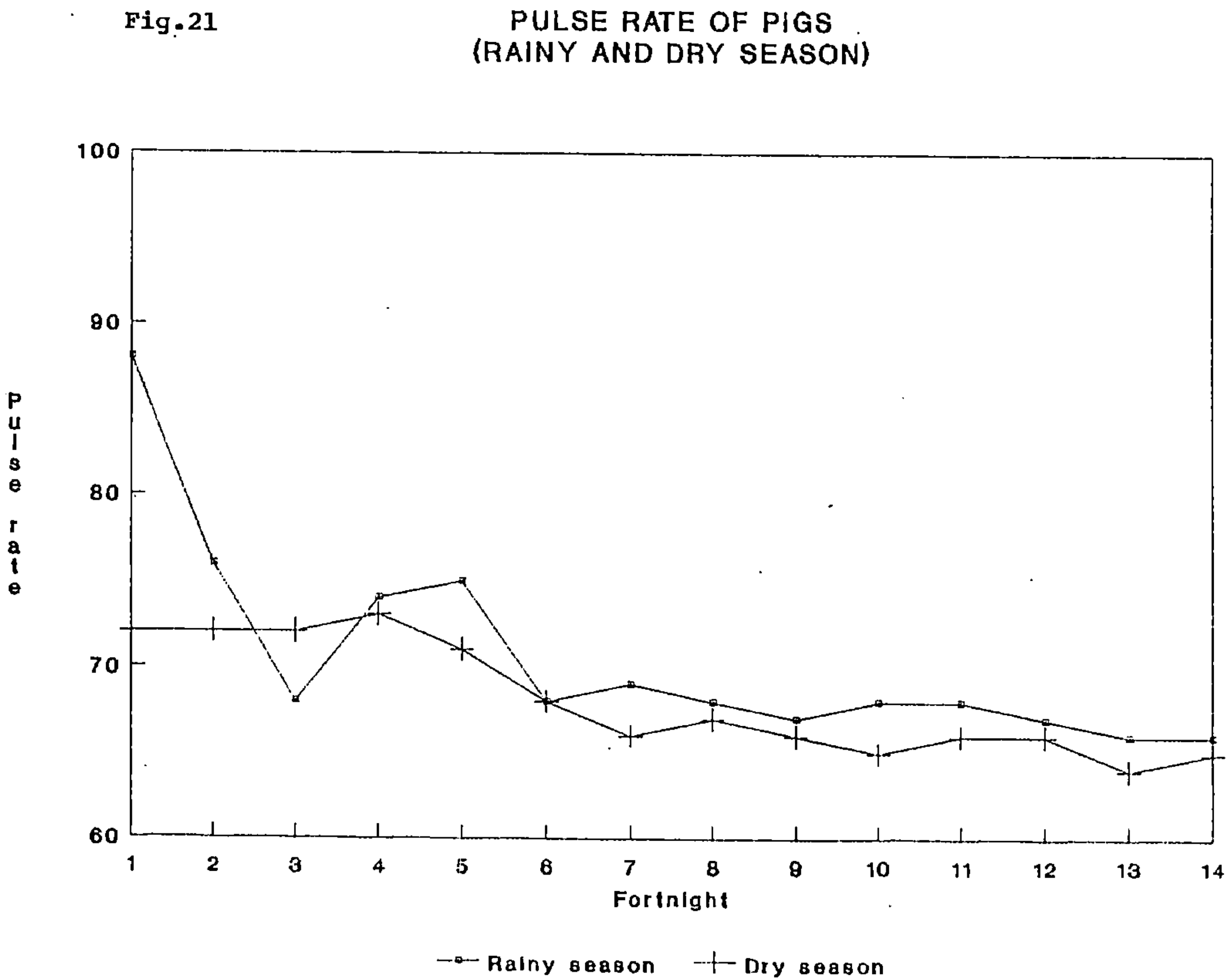

PULSE RATE OF PIGS
(RAINY AND DRY SEASON)
100
90
80
70
60
Pulse rate
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Fortnight
Rainy season
Dry season

Table 23. Fortnightly Body temperature (°F).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
SEASON I														
Treatment I														
M	102.8	103.1	102.7	102.7	101.9	102.0	101.9	102.1	102.1	102.1	102.2	102.2	102.2	101.9
F	102.9	103.1	102.7	102.5	101.8	101.9	101.9	101.9	102.1	102.1	102.4	102.1	102.2	102.0
Mean	102.9	103.1	102.7	102.6	101.9	102.0	101.9	102.0	102.1	102.1	102.3	102.2	102.2	102.0
Treatment II														
M	103.0	103.0	102.6	102.9	102.0	101.7	102.0	102.3	101.9	102.3	102.2	102.2	102.1	101.5
F	103.0	103.2	102.6	102.6	102.1	102.1	102.0	101.7	102.3	101.9	102.0	102.0	102.2	102.0
Mean	103.0	103.1	102.6	102.8	102.1	101.9	102.0	102.0	102.1	102.1	102.1	102.1	102.2	101.8
SEASON II														
Treatment I														
M	102.5	102.5	102.5	102.4	102.4	102.3	102.0	102.2	102.0	102.0	102.0	102.0	102.0	102.0
F	102.6	102.9	102.5	102.5	102.4	102.3	102.0	102.2	102.0	101.8	102.0	101.9	102.0	102.0
Mean	102.6	102.7	102.5	102.5	102.4	102.3	102.0	102.2	102.0	101.9	102.0	102.0	102.0	102.0
Treatment II														
M	102.7	102.6	102.5	102.4	102.2	102.1	101.8	102.0	101.9	101.9	102.0	102.0	102.1	102.1
F	102.5	102.5	102.4	102.3	102.1	102.1	101.8	101.9	102.1	102.1	102.0	102.2	102.1	102.1
Mean	102.6	102.6	102.5	102.4	102.2	102.1	101.8	102.0	102.0	102.0	102.0	102.1	102.1	102.1
Overall mean	102.6	102.6	102.5	102.4	102.3	102.2	101.9	102.1	102.0	102.0	102.0	102.0	102.1	102.1

Table 24. Fortnightly respiratory rate.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
							SEASON I							
Treatment I														
M	35	43	39	40	27	24	25	27	26	25	27	23	25	23
F	37	44	41	40	26	22	25	26	27	26	27	23	25	24
Mean	36	44	40	40	27	23	25	27	27	26	27	23	25	24
Treatment II														
M	39	44	42	42	25	24	25	24	27	27	26	24	23	20
F	37	47	43	40	26	24	25	24	27	25	26	23	24	22
Mean	38	46	43	41	26	24	25	24	27	26	26	24	24	21
							SEASON II							
Treatment I														
M	29	27	27	28	27	24	25	25	24	18	20	19	19	18
F	30	26	28	27	25	22	22	21	21	19	19	20	18	19
Mean	30	27	28	28	26	23	24	23	23	19	20	20	19	19
Treatment II														
M	30	29	28	27	26	23	21	20	21	20	19	20	18	19
F	29	30	28	27	26	21	20	21	20	19	19	19	19	20
Mean	30	30	28	27	26	22	22	21	21	20	19	20	19	20
Overall mean	29	28	28	27	26	23	23	22	22	19	19	20	19	19

Table 25. Fortnightly pulse rate.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
							SEASON I							
Treatment I														
M	87	75	67	71	77	68	67	72	66	66	68	66	65	66
F	89	75	69	71	74	68	68	70	67	70	68	67	66	65
Mean	88	75	68	71	76	68	68	71	67	68	68	67	66	66
Treatment II														
M	86	76	68	74	76	68	69	67	66	69	68	66	65	68
F	88	77	66	80	72	68	71	68	69	68	69	68	67	64
Mean	87	77	67	77	74	68	70	68	68	69	69	67	66	66
							SEASON II							
Treatment I														
M	70	72	73	72	71	71	68	70	67	66	66	66	64	65
F	71	71	71	71	72	66	66	68	66	64	66	66	64	64
Mean	71	72	72	72	72	69	67	69	67	65	66	66	64	65
Treatment II														
M	73	71	72	74	69	68	65	65	65	66	66	65	64	65
F	74	74	73	75	71	69	65	66	65	64	65	67	64	65
Mean	74	73	73	75	70	69	65	66	65	65	66	66	64	65
Overall mean	72	72	72	73	71	68	66	67	66	65	66	66	64	65

Discussion

DISCUSSION

1. Rate of growth

Fortnightly rate of growth of NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females were found to be 4.39±0.64, 4.55±0.68, 4.05±0.53 and 4.27±0.42 kg respectively in season I. In season II, a fortnightly rate of growth of 5.33±0.46, 6.63±0.63, 5.06±0.55 and 5.31±0.48 kg were observed in NRC males, NRC females, 15 per cent less than NRC males and 15 per cent NRC females respectively. In general NRC animals of season I and season II showed a better growth rate (4.47±0.66 kg and 5.88±0.36 kg) than the animals of 15 per cent less than NRC in season I and season II (4.22±0.48 kg and 5.19±0.37 kg). This finding is in agreement with reports by Stahly _et al_. (1979) who had observed that inclusion of dietary fat increased metabolisable energy intake and improved growth rate and efficiency of energy utilization in pigs; Holmes _et al_. (1977) and Campbell (1988) reported that reduced feed or energy intake results in dipressed growth rate.

Seasonwise, when observed, the animals of season I recorded a lower rate of growth (4.34±0.28 kg) than the animals of season II (5.52±0.27 kg).

The differences observed when sexwise were found to be non-significant statistically in all seasons except between NRC females of season II and NRC females of season I and also between NRC females of season II and 15 per cent less than NRC males of season II, where significant difference could be observed.

2. Daily gain

The daily gain observed in NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females of season I were 333 g, 357 g, 312 g and 325 g respectively. In season II average daily gain observed in the same groups were 478 g, 489 g, 450 g and 440 g respectively. The NRC animals of season I and season II had recorded a better daily gain (345 g and 483 g respectively) than the 15 per cent less than NRC animals of season I and season II (318.5 g and 444 g respectively). The values obtained are in agreement with Waterman et al. (1973) who had reported that pigs fed low levels of supplemental fat in their ration gained faster and required less amount of metabolisable energy per unit gain.

The average gain when viewed seasonwise was found to be more in season II (464.25 g) than in season I (332.25 g).

The differences in daily gain when statistically examined between the sex were found to be significant only between season II NRC males and season I NRC males, 15 per cent less than NRC males season II and season I 15 per cent less than NRC males and also between season II 15 per cent less than NRC females and season I 15 per cent less than NRC females. In the remaining cases the differences observed in the daily gain were found to be non-significant.

The rate of growth and average daily gain had shown a similar trend in the experimental animals. Those animals born in season II had shown a better growth rate and average daily gain than those animals born in season I. Similarly the NRC animals of both the seasons were also found to observe a better rate of growth and average daily gain than 15 per cent less than NRC animals of season I and season II. This finding is in agreement with those of Greenley, Maede and Hanson (1964), Tomes and Neilson (1979), Han and Kim (1982), Bardoloi and Raina (1984), Rai and Desai (1987) and Chung and Park (1990).

The increased rate of growth and average daily gain observed in those animals born in season II may be due to the higher initial weight observed in this group of animals.

Those animals having higher initial weight attained the target weight earlier and has also shown better daily gain.

The low relative humidity and ambient temperature equal to the ideal critical temperature observed in season II during the early stages of growth of pigs and a low temperature and high humidity observed in the period of peak growth rate in those animals born in season II might have contributed a better environmental set up for better growth rate and rate of gain.

3. Rate of gain in body length

The average fortnightly gain in body length observed in NRC males, NRC females,15 per cent less than NRC males and 15 per cent less than NRC females born in season I were found to be 3.53$\pm$0.49 cms, 3.72$\pm$0.68 cm, 3.11$\pm$0.53 cm and 2.89$\pm$0.53 cm respectively. In the case of season II this was found to be 3.81$\pm$0.53, 4.28$\pm$0.62 cm, 3.03$\pm$0.39 cm and 3.04$\pm$0.36 cm respectively.

The animals belonging to NRC group of season I (3.65$\pm$0.41 cm) and season II (4.01$\pm$0.40 cm) were found to record a better gain in body length than the 15 per cent less than NRC group of season I (3.0±0.37) and 15 per cent less than NRC group of season II (3.04±0.25). When the animals were compared between seasons the animals born in season I were found to gain less in body length (3.32±0.37) than those born in season II (3.49±0.23 cm).

The fortnightly body length gain when compared sexwise were found to be non-significant. The trend in fortnightly gain in body length is also appeared to be similar to that of growth rate. Though statistically non-significant those animals born in season II appeared to show a better fortnightly gain in body length. Ideal environmental condition required for the growth during the early stages and peak period of growth might be a reason for the increase in the rate of body length gain observed in the animals born in season II.

4. Feed efficiency

The average feed efficiency of NRC males, NRC females,15 per cent less than NRC males and 15 per cent less than NRC females were 3.62±0.20, 3.60±0.25, 4.80±0.24 and 4.82±0.33 respectively in season I. In the case of those animals born in season II the respective figures were

3.68±0.33, 3.41±0.43, 4.53±0.41 and 4.52±0.46. The NRC animals of season I (3.61±0.15) and season II (3.50±0.26) recorded a better feed efficiency than the 15 per cent less than NRC group of season I (4.81±0.18) and 15 per cent less than NRC animals of season II (4.52±0.46).

The NRC females of seaon I (3.60±0.25) and season II (3.41±0.43) were showing the highest feed efficiency.

Seasonwise when observed the animals of season II had a better feed efficiency (4.06±0.21) than those born in season I (4.22±0.14).

The differences in feed efficiency when examined statistically was found to be significant in first and and highly significant from second to fifth fortnight between season indicating that season influences feed efficiency in the early stages of growth of pigs through its effect on the intake of energy under ideal atmospheric condition. This finding is in agreement with the reports by Heitman and Haughes (1949). Heitman *et al*. (1958) who had also observed that the energy requirement in humid tropics were lower than those in temperate zone. This finding is in agreement with the reports by Cole *et al*. (1969) Blair *et al*. (1969) and pay *et al.* (1973) who also observed significant increase in feed efficiency during the early growth period.

This may also be due to the higher initial weight of those animals in season II.

The non-significant effect of season from sixth fortnight onwards may be due to the fact that the animals had grown sufficiently enough and maintained a homeothermic mechanism to get out of the seasonal effect.

The significant effect noticed between treatments from sixth fortnight to eighth fortnight may be due to the effect of added fat in the NRC group and its effect on the rate of growth. This finding is in agreement with Fuller (1965), Moser (1977) and Keschall (1983) who also observed better feed efficiency on addition of fat.

5. Carcass characteristics

a. Live weight at slaughter

The mean fortnightly body weight in NRC males, NRC females,15 per cent less than NRC males and 15 per cent less than NRC females were found to be 88.0 kg, 88.0 kg, 90.0 kg and 90.0 kg respectively. In season II live weight at slaughter recorded 97.0 kg, 99.0 kg, 96.0 kg and 97.0 kg in NRC males, NRC females,15 per cent less than NRC males and 15 per cent less than NRC females respectively.

The average slaughter weight of pigs born in season I was 89.0 kg whereas the live weight of pigs born in season II was 97.3 kg. On analysis of variance of live weight of pigs at slaughter a highly significant difference between animals born in season I and season II was observed.

b). Dressed weight with head

The dressed weight of pigs with head of NRC males, NRC females,15 per cent less than NRC males and 15 per cent less than NRC females born in season I recorded 65.80 kg, 68.10 kg, 67.97 kg and 70.87 kg respectively.

The dressed weight of pigs born in season II were found to be 78.16 kg, 80.35 kg, 78.11 kg and 79.00 kg in NRC males, NRC females,15 per cent less than NRC males and 15 per cent less than NRC females respectively.

The average dressed weight with head of pigs born in season I was 68.85 kg. The same in those animals born in season II recorded an average of 78.91 kg. These differences when tested statistically was found to be highly significant between seasons where as it was non-significant between sex and treatment.

c. Dressed weight of pigs without head

In the NRC group of season I the males recorded 59.83 kg dressed weight without head and females recorded a weight of 62.63 kg. In the case of males and females of NRC group in season II the dressed weight without head was found to be 71.38 kg and 73.75 kg respectively.

In the 15 per cent less than NRC group of season I the males recorded a dressed weight without head of 62.00 kg and females 61.86 kg. Inseason II the males and females of 15 per cent less than NRC group show a dressed weight without head of 71.50 kg and 72.38 kg respectively.

The average dressed weight without head noted in pigs of season I was 61.58 kg against 72.38 kg for animals in season II.

d. Half carcass weight

NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females of season I recorded a half carcass weight of 29.92 kg, 31.31 kg, 31.00 kg and 32.50 kg respectively. The same in season II were found to be 35.69 kg, 36.94 kg, 35.75 kg and 36.44 kg respectively in NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females. The average half carcass weight recorded in pigs born in season I was found to be 31.18 kg against 36.21 kg in season II.

The differences in half carcass weight when tested were found to be highly significant between seasons and non-significant between sex and treatment.

The highly significant difference between seasons in live weight at slaughter may be attributed to the higher initial weight of animals. A low temperature and high humidity observed in the period of peak growth in those animals born in season II might have contributed a better environmental set up for the better growth rate and resultant higher body weight at slaughter.

The analysis of variance of deressed weight of pigs without head show a highly significant difference between seasons. The result was non-significant between sex and treatment. This finding is in agreement with the report of Cheong et al. (1982).

e. Dressing percentage with head

The dressing percentage with head observed in NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females of season I were 75.1, 77.0, 75.6 and 78.5 respectively.

In those pigs born in season II recorded a dressing percentage with head of 80.8, 81.3, 81.5 and 81.9 in NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females respectively. The overall dressing percentage in season I was found to be 75.6 per cent against 81.4 per cent in season II.

The dressing percentage when statistically analysed was found to be highly significant between seasons and non-significant between treatment and sex. Higher dressing percentage can be attributed to higher weight at slaughter.

This is in agreement with the observation of Smith *et al.* (1957); Zobrisky (1959) and Emmerson *et al.* (1964) who had reported an increase in dressing percentage with live weight increase in pigs.

f. Dressing percentage without head

The average values obtained for dressing percentage without head in NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females of season I were 68.3, 71.3, 69.1 and 72.1 respectively.

In the case of season II NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females recorded a dressing percentage without head of 75.3, 74.4, 74.6 and 75.5 respectively.

The overall derssing percentage without head of pigs born in season I was 70.1 against 74.05 in pigs of season II.

The differences noted in dressing percentage when statistically analysed were found non-significant in all parameters except between seasons where it was found to be highly significant. This is in agreement with the obbservations made by Narayan Rao et al. (1968) and Lavrentjeva et al. (1970). Bratzler (1953) concluded that dressing percentage is a major factor in conjunction with weight, length and backfat in determining the yields of perfect cuts. The significant dressing percentage obtained in those animals born in season II may be due to the better feed efficiency and better environmental conditions which has resulted in better weight at slaughter and therefore better dressing percentage.

g. Carcass length

Carcass length of NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females of season I were found to be 78.6 cm, 78.8 cm, 75 cm and 77 cm respectively. The respective carcass length of NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females were found to be 82.0 cm, 80.0 cm, 81.0 cm and 81.0 cm in animals born in season II.

The average carcass length of pigs born in different seasons when statistically tested were found to be non-significant between treatment and sex but the differences noted between the seasons were found to be highly significant.

The difference is mainly due to the higher feed efficiency and better environmental conditions which resulted in higher body weight at the time of slaughter.

This finding is in general agreement with those reported by Lovrentjeva et al. (1970) and Shuler et al. (1970).

h. Back fat thickness

Average back fat thickness of 2.5 cm, 3.0 cm, 3.0 cm and 2.7 cm were observed in NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females of season I respectively. In the case of NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females of pigs born in season II average back fat thickness recorded were 3.2 cm, 3.8 cm, 2.7 cm and 2.8 cm respectively.

An overall back fat thickness of 2.8 cm was noted in animals born in season I against 3.3 cm in season II. The back fat thickness in the females of NRC group in season I and season II were found to be better than the males of the same group.

The results when examined were found highly significant between seasons and season into treatment. The interaction between treatment and sex was also found to be significant whereas it was non-significant in all other groups.

The significant values observed in back fat thickness is in agreement with those reported by Blair et al. (1969), Shuler et al. (1970) and Kumar et al. (1974). The significant difference between season and treatment is in agreement with the findings of Channon et al. (1987) who reported that carcass fat content and carcass fat measurements increased with increased energy intake. Better feed efficiency and weight at slaughter observed in this study in those animals born in season II may be the reason of better back fat thickness observed in season II. The better back fat thickness in the females of NRC groups in both the seasons is also due to better energy intake and gains observed in these class of animals.

i. Eye muscle area

NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females of season I recorded an eye muscle area of 35.2 cm^2, 40.5 cm^2, 36.6 cm^2 and 34.3 cm^2 respectively. The same in pigs born in season II was observed to be 37.3 cm^2, 41.2 cm^2, 39.1 cm^2 and 41.9 cm^2 respectively in NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females.

An average of 36.6 cm^2 of eye muscle area was noted in pigs born in season I against 39.9 cm^2 in those pigs born in season II. The females of NRC group of both seasons were found to have higher eye muscle area than the males of the same group.

The eye muscle area noticed between treatments and between sex were found to be non-significant statistically. But the eye muscle area observed in pigs between seasons were found to be highly significant.

Increase in eye muscle area with increase in live weight has been reported by Shuler (1970), Bellis and Taylor (1961) and Kumar *et al*. (1974) positive correlation between eye muscle area and percentage of lean has been reported by several workers (Henry et al., 1963; Smith and Carpenter, 1973; Shonin, 1973 and Bochno and Rak, 1973). The increased eye muscle area noted in the females of NRC group and animals born in season II may be due to the better feed efficiency and gain observed in those class of animals. This has resulted increased weight at slaughter of these class of animals and better eye muscle area.

j. Weight of ham

Weight of ham of pigs of season I NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females were found to be 7.53 kg, 7.35 kg, 7.35 kg and 8.53 kg respectively. The same in season II were found to be 8.21 kg, 7.89 kg, 7.89 kg and 7.94 kg respectively for NRC males, NRC females, 15 per cent less than NRC males and 15 per cent less than NRC females.

An average of 7.72 kg was noticed in the weight of ham in season I and the same in season II was found to be 7.98 kg.

The weight of ham between season was found to be highly significant. Similarly the interaction of this parameter between season and treatment was also found to be highly significant.

The significant seasonal effect of the weight of ham may also be due to the increased weight of this class of animals at the time of slaughter due to better feed efficiency and gain noted in those animals born in season II.

k. Melting point, Iodine value, Saponification value

The melting point of fat of season I ranged between 39°C to 45°C with an average of 43°C. The range in season II was between 39°C to 44°C with an average of 42°C.

The range obtained in the melting point of fat of animals of both seasons were not found to be statistically significant. The average value obtained in this study is in agreement with that reported by Carton (1965). Season, sex or treatment were not found to influence the melting point of fat in pigs.

The average iodine value of 69 was noted in pigs of season I (ranges between 68-70). In season II this value ranged between 68-73 with an average of 71.

Similarly the saponification value of the fat of pigs belonging to season I ranged between190-195 with an average of 192. The same in season II ranged between 188-192 with an average 190. The iodine value and saponification value obtained between season, between sex and between treatments were not found to be significant.

The value obtained in the present study is in agreement with the results of Woodman (1941), Maynard (1969), Sebastian (1972), Ramachandran (1977) and Carton (1965) who also observed similar range in values of melting point, iodine value and saponification value.

Economics

The cost of the ration at NRC level for four energy levels were found to be Rs 5.40, 5.34, 5.14 and 4.93 respectively with a mean of Rs 5.20 per kg. Similarly the cost of feed per kg at 15 per cent less than NRC levels of energy were found to be Rs 4.86, 4.80, 4.77 and 4.71 respectively with an average of 4.79. The average feed efficiency of animals on NRC levels of feed in season I and II were found to be 3.62, 3.60, 3.68 and 3.41 against 4.80, 4.82, 4.53 and 4.52 for animals on 15 per cent less than NRC levels.

	SEASON I				SEASON II			
	NRC Cost 5.20		15% less NRC Cost 4.79		NRC Cost 5.20		15% less NRC Cost 4.79	
	Males	Females	Males	Females	Males	Females	Males	Females
Feed efficiency	3.62	3.60	4.80	4.82	3.68	3.41	4.53	4.58
Cost/kg pork	18.82	18.72	22.99	23.08	19.14	17.73	21.70	21.65

NRC overall mean = Rs 18.60

15% less than NRC overall mean = Rs 22.36

The cost of feed per kg gain in live weight of animals on NRC levels of energy were found to be Rs 18.82 and 18.72 for males and females in season I and Rs 19.14 and Rs 17.73 for males and females in season II. In the case of animals belonging to 15 per cent less than NRC group, the cost of feed per kg gain in live weight were found to be Rs 22.99 for males and Rs 23.08 for females in season I. In season II, the same was found to be Rs 21.70 and 21.65 respectively for males and females. Eventhough the cost of ration is high for NRC levels, the cost of production for 1 kg body weight was found to be 17 per cent less in NRC group than the 15 per cent less than NRC group (Rs 18.60 versus 22.36). Average time taken to attain target weight is also little longer for 15 per cent less than NRC group.

Summary

SUMMARY

An investigation was carried out with 32 weaned Large White Yorkshire pigs (16 males and 16 females) born in two seasons. Sixteen weaned piglets born in season I (8 males and 8 females) were divided into two groups of 4 males and 4 females each. Group one was fed with a ration specified by NRC and group two with a ration containing 15 per cent less energy than NRC recommendation. Similarly 16 weaned piglets born in season II were taken. They were grouped and fed similar to that in season I. The animals were fed _ad libitum_ and housed individually till they attained a target body weight of 90 kg and slaughtered for studies of carcass characteristics.

The experiment was aimed to assess growth rate, gain in body weight and body length, feed efficiency and carcass characteristics. The rectal temperature, pulse rate and respiratory rate were recorded weekly in the morning and evening.

The animals on NRC level of energy attained the target weight in 15.8 fortnights whereas the animals on 15 per cent less than NRC attained the target weight of 90 kg in 16 fortnights.

The rate of growth observed in animals on NRC ration of season I and season II were better than animals on 15 per cent less than NRC groups. Animals of season I on both treatments recorded a lower rate of growth.

The animals on NRC levels of energy showed higher rates of daily gain in both the seasons than animals of 15 per cent less than NRC group. Animals of season I on both treatments recorded a lower rate of growth.

Animals of NRC level of energy showed a better rate of gain in body length in season I and II. Animals born in season II of both groups recorded a better rate of gain in body length.

NRC males and females of both season showed higher feed efficiency. Animals born in season II had a better feed efficiency than animals born in season I. Significant difference in feed efficiency was noticed only during the early stages of growth.

Live weight at slaughter and dressed weight showed a highly significant difference between season I and II but there was no difference between sexes and treatments.

Half carcass weight and dressed weight with out head showed a significant difference between seasons. There were no significant differences between sexes and between treatments. However a trend in favour of females as well as NRC ration fed pigs was visible.

Dressing percentage with head, dressing percentage without head and carcass length were higher in animals born in season II. There were no differences between treatments and sexes.

Average back fat thickness was higher in season II the difference being highly significant. A highly significant interaction was seen between season and treatment. While in season I, treatments did not cause any significant difference in back-fat thickness, in season II, it was significantly higher in the NRC ration fed group.

Eye muscle area and weight of ham were more in animals born in season II. Season x treatment interaction were significant in the case of weight of ham.

Saponification value, iodin value and melting point did not show any significant difference between seasons, sexes and treatments.

Animals born in season II and maintained on NRC level of rations was found to be superior to animals born in season I and maintained on 15 per cent less than NRC energy levels.

The low relative humidity and optimum ambient temperature for the animals born in season II and the cool atmospheric condition and high relative humidity in the peak of growth rate has further supplemented for a better growth rate, feed efficiency and absolute gain in these class of animals.

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EFFECT OF SEASON OF BIRTH AND ENERGY LEVELS OF FEED ON PRODUCTION PERFORMANCE OF PIGS

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ABSTRACT OF A THESIS

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ABSTRACT

A detailed investigation was carried out to study the effect of season and level of energy intake on growth rate, feed efficiency, carcass quality and economics of production of fattening pigs reared upto a slaughter weight of 90 kg.

Thirty two weaner pigs of large White Yorkshire breed belonging to the University Pig Breeding Farm, Mannuthy born in two seasons were distributed under two dietary treatments. All animals were slaughtered on attaining the target weight of 90 kg.

Animals born in season II were superior to animals born in season I in all the parameters like growth rate, feed efficiency, average daily gain and carcass characteristics.

The energy level in the ration had a moderate influence on the performance of grower pigs. Animals on NRC level of feed were found to be better than animals on 15 per cent less than NRC levels in all the traits under study except for fat characteristics.

The cost of production per kg pork was found to be less (Rs 18.72) in NRC group than 15 per cent less than NRC group (Rs 22.99) due to higher feed efficiency and better growth rate.

The overall results obtained during the course of present study is that the unit cost of production is less for animals maintained on NRC level of ration. Animals born in season II were found to be better than animals born in season I in production performances.