EFFECT OF FLOOR DENSITY ON PRODUCTION PERFORMANCE IN JAPANESE QUAILS REARED IN CAGES AND DEEP LITTER

By

B. PADMAKUMAR

THESIS

Submitted in partial fulfilment of the requirement for the degree

Master of Veterinary Science

Faculty of Veterinary and Animal Sciences
Kerala Agricultural University

Department of Poultry Science
COLLEGE OF VETERINARY AND ANIMAL SCIENCES
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DECLARATION

I hereby declare that this thesis entitled EFFECT OF FLOOR DENSITY ON PRODUCTION PERFORMANCE IN JAPANESE QUAILS REARED IN CAGES AND DEEP LITTER is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship or other similar title, of any other university or society.

Mannuthy,

P. PADMAKUMAR

DECLARATION

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Mannuthy,
31-12-1993.

B. PADMAKUMAR

CERTIFICATE

I hereby declare that this thesis entitled **EFFECT OF FLOOR DENSITY ON PRODUCTION PERFORMANCE IN JAPANESE QUAILS REARED IN CAGES AND DEEP LITTER** is a record of research work done independently by **Sri. B. PADMAKUMAR** 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.

Mannuthy,
31-12-1993

Dr. G. **REGHUNATHAN NAIR**,
Chairman, Advisory Committee,
Professor,
University Poultry Farm,
College of Veterinary & Animal
Sciences, Mannuthy.

CERTIFICATE

We, the undersigned members of the Advisory Committee of **Sri B. PADMAKUMAR**, a candidate for the degree of Master of Veterinary Science in Poultry Science, agree that the thesis entitled **EFFECT OF FLOOR DENSITY ON PRODUCTION PERFORMANCE IN JAPANESE QUAILS REARED IN CAGES AND DEEP LITTER** may be submitted by **Sri B. PADMAKUMAR** in partial fulfilment of the requirement for the degree.

Dr. G. REGHUNATHAN NAIR,
Chairman, Advisory Committee,
Professor,
University Poultry Farm,
College of Veterinary & Animal
Sciences, Mannuthy.

Dr. A. RAMAKRISHNAN
Director, Centre for Advanced
Studies in Poultry Science,
Kerala Agricultural
University, Mannuthy.

Dr. A.K.K. UNNI,
Senior Scientist,
A.I.C.R.P. on Poultry
for eggs, Mannuthy.

Sri. N. RAVINDRANATHAN,
Associate Professor,
Department of Statistics,
College of Co-operation & Banking,
Mannuthy.

11.6.84.
EXTERNAL EXAMINER
(DR. P. RANGA REDDY)

To My Parents & Sister

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Introduction

INTRODUCTION

A giant leap of the poultry enterprise resulted during the last two decades and has now stabilized as a balanced industrial set up in our country. Chicken production has particularly contributed to this dramatic improvement and other avian species like ducks and quails also had contributed their share greatly. The importance of quails in the poultry scenario of India was recognised and quail rearing has shown promising development in India since its introduction during mid seventies.

Quails belonging to the genus Coturnix are native of all continents. The domesticated quails (Coturnix coturnix japonica) are popularly known as Japanese quails. They were domesticated in Japan as early as 12th century and were kept mainly as pet birds for singing (Cooper, 1976). Later, during the early part of this century, people started breeding Japanese quails for egg and meat production. From time immemorial, wild quail meat and eggs had been known for their taste and delicacy. Indiscriminate hunting of them has resulted in their near extinction and to preserve this species and make it thrive in its natural habitats, an alternate quail delicacy is being made available to consumers as Japanese quails.

Realising the potential of quails for commercial exploitation and for research purposes, Japanese quails were introduced for the first time in the country at Central Avian Research Institute (C.A.R.I.) in 1974. Since then scientists of C.A.R.I. and of other research institutions on poultry are engaged in research and development of specialized lines of quails for meat and egg production as well as for improving them genetically through appropriate selection and breeding programmes (Thomas, 1988). The quails are being widely utilized as a pilot animal for research in the field of genetics and breeding, nutrition, physiology, diseases and products technology.

Quails are blessed with several desirable characters like fast growth, early sexual maturity, high rate of egg production, short generation interval, requirement of less floor space, short incubation period, less susceptibility to diseases. It needs no vaccination under ordinary circumstances. Heavy demand coupled with high price of quail products makes it an ideal bird for viable farming.

Generally, quails are reared in multi-tier cages both during growing and laying periods. The convenience in handling and conservation of space and energy are major advantages with this system. However, quails are also being reared on floor equally well. But semi intensive systems of rearing are not popular due to their flight behaviour.

The research work carried out on the stocking density of quails under different systems of rearing in tropical conditions are scanty. Therefore, it was thought appropriate that studies on floor space requirements of quails for optimising production are undertaken to suggest modern technologies for boosting quail production in our country. Taking into consideration the above, a biological trial was undertaken with the following objectives.

1. To evaluate the production traits of Japanese quails in cage and deep litter systems of rearing with different floor space allowances.

2. To investigate the correlation between part year egg productions and annual egg production in order to determine an early age for selection in breeder quails.

3. To suggest an optimum density for both cage and deep litter systems of rearing quails, so that parameters of economic importance elicit a maximum response. This information will help transfer of appropriate technology for of economic quail production.

Review of Literature

REVIEW OF LITERATURE

The literature pertaining to selective economic traits of Japanese quails (Coturnix coturnix japonica) and the influence of housing systems and floor space allowances on the various parameters under cage and deep litter systems of rearing are presented in this chapter.

Somanathan (1980) had reported meteorological profile at Mannuthy based on the summary of five year monthly averages of the meteorological observations prevailing at a Latitude of 10°32"N; Longitude of 76°16"E and Altitude of 22.25 M above M.S.L. and the details of data are given below.

The highest mean daily maximum temperature was recorded during April (34.55°C) and lowest during July (28.15°C). Then the temperature again rose and by February it reached 33.63°C.

The lowest mean minimum temperature recorded was 23.28°C during July and highest mean minimum temperature was 25.27°C during May. The average of the mean daily relative humidity was 70.03 per cent during April, increased gradually and reached a maximum of 86.52 per cent during July and then gradually decreased to 57.54 per cent by February.

According to him the rainy season in Mannuthy falls from May to November, of which June to August is cold and wet,and May to September and November is warm and wet.

Dry season in Mannuthy is from December to April, of which December and January is warm and dry; and February to April is hot and dry. Climograph of the locality fell within the hot and moist climate.

Impact of Meteorological Factors on Production Parameters

Froning and Funk (1958) in their studies on the seasonal variations in quality of eggs laid by caged layers and their sisters on floor reported that egg weight was higher in caged birds than floor reared birds. They further observed that egg size was significantly lowered ($P < 0.01$) when the temperature was highest and it increased when the temperature was lower. They also stated that warm temperature apparently had an adverse effect on shell thickness. Seasonal variations in Haugh Units were found to be significant at one per cent level. No seasonal trend was noted in the per cent of thick albumen.

According to McDowell (1972), at high temperatures, both high and low humidities have marked effects on the well being of livestock. He reported that in warm, humid regions, where air temperatures are 21°C or above, humidity becomes a problem for livestock production, when the relative humidity is 60 per cent and above or the vapour pressure is above 20 mm Hg

Sakurai (1983) has conducted experiments on the effect of ambient temperature and length of day light on growth and egg production characters of Japanese quail. He found that growth was better at 29°C than at 23°C and 35°C temperatures. Sexual maturity was delayed under an 8 hour day light regime and so egg production in the first month was significantly lower than that of birds with 16 hour and 24 hour light regime. No difference in egg production was observed among groups after the second month.

Sachdev and Ram Gopal (1988) observed highly significant differences ($P < 0.01$) between seasons (winter, summer, rainy) on the albumen index, internal quality unit and shell weight of Japanese quail. The shape indices were 78.86, 77.75 and 79.61 during the winter, summer and rainy seasons respectively and were non-significant among themselves. The albumen indices were 0.1262, 0.1239 and 0.1107 showing significant difference among each other. Likewise, shell weight also differed markedly ($P < 0.01$) during various seasons.

Body weight

Sefton and Siegel(1974) studied the inheritance of body weight in Japanese quail and reported that there was an acceleration of weight gain in female quails just prior to sexual maturity. They experimented on two generations of quails viz. generation A and generation B. Males of generation A quails had a body weight of 94.7±5.7 g at 35 days of age and females had a body weight of 99.3±6.4 g. Males of generation B quails had a body weight of 94.4±6.6 g at 35 days of age and females had a body weight of 99.3±19.1 g. Similarly, body weight of males and females of generation A at 56 days of age averaged 105.8±7.2 g and 126.4±12.3 g respectively and that of generation B averaged 102.1±6.5 g and 122.7±11.8 g respectively. They also observed that all phenotypic correlations between weights at various ages were positive. The magnitude of variation generally decreased as the interval between weighings increased. Genotypic correlations also followed the same general trends except when the age was day one and when the ages involved maturity of females.

Jones and Hughes (1978) in a comparative study on the growth rate and body weight between coturnix quails and Bob white quail reported that the former reached mature body size (162 g) in six weeks, whereas Bob white quails required 12 weeks to reach comparable body weight.

Panda *et al*. (1980) on evaluation of a quail line reported that rearing quails after four weeks of age may not be an economical preposition for production of meat because growth rate reduced considerably after fourth week of age.

Sato *et al*. (1981) studied the genetic parameters of body weight in Japanese quail and observed that the mean body weights were 109.0 and 118.6 g in females and 94.6 and 96.7 g in males at sixth and eighth weeks of age respectively.

Kohler (1984) in a study on the phenotypic parameters of Japanese quail reported that the 42 day body weight of the five unselected lines averaged 118-152 g.

Kumar *et al*. (1990) in a study to determine the influence of parental age on body weight found that progeny from young males and females had better body weight at 8 weeks of age in comparison to those produced from old and old x young parents.

Praharaj *et al*. (1990) compared a line of Japanese quails selected for high four week body weight with a random bred control line. It was observed that in females the selected line had significantly higher body weights than those of control line.

Age at first egg

Wilson *et al.* (1961) in the evaluation of Japanese quail (*Coturnix coturnix japonica*) reported that quails reached sexual maturity as early as five to six weeks of age.

Howes and Ivy (1962) in their initial studies on coturnix quail reported that the age at first egg was 35 days.

Krazewska-Doman'ska *et al.* (1967) reported that in polish conditions, Japanese quails reached sexual maturity at 46 days of age.

Jones and Hughes (1978) reported that Japanese quails were sexually mature at six weeks of age.

Tiwari and Panda (1978) observed that Japanese quail hens produced their first egg by the age of 51 days.

Kohler (1984) in his study on the longevity of Japanese quails kept in individual cages observed that the age at first egg averaged 56.2 days.

Age at 50 per cent production

Tiwari and Panda (1978) from their investigations on quails reported that the quail hen attained 50 per cent production at 67 days of age.

Gildersleeve et al. (1987) in a study on egg production in four generations of paired Japanese quails, observed that age at 50 per cent production increased from first to fourth generation.

Egg production

Wilson et al. (1961) observed that some individual quail hens laid over 300 eggs in their first year of production. The percentage rate of lay averaged 70-90.

Kraszewska-Doman'ska et al. (1967) in their observation on Japanese quail under laboratory conditions reported that the rate of egg laying was 77 per cent.

Jones et al. (1979) conducted an experiment with breeder quails housed at six weeks of age in breeder cages measuring 30.48 cm x 50.81 cm with one male being caged with either 1, 2 or 3 females. It was concluded that the number of females per cage had no effect on reproductive efficiency.

Panda et al. (1980) on evaluation of economic traits in a quail line reported that the per cent hen-day egg production was 73.28 in the parent stock.

Sato et al. (1983) while comparing the egg production for four generations in a full-sib and random bred group observed that the number of families with low production was higher in full-sib than in random bred group. In the above groups the laying rates were 68.5 and 86.7 , 66.0 and 85.8 and 70.1 and 84.3 per cent in the second, third and fourth generations respectively. The differences between groups were significant ($P < 0.01$) in all generations.

Kohler (1984) reported that egg production upto 100, 200 and 365 days of age averaged 39.7, 128.3 and 255.8 eggs per bird respectively.

Sachdev and Ahuja (1986) studied the influence of various ranges of body weights viz. 100 to 120, 120 to 140, 141 to 160, 161 to 180 and 181 to 200 g per quail at sexual maturity on the subsequent production performance upto 50 weeks of age. There were no significant differences between weight groups in egg production. The egg production recorded in the above groups were 115.87±3.27, 183.84±7.78, 179.36±5.41, 172.03±5.42 and 205.77±8.21 respectively.

Gildersleeve *et al*. (1987) observed that hen-day production and total number of eggs produced increased from first to fourth generation. The per cent production in these generations were 69±12, 75±8, 80±9 and 78±10 respectively.

Mohanty et al. (1987) reported that the rate of hen-housed egg production was 15 per cent in Japanese quails at the age of 15 months.

In a study on the influence of hatching seasons on subsequent egg production in Japanese quails, Sreenivasaiah and Joshi (1988) observed that the mean per cent hen-day production in monsoon and winter hatched quails were 63.90±0.40 and 63.30±0.40 respectively.

Praharaj et al. (1990) in a comparative study of random bred control line with a line of Japanese quails selected for high (four week) body weight observed that control line quails produced 3.8 more eggs at 16 weeks of age than quails of selected line.

Feed consumption and Feed efficiency

Wilson et al. (1961) reported in a study on Japanese quail that to put on 122 g of body weight, a quail consumed 496 g of feed.

Panda et al. (1977) in a study on the nutrient requirements and feeding of Japanese quail, fed different protein levels to quails. They reported that at 22 per cent crude protein and 2900 K cal/kg ME, the feed intake of quail average 24.3 g per bird/day and the feed efficiency averaged 2.80±0.052.

Tiwari and Panda (1978) reported that the average feed/egg ratio, ie., feed efficiency was 3.8 in Japanese quails from 30 to 200 days of age.

Livability

Kraszewska-Doman'ska *et al*. (1967) reported that mortality among adult birds in four months of lay was 2.4 per cent.

Köhler (1984) during his investigation on the longevity of Japanese quails kept in individual cages reported that the mean live span was 465 days with a range of 153-1004 days in female quails.

Gildersleeve *et al*. (1987) on studying the egg production in four generations of Japanese quails observed that mortality decreased from the first to the fourth generation.

Kumar *et al*. (1990) studied the influence of parental age on the livability in Japanese quails and observed that survival of quail chicks hatched from old male and female parents was highest (83 per cent) upto eight weeks of age, as compared to that from young parents and mixture of young and old parents.

Egg weight

Garret *et al*. (1972) in a study on the selected characteristics of eggs in Japanese quails observed that the egg weight averaged 11 g.

Sharma and Panda (1978) in their investigations in production traits in Japanese quails reported that the mean egg weight in quails was 9.46 ± 0.18 g.

Tiwari and Panda (1978) in an experiment on quality characteristics of quail eggs observed that the egg weight of quails averaged 10.2 ± 0.58 g which represented about eight per cent of the body weight.

Kohler (1984) in a study on the phenotypic parameters of Japanese quail reported that the egg weight averaged from 9.1 to 10.9 g in different lines of quails.

Yannakopoulos and Tserveni-Gousi (1985) in a study on the quality traits of quails reported that the age of quails significantly affected egg weight ($P < 0.01$). From seventh to twenty second week, egg weight increased from 11.33 to 12.95 g.

Singh and Panda (1986) evaluated the physical quality of eggs from four different lines of quails viz. egg type, white egg shell type, selected meat type and meat type control, significant differences were found ($P < 0.01$) in respect of egg weight between different lines and the egg weight averaged 10.05 g. The eggs of meat type birds were significantly heavier than the egg type and white egg shell lines.

Ulmek (1986) reported that in quails, the weight of eggs increased according to the age.

Mohanty et al. (1987) in a study on the quality characters of eggs from 15 month old Japanese quails reported that the mean egg weight was 6.41 g.

Sreenivasaiah and Joshi (1988) conducted studies to determine the influence of season on egg quality characteristics in Japanese quails. The mean egg weight in the first ten eggs laid was significantly higher in winter hatched birds in comparison to Monsoon hatched birds (9.72 ± 0.10 Vs 8.99 ± 0.07 g). In the corresponding groups, the average egg weight was 10.15 ± 0.05 and 9.47 ± 0.06 g respectively.

Narayanankutty et al. (1989) in an investigation on the quality characteristics of Japanese quail eggs reported that egg weight of 12 week old quails averaged 8.56 ± 0.10 g and that of 24 week old quails averaged 9.93 ± 0.13 g.

Praharaj et al. (1990) reported that the heritability estimates for egg weight in Japanese quails ranged from 0.27 to 0.6.

Nagarajan et al. (1991) in a study on the influence of stocking density and layer age on egg quality observed that egg weight gradually increased with age in Japanese quails.

Shape Index

Garret et al. (1972) in a study on the selected characteristics of egg reported an average shape index of 75.76 for quail eggs.

Sharma and Panda (1978) reported a shape index of 81.1 ± 1.45 for Japanese quail eggs.

Tiwari and Panda (1978) reported a shape index of 79.1 ± 1.38 for quail eggs.

Sreenivasaiah et al. (1980) in their studies on the repeatability of egg quality characteristics in Japanese quails reported a shape index of 79.82 ± 0.2916.

Yannakopoulos and Tserveni-Gousi (1985) reported that age of quails significantly affected egg traits. They also observed that shape index was significantly correlated with albumen weight and egg specific gravity.

Singh and Panda (1986) in an evaluation of physical quality of eggs from different lines of quails reported that shape index ranged from 78.15 to 79.20. There were no significant differences in shape index between the different lines.

Yannakopoulos and Tserveni-Gousi (1986) in a study on the quality characteristics of quail eggs reported that shape index decreased between 49 to 154 days of age. They concluded that the best criterion of shell strength is egg shape.

Mohanty *et al*. (1987) in an investigation of quality of eggs from aged (15 months) quails reported an egg shape index of 77.20.

Sachdev and Ram Gopal (1988) in a study on the influence of seasonal variation on the quality of quail eggs observed that seasons did not affect the shape index significantly. They reported an average shape index of 78.86 ± 0.001 in winter, 77.75 ± 0.17 in summer and 79.61 ± 1.96 in rainy season for quail eggs.

Narayanankutty *et al*. (1989) reported that eggs from 12 week old quails had a shape index of 80.42 ± 0.55 and that from 24 week old quails had a shape index of 76.28 ± 0.66.

Albumen Index

Tiwari and Panda (1978) in an investigation on the production and quality characteristics of quail eggs reported an albumen index of 0.100±0.003 for quail eggs.

Sreenivasaiah _et al_. (1980) reported an albumen index of 0.1367±0.0023 from the studies on the repeatability of egg quality characteristics of Japanese quail.

According to Ulmek (1986) the albumen index of quail eggs was 0.14

Singh and Panda (1986) reared egg type, white egg shell type, selected meat type and meat type control lines of Japanese quails. They could observe that the lowest albumen index was for the control group and the same was found to be non significant among the other three lines.

Mohanty _et al_. (1987) reported an albumen index of 0.1223 for quail eggs.

Sachdev and Ram Gopal (1988) in a study on the influence of seasonal variation on the quality of quail eggs reported that albumen index was superior in winter than during summer and rainy seasons. Albumen index during winter was found to be 0.1262±0.001, during summer, 0.1239±0.001 and during rainy season 0.1107±0.001.

Narayanankutty et al. (1989) reported that albumen index of eggs from 12 week old quails averaged 0.097±0.003 and that from 24 week old quails averaged 0.105±0.002.

Nagarajan et al. (1991) observed that albumen index of Japanese quail eggs increased with age of the birds.

Yolk index

Tiwari and Panda (1978) in an investigation on the production and quality characteristics of quail eggs reported a yolk index of 0.489±0.009.

Sreenivasaiah et al. (1980) in a study on the repeatability of egg quality characteristics in Japanese quails observed a yolk index of 0.5444±0.0045.

Ulmek (1986) reported a yolk index of 0.450 - 0.550 for eggs from Japanese quails.

Singh and Panda (1986) in the evaluation of physical quality of eggs from different lines of quails observed that comparatively, eggs laid by the selected meat line had better yolk index compared to other lines under study.

Mohanty et al. (1987) in a study on the quality of eggs laid by aged (15 months old) Japanese quails observed a yolk index of 0.2841 for quail eggs.

Sachdev and Ram Gopal (1988) in a study on the influence of seasonal variation on the quality of quail eggs observed that yolk index was superior in winter than in summer and rainy season. Negative correlations were recorded between environmental changes (Temperature and R.H) and yolk index. Yolk index in winter was 0.4856±0.002, that in summer was 0.4841±0.002 and that in rainy season was 0.4696±0.011.

Narayanankutty et al. (1989) observed that eggs from 12 week old quails had a yolk index of 0.424±0.014 and that from 24 week old quails had a yolk index of 0.505±0.006.

Shell thickness

Mahmoud and Coleman (1967) in a comparison of the proportion of component parts of Bob white and Coturnix quail eggs reported a shell thickness of 0.197 mm for coturnix eggs which was significantly thicker than those of Bob white quail eggs, which averaged 0.173 mm.

Garret et al. (1972) in a study of the selected characteristics of eggs produced by Japanese quail observed a shell thickness of 0.215 mm.

Sreenivasaiah et al. (1980) in their studies on the repeatability of egg quality characteristics in Japanese quails reported a shell thickness of 0.1715±0.009 mm.

Ulmek (1986) reported the shell thickness of eggs produced by Japanese quails as 0.13 to 0.19 mm.

Singh and Panda (1986) found significant line difference in shell thickness when the physical quality of eggs from different lines were evaluated. According to them, the shell thickness of quail eggs averaged 0.183 mm comparatively eggs laid by the selected meat line had better shell thickness than egg line, white egg shell line or meat line control.

Mohanty et al. (1987) reported a shell thickness of 0.2 mm for eggs from quails aged about 15 months.

Narayanankutty et al. (1989) observed a shell thickness of 0.193 ± 0.003 mm for eggs from 12 week old quails which was significantly different from those of 24 week old quails which averaged 0.178 ± 0.002 mm.

Haugh Unit

Tiwari and Panda (1978) in a study on the quality characteristics of quail eggs reported the Haugh Unit value of quail eggs as 87.1

Kondaiah et al. (1983) framed a method to determine the internal egg quality measure for quail eggs, wherein they made a unit called internal egg quality unit (IQU). It was defined as

IQU = 100 log (H+4.18 - 0.8948 W), 0.6674

Where H = albumen height in mm, and

W = Egg weight in g.

The correlation between IQU and albumen height was 0.85, with albumen index 0.82 and with yolk index 0.50.

Mohanty et al. (1987) in a study on the quality characteristics of eggs from Japanese quails aged 15 months reported a Haugh Unit score of 77.39 for quail eggs.

Sachdev and Ramgopal (1988) in a study on the seasonal variation on quality characteristics of Japanese quail eggs observed that internal egg quality unit or Haugh Unit was superior in winter than in summer and rainy season. Variation in the internal quality unit was predicted to have been mainly due to relative humidity.

Narayanankutty et al. (1989) reported that eggs from 12 week old quails had a Haugh Unit score of 85.18±0.51 which was significantly lesser than that from 24 week old quails, where it was 86.34±0.54.

Nagarajan et al. (1991) reported that internal quality unit or Haugh Unit of quail eggs increased with age of the quail hens.

Effect of Housing System and floor space

1. Body weight

Ernst and Coleman (1964) conducted a study on the influence of floor space on growth of <u>Coturnix coturnix japonica</u> to determine the floor space requirement for optimum growth of coturnix quails from three to thirteen weeks of age. Birds were reared at the rate of four, eight, twelve, sixteen and twenty per square foot in three replicates each. The results showed that the mean body weights in the five densities studied were not significantly different ($P < 0.05$).

Sharma and Panda (1978) reported a mean body weight of Japanese quails at eight weeks of age as 108.0 g in battery cages compared to 105.8 g in deep litter.

Chidananda <u>et al</u>. (1986) reported that Japanese quails reared in cages were heavier at 5-10 weeks of age in comparison to deep litter reared ones. The difference in weight was significant at five weeks of age (129.8 ± 2.92 Vs 121.7 ± 2.74 g).

Okamoto <u>et al</u>. (1989) in a study on the effect of cage density and photoperiod on the growth in two lines of quails (large and small) found that high stocking density resulted in greater body weight gain than the low density groups.

Bandyopadhyaya and Ahuja (1990) reared female quails from seven to twenty one weeks of age in an investigation to study the effect of cage density on body weight. The quails were housed at the rate of two, three, four and five birds per cage having measurement of 25 x 17 cm. A general trend of decrease in body weight was observed as the number of quails increased in cages.

Nagarajan _et al_. (1990) reared Japanese quails in cages with a floor space of 150, 180, 210 and 240 sq.cm per bird, from six to twenty six weeks of age and found that with increasing cage space allowances, the hens gained higher weights. The sixth week body weights were not significantly different and the twenty sixth week body weights were 157.4 ± 2.89, 166.9 ± 2.41, 167.2 ± 2.71 and 170.1 ± 1.95, which were significantly different ($P < 0.05$).

Viswanathan (1992) in an investigation on the effect of housing system and of floor space on the body weight of Japanese quail, reared female quails in both cage and deep litter system of rearing at floor space of 150, 175 and 200 sq.cm per bird. He noticed that the body weights of the three treatment groups reared in cages at six weeks of age averaged 152.49 ± 0.74, 150.33 ± 0.42 and 153.14 ± 0.76 respectively and that of deep litter reared quails averaged 150.89 ± 0.77, 150.93 ± 0.49 and 151.32 ± 0.58 respectively. The results were found to be not significantly different among the treatment groups and housing systems. The body weights of the treatment groups in cages at 30 weeks of age averaged 184.45 ± 0.93, 185.09 ± 1.19 and 178.22 ± 0.25 respectively and that in deep litter averaged 172.00 ± 0.70, 173.06 ± 0.87 and 172.18 ± 0.40 respectively. The weights were found to be highly significant ($P < 0.01$) both between cage and deep litter systems of rearing and also between the different floor densities.

Age at first egg

In an experiment on the comparative performance of Japanese quails in cages and deep litter, Chidananda _et al_. (1986) found that age at first egg was delayed in litter reared birds than in cage reared ones.

Narahari _et al_. (1986) reported that quails reared in cages laid their first egg at 42 days as against 45 days of age on deep litter.

Nagarajan _et al_. (1990) investigated the laying performance of Japanese quail hens under different stocking densities of 150, 180, 210 and 240 sq.cm per bird. It was observed that the age at first egg were 45.8 ± 0.41, 45.3 ± 0.43, 45.5 ± 0.50 and 45.5 ± 0.50 respectively for different treatment groups which were not significantly different among one another.

Viswanathan (1992) reared Japanese quails in cages and deep litter at floor densities of 150, 175 and 200 sq.cm per bird. He observed that in cages, age at first egg averaged 43.50±0.65, 43.50±0.65 and 45.50±0.50 days respectively and in deep litter, age at first egg averaged 43.25±1.03, 44.75±0.63 and 44.75±0.85 respectively which were not significantly different.

Age at 50 per cent production

Chidananda *et al*. (1986) in a study on the comparative performance of Japanese quails on cage and deep litter observed that age at 50 per cent production was lower in cage reared birds than the litter reared birds. The results indicated that the cage raised birds took lower days (77.62±2.12) than litter reared birds (80.12±1.79) although the difference was not statistically significant.

Nagarajan *et al*. (1991) reported that age at 50 per cent production showed significant improvement with proportionate increase in cage space per quail layer.

Viswanathan (1992) reported that when quails were reared in both cage and deep litter at floor spaces of 150, 175 and 200 sq.cm per bird,the age at 50 per cent production averaged 55.75$\pm$1.80, 55.00$\pm$0.41 and 53.40$\pm$1.60 respectively for cage reared birds and 55.00$\pm$0.58, 51.75$\pm$0.48 and 51.75$\pm$0.48 respectively for litter reared birds. The results were found to be highly significant ($P < 0.01$).

Egg production

Ernst and Coleman (1964) conducted an experiment in which coturnix quails were raised in concentrations of four, eight, twelve, sixteen and twenty birds per square foot. It was observed that egg production was higher at a concentration of four birds per square foot than in those groups having higher density.

Chidananda et al. (1986) in their study on the comparative performance of Japanese quail on cage and deep litter showed that birds in deep litter produced lower ($P < 0.05$) number of eggs than cage reared birds. They concluded that cage system of rearing had marginal advantage over deep litter system of rearing.

Bandyopadhyaya and Ahuja(1990) in a study on the effect of cage density on egg production observed a general trend of decline in egg production, as the number of birds per cage were increased. Female quails were reared in cages measuring 25 x 17 cm at the rate of two, three, four and five birds per cage from seven to twenty one weeks of age and the total egg production averaged 83.83±1.46, 72.89±2.39, 72.45±1.26 and 62.66±1.59 respectively, which were significantly different.

Nagarajan *et al.* (1990) in an investigation on the laying performance of Japanese quail hens in cages under different stocking densities viz., 50, 180, 210 and 240 sq.cm per bird observed that the hens laid more eggs as the floor space per bird increased. They reported that the egg production was significantly higher when 240 sq.cm space was provided per bird.

Nagarajan *et al.* (1991) reported that hen-day egg production showed significant improvement with proportionate increase in space per quail in cages.

Viswanathan (1992) reared female Japanese quails in cages and deep litter at floor space allowance of 150, 175 and 200 sq.cm per bird. The per cent hen-day egg production (7-30 weeks of age) in cages averaged 49.08±0.48, 50.62±1.18 and 52.34±0.45 respectively and 49.21±0.23, 49.24±0.37 and 49.29±0.37 respectively in deep litter. The results were found to be highly significant ($P < 0.01$). Hen housed egg production in cages (7 to 30 weeks of age) were 82.48$\pm$0.80, 85.04$\pm$0.30 and 87.93$\pm$0.75 respectively for different floor densities and 82.68$\pm$0.39, 82.72$\pm$0.62 and 82.81$\pm$0.62 respectively for birds on deep litter.

Feed consumption and Feed efficiency

Ernst and Coleman (1964) reported that stocking densities had no significant effect on the feed conversion in Japanese quails.

Sharma and Panda (1978) in their studies on the production traits in Japanese quails reported a feed intake of 11.7 g on litter and 11.1 g in battery on a per bird per day basis upto 8 weeks of age.

Chidananda et al. (1985) in a comparative study on the feed efficiency of Japanese quails reared in cages and on deep litter reported a feed conversion ratio of 2.06$\pm$0.02 for cage reared and 2.11$\pm$0.02 for litter reared birds and the results were found to be statistically non-significant.

Narahari et al. (1986) while studying the effect of rearing system and marketing age on the performance of Japanese quails observed that cage reared birds had significantly better food conversion indices at five, six, seven and eight weeks of age. The feed conversion indices for cage reared birds averaged 3.28-5.79 and that for litter reared birds averaged 3.36-5.91.

Das et al. (1990) while studying the effect of stocking density and length of rearing on the growth performance of Japanese quail reared 492 quails in cages, from three to six weeks of age at stocking densities of 83, 94, 109, 125 and 1156.5 sq.cm per bird. It was observed that the feed conversion efficiency averaged 3.54, 3.73, 3.92,3.89 and 3.33 for the five stocking densities respectively.

Viswanathan (1992) reported that in general, the average feed intake (per bird per day) is lesser in cage reared quails than in the litter reared birds and the results were found to be significant. The average feed intake (g) per bird per day were 22.75±0.05 and 23.38±0.04 respectively for cage and litter reared layer quails. The results also revealed that there was no statistical significance for feed consumption between the different density groups. The overall feed efficiency values showed a highly significant difference in feed efficiency between cage and deep litter reared quails. The results of the analysis of the data further showed a significant difference in feed efficiency between different density groups.

Livability

Wilson *et al*. (1978) in an experiment on the evaluation of floor space for brooding Bob white quail found that mortality increased bv floor space less than 232 sq. cm per quail.

Chidananda *et al*. (1985) compared the mortality pattern of Japanese quails reared in cages and deep litter. For cage reared quails, weekly mortality ranged from 1.02 per cent in week seven to 13.12 per cent in week four. In birds on deep litter, mortality rates ranged from 1.49 per cent in week five to 10.47 per cent in week two. The overall mortality upto eight week was 38.70 ± 2.84 per cent in cage reared birds and 33.72 ± 2.84 per cent in birds on deep litter. The differences among rearing systems were non significant.

Bandyopadhyaya and Ahuja (1990) in an investigation in Japanese quail observed that mortality was not influenced by cage density.

Nagarajan *et al*. (1990) reported that with increasing space allowance in cages, mortality was reduced in quail hens.

Viswanathan (1992) observed that percentage mortality in Japanese quail layers (7-30 weeks) in cages averaged 14.33 and that on litter averaged 20.33.

Egg weight

Chidananda et al. (1986) observed that cage reared quails laid more eggs with higher mean egg weight when compared to litter reared birds.

The egg quality was significantly affected by the type of housing in Japanese quails (Mohapatra et al., 1988). These workers reported the mean egg weights as 10.30±0.09 and 10.62±0.07 g in floor and cage system of rearing respectively.

In order to investigate the effect of cage density on egg quality traits in Japanese quails, Bandyopadhyaya and Ahuja (1990) reared birds at the rate of two, three, four and five birds per cage having a size of 25 x 17 cm. They observed that the egg weight remained unaffected in the different floor densities.

Nagarajan et al. (1990) while evaluating the laying performance of Japanese quails under different stocking densities with a space of 150, 180, 210 and 240 sq.cm per bird observed that there was no significant difference in weight of egg among birds reared in the different densities.

Viswanathan (1992) reported that cage reared Japanese quail females had a mean egg weight of 9.67±0.05 and litter reared quails had a mean egg weight of 9.75±0.05.

Shape Index

Mahapatra et al. (1988) in an experiment to determine the effect of housing system on egg quality characters in Japanese quails found out that shape index was not influenced significantly by type of housing. They observed a mean shape index of 80.39±0.18 for eggs from floor reared birds and a shape index of 79.92±0.27 for eggs from cage reared birds.

Bandyopadhyaya and Ahuja (1990) reported that cage density had no significant effect on the egg shape in Japanese quails.

Albumen index

Mahapatra et al. (1988) in a study on the effect of housing system on the egg quality of Japanese quails reported that albumen index was not significantly affected by type of housing. Albumen index of quail eggs was found to be 0.091±0.001 for both floor and cage reared birds.

Bandyopadhyaya and Ahuja (1990) reported that cage density significantly influenced albumen index of eggs from Japanese quails.

Viswanathan (1992) in an investigation on the effect of floor space and housing system on the internal quality of quail eggs found that cage reared birds had an albumen index of 0.100±0.007 and 0.112±0.001 for litter reared birds. The effect of different floor spaces had no significant effect on the albumen index.

Yolk index

Mahapatra et al. (1988) reported a yolk index of 0.386±0.003 for eggs from Japanese quails reared on floor and a yolk index of 0.382±0.002 for eggs from those reared in cages. They observed that yolk index was not significantly affected by type of housing.

Nagarajan et al. (1991) in a study on the influence of stocking density and layer age on production traits and egg quality of Japanese quails observed that yolk index was highest in eggs from the lowest stocking density. It was also observed that yolk index increased with age.

Viswanathan (1992) reared female quails in cages and deep litter at floor space of 150, 175 and 200 sq.cm per bird. He observed that yolk index of eggs from cages averaged 0.44±0.003, 0.47±0.003 and 0.45±0.002 respectively and that from deep litter averaged 0.44±0.005, 0.44±0.007 and 0.43±0.006 and these results were highly significant ($P < 0.01$).

Shell thickness

Mahapatra *et al.* (1988) observed from an experiment on the effect of housing system on egg quality in Japanese quail, that shell thickness was not significantly influenced by the type of housing. They reported a shell thickness of 0.174±0.001 for eggs of floor reared birds and 0.172±0.001 for those of cage reared birds.

Bandyopadhyaya and Ahuja (1990) observed that the shell thickness of Japanese quail eggs remained unaffected when birds were reared under different cage densities.

Nagarajan *et al.* (1991) reported that shell thickness of Japanese quail eggs was influenced neither by age nor by stocking density.

Viswanathan (1992) reported that Japanese quails reared in cages had an average shell thickness of 0.200±0.001 and that on deep litter had an average shell thickness of 0.199±0.001.

Haugh Unit

Bandyopadhyaya and Ahuja (1990) in a study on the effect of cage density on the egg quality traits in Japanese quail reported that cage density significantly affected Haugh unit score.

Viswanathan (1992) in a study on the effect of housing system and floor space on the egg quality of quails observed that birds in cages had an average internal quality unit of 66.19 ± 0.370 and those on deep litter 65.73 ± 0.350; the results were not significantly different.

Correlation between part year and full year production

On scanning the literature, since no information on correlation of part year production records of quails were available, data pertaining to chicken are presented here.

Lal and Sandhu (1977) in a comparative study on different measures of part year egg production of March-May hatched chicken observed the genetic correlations of annual rate of lay with egg production during the first 100 days of laying, egg production to 40 week of age and to 31 January and percentage egg production to 40 week. The values were found to be 0.78, 0.69, 0.75 and 0.70 respectively. It was concluded that the selection for egg production to 31 January was the most efficient one.

Fostel (1981) while conducting an experiment with the objective as to consider the best method of estimating the laying rate from part year record of egg production observed that the most suitable estimator was the number of eggs laid by each sexually mature hen which survives over a standard test period between the age of 30 to 40 weeks.

Ibe (1984) observed that selection based on part year record of rate of lay slightly increased the rate of lay and full-record egg number.

Harpreet Singh and Mohanty (1985) while studying the efficiency of using residual egg production records as a part of the flock for the genetic improvement of annual egg production observed the correlations between the designated production, residual production and annual production in two strains of white Leghorn chicken, namely OY and OT strain.

Correlations between part year and residual production for OY and OT strains were 0.37±0.22 and 0.46±0.14; residual with annual production were 0.98±0.01 and 0.95±0.02 and that of part year with annual production were 0.69±0.13 and 0.71±0.08 respectively.

Varakina et al. (1985) while studying the methods of breeding laying fowls observed that the correlation of 42 week with 72 week egg production were 0.23 to 0.80 in different generations and those of 42 week egg production with 43-72 week were 0.22 to 0.42. All the correlations were found to be highly significant.

Ezzeldin and Mostageer (1987) studied the correlation between 365 days egg production and cumulative egg numbers upto 40, 44, 48, 52 and 70 week of age in Fayoumi and observed that the correlations were 0.36±0.11 to 0.93±0.02 (Genetic correlation). The genetic correlation of 365 day egg production with restricted egg recording traits (3 days per week) ranged from 0.62±0.13 to > 1.00

McMillan (1988) while designing the prediction of annual production from part record egg production in chicken, experimented with three mathematical models namely Wood model, compartment model and regression model for predicting 50 week egg production from actual egg production records for 16, 20 and 24 weeks. They observed that the Wood model was not as accurate as the other two models.

Sarica and Uluocak (1992) estimated the egg production during the first and second 26 week periods of laying using records taken at 1-, 2-, 3-, 4-, 5- or 6- day intervals. As the interval between records decreased when all inputs and labour requirements were taken into consideration, recording at 3-day intervals was considered optimum.

Tolpinskaya et al. (1992) while evaluating the egg production of hens observed that egg production from 40 to 64 week was significantly correlated with egg production to 40 week (0.27), peak one month production (0.36), 2 month peak production (0.50) and production in week 27-40 (0.49).

Materials and Methods

MATERIALS AND METHODS

An experiment was carried out at the Department of Poultry Science, College of Veterinary and Animal Sciences, Kerala Agricultural University, Mannuthy to evaluate the production performance of Japanese quails (Coturnix coturnix japonica) with different floor densities under cage and deep litter systems of rearing.

The study was carried out for 45 weeks during the period from April 1992 to February, 1993 at the University Poultry Farm, Mannuthy. Three hundred and twenty eight (328) Japanese quails at the age of five weeks were used for the study. The birds were from a single hatch and they were brooded and reared under identical conditions. The chicks were not given any vaccination. Battery brooders with mesh size of 1 x 1.5 cm were utilized for cage rearing. Small coups were constructed with wooden reepers and wood shavings were spread on the floor for deep litter rearing.

The birds were wing banded and weighed on 35th day of hatch for commencement of the experiment. The quail chicks were randomly allotted to different floor density levels in cages and deep litter floor pens as detailed below.

System of rearing	Experimental groups	Floor space per bird (sq. cm)	Number of birds per replication
A. Cage system	I	100	20
	II	150	13
	III	200	10
	IV	250	8
B. Deep Litter system	V	150	13
	VI	200	10
	VII	250	8

All the experimental groups consisted of four replications each. The allotment of birds to each treatment group and replicate was made randomly. The mean body weights of birds in each treatment and replication were made fairly uniform at the commencement of the experiment.

Feed and water were provided ad lib. Layer mash was fed throughout the experimental period. The ingredient composition and nutrient composition of the feed are presented in Tables 1 and 2 respectively. The proximate analysis of the feed was carried out periodically at ten week intervals and the quality of the feed was assessed and kept similar throughout the experiment. Standard managemental practices were followed throughout the experimental period. The production performance of the birds were recorded for nine periods of 35 days each.

Table 1. Ingredient composition of layer mash used for the experiment (in per cent)

Yellow maize	30.0
Groundnut cake	26.0
Gingelly oil	10.0
Rice polish	20.0
Unsalted dry fish	7.0
Salt	0.4
Shell meal	6.3
Mineral mixture	0.3
For every 100 kg feed, added the following (g/100 kg)	
i. Rovibe*	63
ii. Rovimix**	25
iii. Choline chloride	30
iv. Lysine hydrochloride	20
v. DL-Methionine	30

* ROVIBE (Roche Products Ltd).
Guaranteed potency per gram
Vit. B1-4 mg, B6-8 mg, B12-40 mg, Niacin-60 mg;
Calcium pantothenate - 40 mg and Vit. E-40 i.u.

** ROVIMIX A, B2, D3 (Roche Products Ltd.)
Guaranteed Potency per gram
Vit. A-40,000 I.U., B2-20 mg, D3-5,000 I.U.

Table 2. Chemical composition of layer mash on dry matter basis.

Nutrient	Per cent
Dry matter	90.37
Crude protein	22.90
Ether extract	3.67
Nitrogen free extract	57.16
Crude fibre	4.75
Total Ash	11.52
Acid Insoluble Ash	2.73
Calcium	3.14
Phosphorus	0.85
Calculated value of Metabolisable Energy (K cal/kg feed)	2876

The following observations were recorded during the experimental period.

1. Meteorological observations such as temperature (°C) and per cent relative humidity inside the experimental house.

2. Body weight at five week intervals from fifth week of age.

3. Age at first egg in the flock

4. Age at 10 and 50 per cent production

5. Per cent egg production

6. Feed consumption and feed efficiency

7. Livability per cent

8. Egg weight based on weight of eggs produced during the last three days in each period

9. Egg quality parameters such as shape index, shell thickness, Albumen index, yolk index and Haugh Unit.

10. Correlation between part year and annual production.

Individual body weight of the birds were recorded at the end of each period to the nearest one gram. Treatmentwise feed issue and balance at the end of each period were recorded and from that the feed intake was calculated. Feed efficiency was calculated as quantity of feed consumed per dozen egg production.

The dead birds were replaced with birds from the same hatch reared separately as reserve for this purpose and thereby a constant floor density was maintained throughout the experimental period.

All eggs from each replicate during the last three consecutive days in each period weighed using a Sartorious top pan balance and recorded individually and mean egg weight was calculated. Two eggs from each replicate were taken at random during last three days of each period. They were marked, weighed individually and stored in refrigerator overnight for conducting internal quality studies in the next day. The breadth and length of eggs were recorded using Vernier Calipers and shape index was calculated as Breadth/Length x 100. The width of albumen and diameter of yolk were measured using Vernier Calipers. The heights of albumen and yolk were measured using Ames tripod stand micrometer. From the above data albumen and yolk indices were calculated. Shell thickness was measured using Ames micrometer after removing the shell membranes. Haugh Unit values were obtained by utilizing the ready reckoner table for Haugh Unit (Kondaiah et al., 1981).

The data were analysed as per methods followed by Snedecor and Cochran (1967).

Results

RESULTS

The observations recorded in the study to indicate the effects of floor density on production performance of Japanese quails in cage and deep litter systems of rearing are presented in this chapter.

Meteorological observations

The data pertaining to microclimate inside the experimental house in respect of ambient temperature (°C) and per cent relative humidity recorded during the experimental period are presented in table 3. the mean maximum temperature recorded was highest during the first period of the study, namely April-May and was 36.18°C. Subsequently the temperature gradually declined and reached 28.42°C during July-August which synchronised with fourth period of experiment and 21-25 weeks of age. Later, the mean maximum temperature again rose to 33.14°C at the ninth period ie. during January-February.

The mean minimum temperature varied from 24.64°C to 20.90°C during the period of experimentation.

The mean per cent relative humidity ranged from 70.4 to 95.0 in the morning and 35.6 to 83.8 in the afternoon.

In the first and second periods, the per cent RH in the morning was 81.2 and 87.8 respectively. During the periods from three to six, the RH was very high and was more than 90 per cent. Thereafter, it was 85.2, 70.4 and 74.8 per cent respectively in periods VII, VIII and IX. In the afternoon the per cent RH was not as high as that in the morning. In the first two periods, the RH was 48.2 and 65.6 per cent and thereafter showed an increase and remained between 73.6 and 83.8 per cent during third to six periods corresponding to June to October. The per cent RH showed a declining trend during VII and VIII periods (65.8 and 45.6 per cent) and was lowest during the ninth period (35.6 per cent).

Body weight

The mean body weight of Japanese quails recorded in the two systems of rearing as influenced by floor space allowance are presented in table 4. It was observed that the quails in cages showed a mean body weight of 168.80 g and that in deep litter was 167.79 g. On statistical analysis, it was revealed that the mean body weights were not significantly different between the systems of rearing ie. cage and deep litter.

The initial body weight of quails at the beginning of the experiment, ie. at the end of five weeks of age, averaged 98.13, 96.96, 96.25 and 96.47 g for experimental groups with floor space of 100, 150, 200 and 250 sq.cm. per bird respectively in cage systems. The mean body weights in deep litter system were 95.00, 95.25 and 95.99 g in groups given floor space of 150, 200 and 250 sq. cm per bird respectively. The differences in initial weights were not statistically significant among groups. The body weight recorded at the end of every five weeks were subjected to statistical analysis in order to evaluate the pattern of body weight maintenance in laying quails. However, in cage system of rearing, the quails reared on floor spaces 100 and 150 sq.cm per bird, the body weights were significantly lower than those reared with floor spaces of 200 and 250 sq.cm per bird ($P < 0.05$). The mean body weights of quails reared in floor space of 100 and 150 sq.cm per bird were in the same homogeneous group and the other two groups with higher floor space allowances formed another homogeneous group having higher body weights.

In deep litter system, the quails reared with floor space of 250 sq.cm per bird had significantly higher body weights than those reared with floor space of 200 sq.cm per bird. The body weights of groups reared with floor space of 150 sq.cm per bird was intermediary between 200 and 250 sq.cm per bird.

The mean body weights recorded at various periods showed that there was a trend of marked increase in body weights upto 15 weeks of age followed by a sudden decline in respective weights at 20 weeks of age with all floor spaces studied in both cage and deep litter systems of rearing. Thereafter the body weights increased at 30 weeks of age. The highest weight in group I was recorded at 35th week whereas in group II and III were at 30th week and that in group IV at an early age,ie.,15th week of age. In deep litter system, the highest mean weights were recorded at 25 weeks of age. The difference in weights among periods in their respective groups were statistically significant ($P < 0.05$).

The variation in mean body weights in quail hens recorded at five weeks intervals from fifth to fiftieth weeks of age in cage system of rearing with varying floor space allowances are depicted in fig. 1. Table 4 shows that the mean of body weights of birds in treatment groups reared with floor space of 100, 150, 200 and 250 sq.cm per bird in the cage system of rearing averaged to 166.75 ± 8.62, 166.08 ± 8.99, 171.05 ± 9.46 and 171.32 ± 9.31 g respectively and is diagramatically represented in fig. 3.

The periodwise variation of body weight pattern in deep litter reared quails in depicted in fig.2

The pooled mean for the weight of birds at various periods on deep litter with floor space of 150, 200 and 250 sq.cm per bird averaged to 165.10 ± 8.83, 167.48 ± 9.05 and 170.67 ± 9.93 g respectively and its variation is represented graphically in fig.3.

Fig.1. Effect of floor space on the body weight(g) in Japanese quails reared in cages

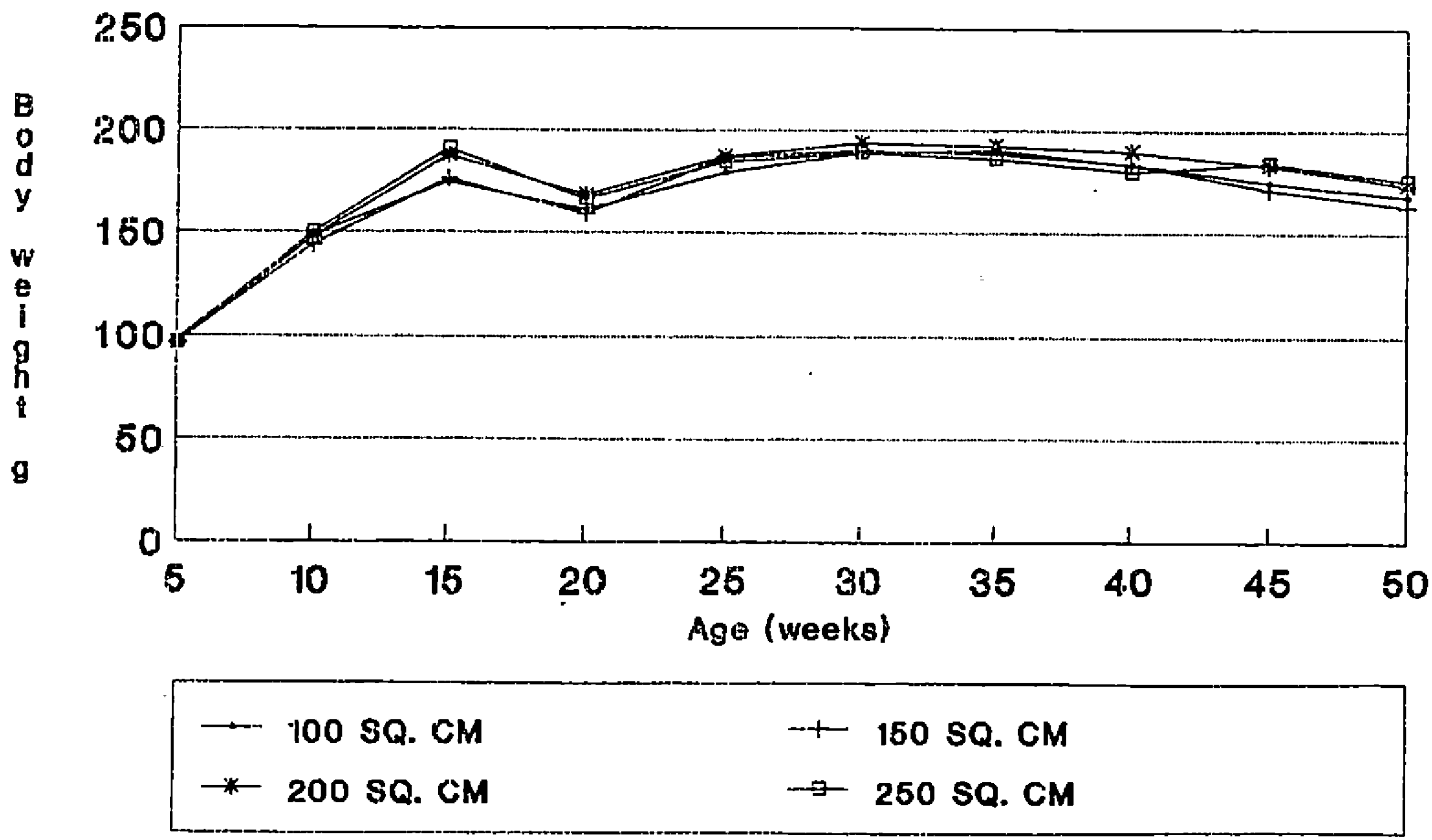


Fig.2. Effect of floor space on the body weight(g) in Japanese quails reared in deep litter

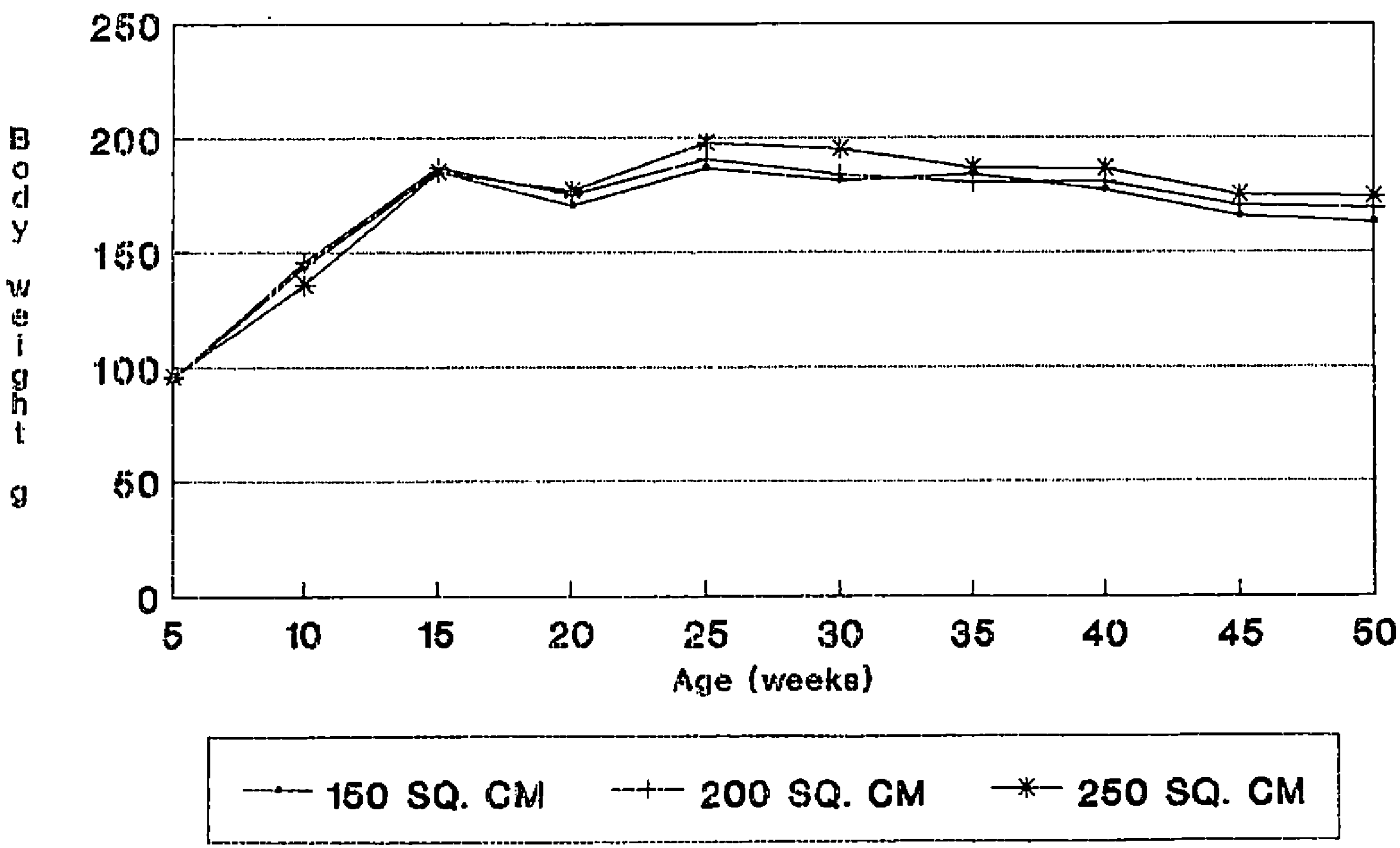
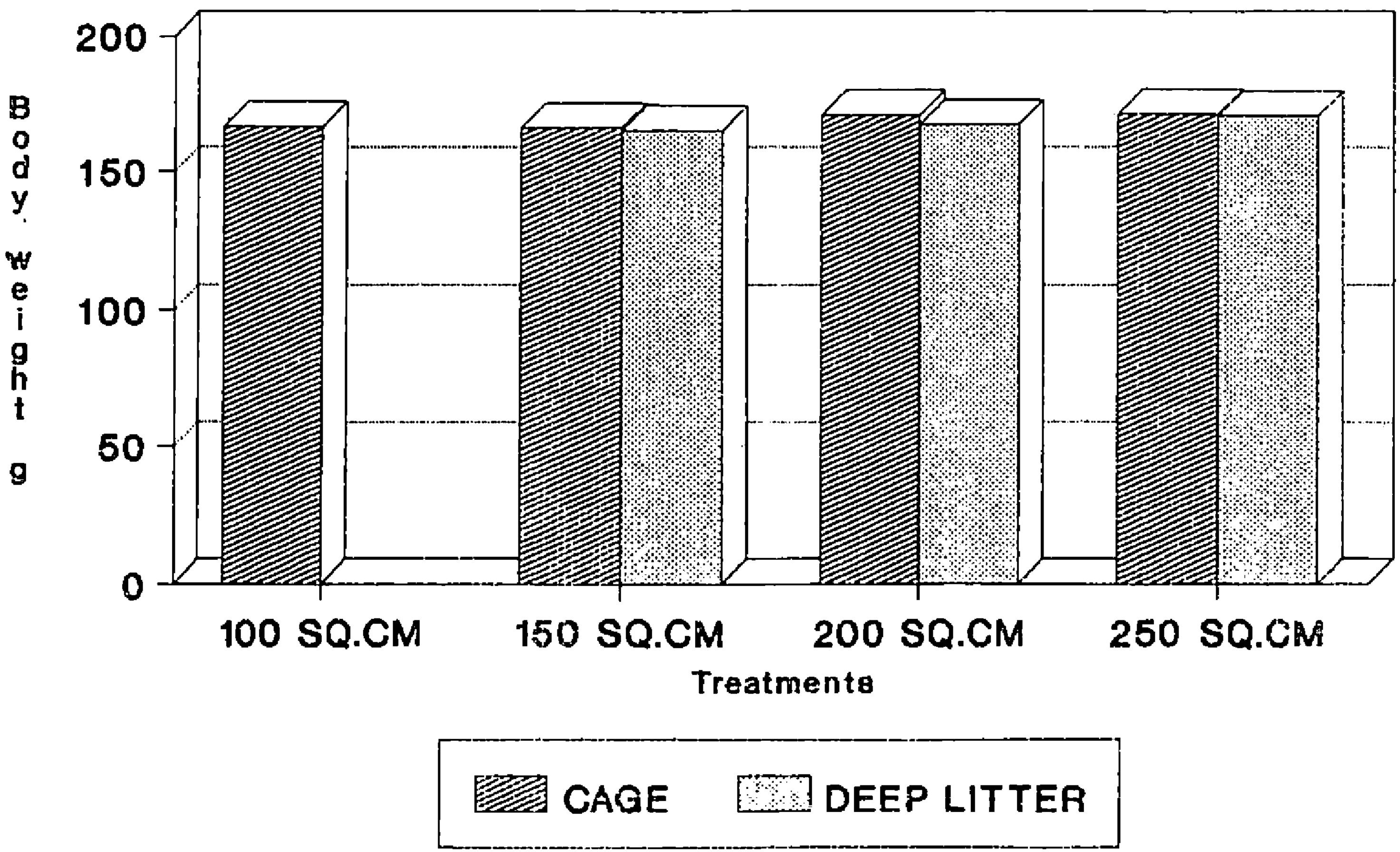


Fig.3.Effect of floor space allowance on the body weight(g) of Japanese quails in cage and deep litter system of rearing



Age at first egg

The data pertaining to age at first egg as influenced by floor space and systems of rearing are presented replicate wise in Table 5. These results show age at first egg in the flock as well as the average age at first egg in each floor space. Statistical analysis of the data showed significant difference between the two systems of rearing ($P < 0.05$). The age at first egg of caged birds within the groups which was provided with floor space of 100, 150, 200 and 250 sq.cm per bird were 51, 52, 54 and 55 days respectively. In the corresponding groups, the average age at first egg for replicates put together were 57.00$\pm$2.04, 55.50$\pm$1.71, 56.75$\pm$1.80 and 60.50$\pm$2.66 day.

In deep litter system of rearing the mean age at first egg was 64.25$\pm$3.82, 61.25$\pm$4.03 and 85.50$\pm$5.25 days in floor space of 150, 200 and 250 sq.cm per bird respectively. Analysis of the data showed significant difference between the various floor space allowances ($P < 0.05$). The age at first egg in groups with floor space of 150 and 200 sq.cm per bird were statistically similar. However in the groups given 250 sq.cm per bird, the age at first egg was significantly higher than those in the other groups ($P<0.05$).

In deep litter system the first egg in groups provided with floor space of 150, 200 and 250 sq.cm. were recorded at the age of 55, 53 and 76 days respectively showing a different trend in comparison to cage system. Moreover, the sexual maturity in the group given floor space of 250 sq.cm per bird was delayed in all replicates.

Age at 10 per cent production

The data presented in Table 6 showed that the birds reached 10 per cent production at 61.75 days of age in cages as against 73.42 days in deep litter system of rearing. Statistical analysis showed that there is significant difference in age at 10 per cent production between cages and deep litter reared birds ($P < 0.05$). These results indicated that the birds reached 10 per cent production earlier in cages than in deep litter system.

The age at 10 per cent production in birds reared in cages was analysed by taking into consideration replications in each of the four experimental groups. It was found that there was no significant difference between the treatments ($P < 0.05$).

The mean age at 10 per cent production were 60.25 ± 2.56, 69.50 ± 7.73, 56.75 ± 1.80 and 60.50 ± 2.66 in groups given floor space of 100, 150, 200 and 250 sq.cm. per bird. The data revealed that age at 10 per cent production was higher in groups I and IV given floor space of 100 and 250 sq.cm per bird, but was the lowest in group III given a floor space of

200 sq.cm per bird and the highest in group II given a floor space of 150 sq.cm per bird.

In deep litter system, the group VI given floor space of 200 sq.cm per bird recorded the lowest mean age at 10 per cent production (61.25±4.03) as was observed in cages. On the contrary, the floor space of 250 sq.cm per bird resulted in a highest value of 85.00±5.25 days as against 60.50±2.66 in cages. The birds given floor space of 150 sq. cm per bird attained 10 per cent production at an age of 73.50±4.57 days. The difference between the mean values among the floor spaces were statistically significant in deep litter system of rearing and the mean values recorded in this system were higher in comparison with all the respective values in cage system. Thus, the age at 10 per cent production was very much delayed in deep litter system of rearing.

Age at 50 per cent production

The age at 50 per cent production (Table 7) showed that the overall mean was lower in cages (88.75 days) than in deep litter (103.75 days) system of rearing. Statistical analysis has shown that age at 50 per cent production is significantly lower in cages than that in deep litter ($P < 0.05$).

The data pertaining to the effect of different floor spaces on the age at 50 per cent production revealed that as floor space per bird was increased in cages, Japanese quails reached 50 per cent production at an early date. Thus the mean values recorded with floor space of 100, 150, 200 and 250 sq.cm per bird were 99.00±8.38, 89.75±14.59, 82.75±6.61 and 83.50±5.55 days respectively. The group III given a floor space of 200 sq.cm per bird had the lowest age at 50 per cent production. The data on the effect of different floor space allowance in deep litter reared birds on the age at 50 per cent production are given in table 7. The overall means of the age at 50 per cent production for 150, 200 and 250 sq.cm floor space per bird are 103.50±9.91, 107.00±5.99 and 100.75±0.85 days respectively. On statistical analysis, it was observed that there is no significant difference among the three treatment groups under consideration. The age at 50 per cent production in group VII given a floor space of 250 sq.cm per bird was advanced eventhough the 10 per cent production was delayed in this group.

Per cent Egg Production

The age-wise mean per cent egg production in different treatment groups are presented in table 8.

The overall mean per cent egg production during the period from five to fifty weeks of age in cage and deep litter systems of rearing were 46.21 and 38.90 respectively. On analysis, it was observed that the egg production was statistically non-significant in any of the systems studied. However, the trend of results showed that the egg production was numerically higher in cage system to the tune of 7.31 per cent.

Statistical analysis of difference in egg production among the different floor space allowances within cage system revealed that per cent egg production increased with increase in floor space allowance provided. Quails provided with 200 and 250 sq.cm in cages showed superior production than the two lower levels of floor spaces provided. Statistical analysis of the data within cage system showed that the egg production was increased significantly at higher floor space allowances of 200 and 250 sq.cm per bird in comparison to lower floor space allowances ($P < 0.05$).

The highest per cent egg production in the cage system was recorded in group III provided with floor space of 200 sq. cm per bird.

The overall mean per cent egg production in cages were 44.27 ± 7.10, 41.64 ± 7.16, 51.03 ± 6.78 and 48.56 ± 7.18 for the groups provided with floor space of 100, 150, 200 and 250 respectively and are depicted in fig.6.

Periodwise egg production (Table 8) showed that there was significant difference in egg production ($P < 0.01$) and the periodwise trend is shown in fig. 4. The egg production during the periods from 21 to 40 weeks of age was more or less uniform and was classified into a homogeneous group with all floor spaces studied in cage system of rearing. The egg production recorded during 41 to 50 weeks of age showed drastic reduction. The magnitude of difference in egg production between the period seven (36-40 weeks) and eight (41-45 weeks) was more than twenty per cent and that between eighth and ninth (46-50 weeks) periods was around ten per cent. The egg production recorded during 46-50 weeks of age was almost similar to that recorded during 11 to 15 weeks of age and thus these periods formed a homogeneous group.

The egg production during the periods 16 to 20 and that during 41 to 45 weeks of age were intermediary and were significantly different from one another.

The peak production in groups I and IV given floor space of 100 and 250 sq.cm per bird were 68.23 and 66.89 per cent respectively at 31-55 and 21-25 weeks of age, whereas in groups II and III the peak yield with floor spaces of 150 and 200 sq.cm per bird were 65.34 and 69.80 per cent respectively both being recorded at the age of 26-30 weeks.

The mean per cent egg production revealed from the three experimental groups in deep litter systems are given in Table 8 and the influence of floor space on egg production is graphically represented in figs. 5 & 6. The mean per cent production for the treatment groups are 35.87±6.56, 39.64±7.10 and 41.19±8.06 with an overall mean of 38.90±S.E.

The differences between the mean values were statistically . . . ·significant among each other. The lowest per cent production was recorded with a floor space of 150 sq.cm and the highest with 250 sq.cm per bird.

In all the three groups, the egg production was lower than those recorded in the corresponding groups employed in cages. The peak production was very low with floor space of 150 sq.cm and was only 5 per cent at 21-25 weeks of age whereas in groups given floor space of 200 and 250 sq.cm per bird, the peak yield were 62.86 and 68.94 per cent respectively, at the age of 26-30 weeks. In group given floor space of 250 sq.cm per bird, the peak yield as well as the total yield were relatively better inspite of the fact that these birds did not come to lay until 10 weeks of age.

Feed consumption

The mean daily feed consumption (g) as influenced by floor space and systems of housing are given in Table 9.

Fig.4. Effect floor space on the per cent egg production in Japanese quails reared in cages

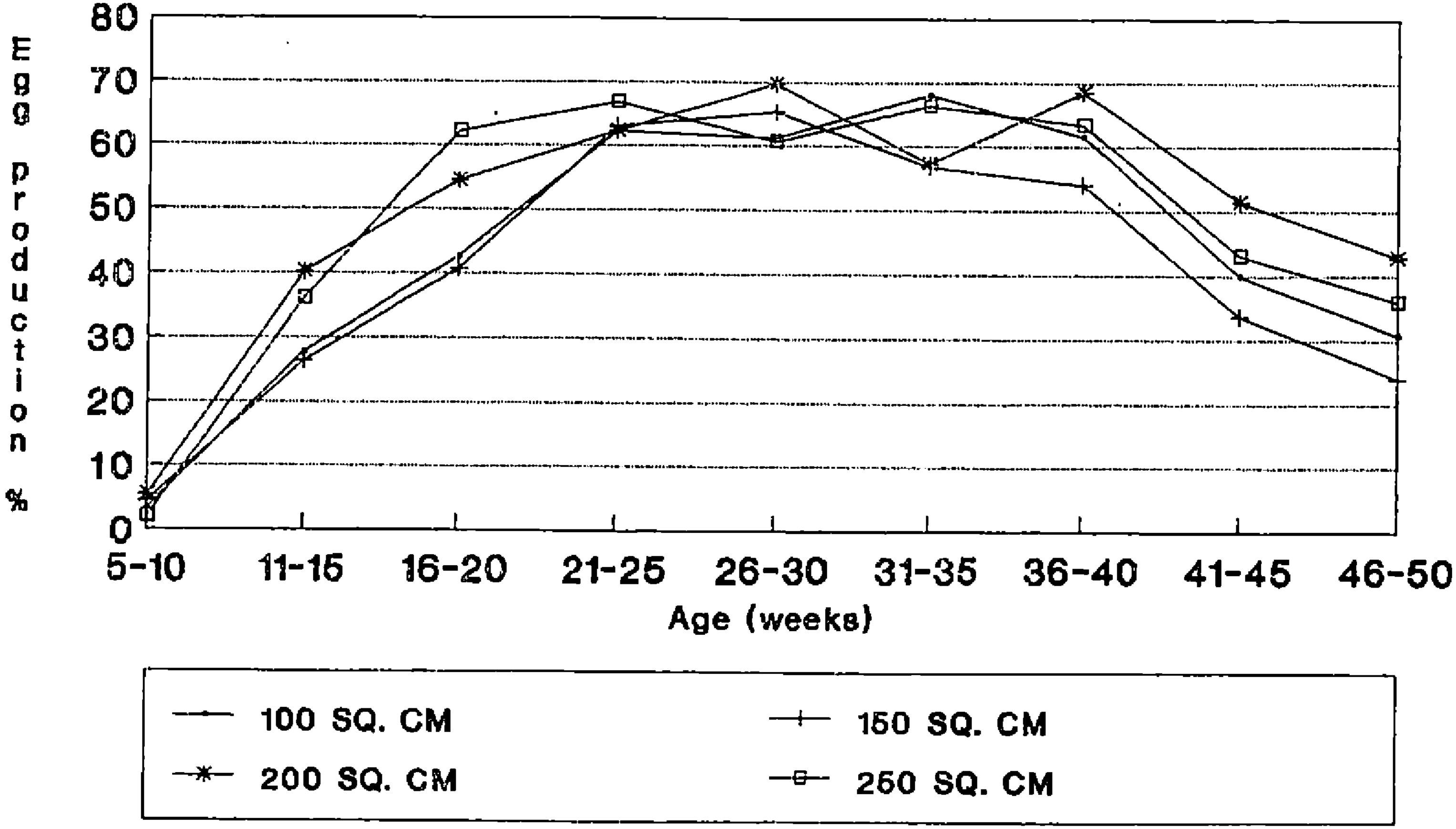


Fig.5. Effect of floor space on the per cent egg production in Japanese quails reared in deep litter

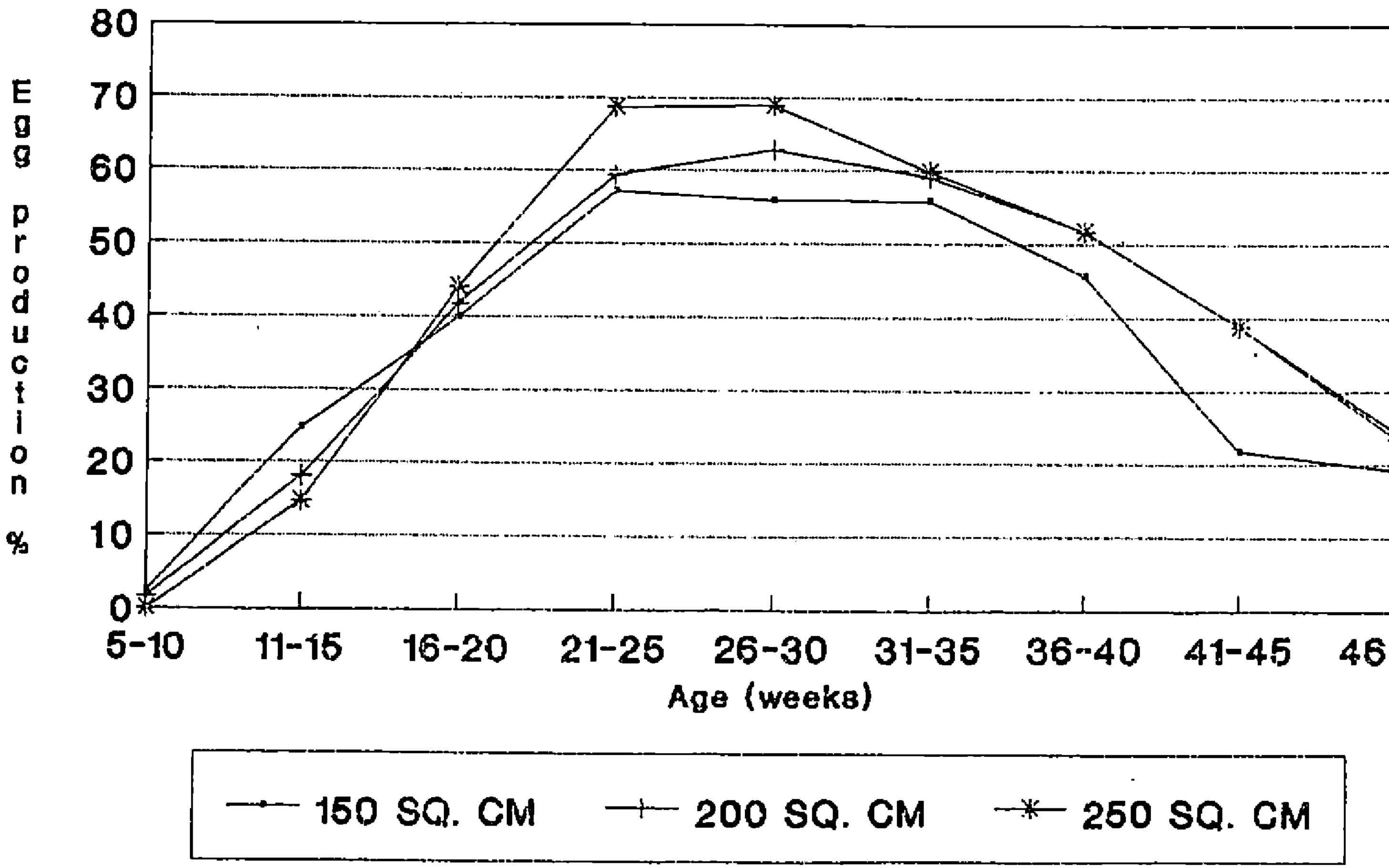
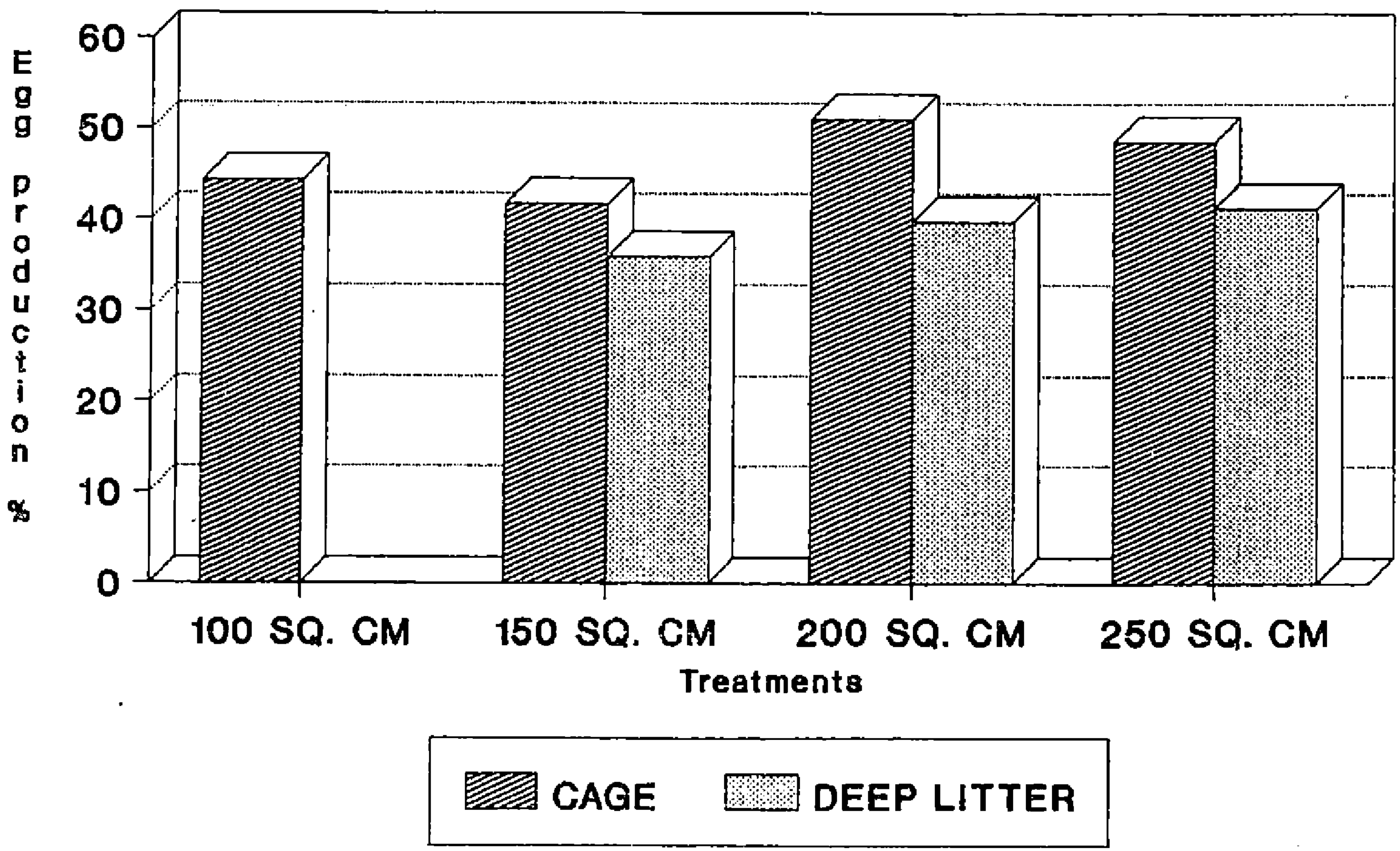


Fig.6.Effect of floor space allowance on the per cent egg production in Japanese quails in cage and deep litter system of rearing

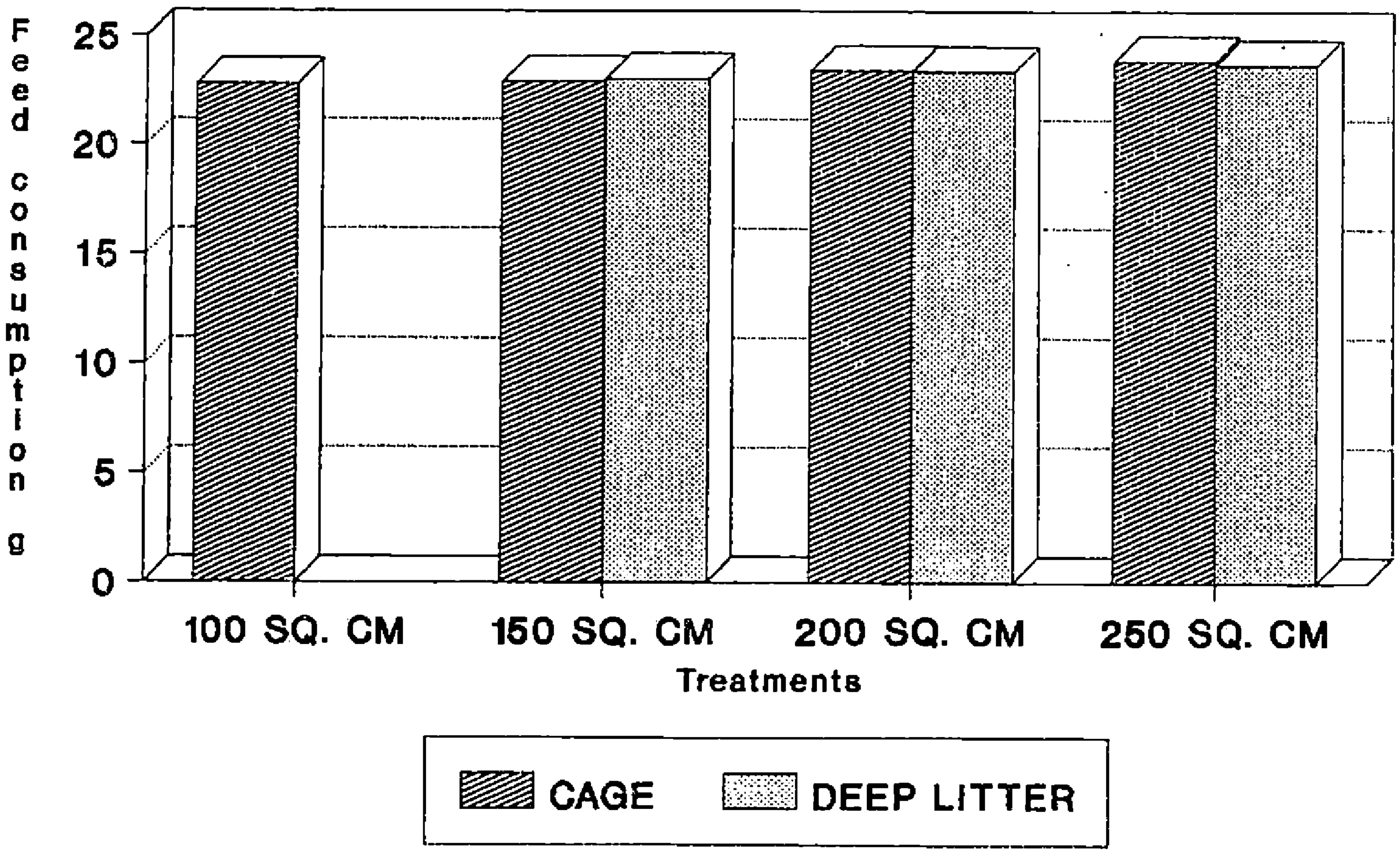


The average feed consumed per bird per day during the period from five to fifty weeks in cages was found to be 23.24 (g) and that in deep litter was 23.38 (g) and the mean values did not differ significantly (P < 0.05). However the differences in feed intake within the system were significant between the floor space allowances studied. The average feed consumption per bird per day for the four treatment groups in cages, ie. 100, 150, 200 and 250 sq.cm per bird are 22.81±0.66, 22.93±0.65, 23.42±0.68 and 23.87±0.58 g respectively. The graphical representation of the overall means are given in fig.7. Statistical analysis indicated that there is significant difference in feed consumption due to variation in floor space. The feed consumption in quails given floor space upto 200 sq.cm per bird was statistically comparable whereas quails reared with floor space of 250 sq.cm per bird consumed significantly higher quantities of feed than those given lesser space.

The periodwise data showed that the highest feed intake occurred during 31 to 35 weeks of age in all the groups (Table 9). The variation in mean daily feed intake ranged from 19.29 to 24.73, 19.84 to 25.0, 20.11 to 25.29 and 20.27 to 25.67 g in groups given floor space of 100, 150, 200 and 250 sq.cm per bird respectively.

In deep litter system, the mean daily feed intake averaged 23.05±0.67, 23.39±0.75 and 23.71±0.71 g in groups

Fig.7. Effect of floor space allowance on the feed consumption (g/bird/day) in Japanese quails in cage and deep litter system of rearing



given floor space of 150, 200, 250 sq. cm per bird respectively and was significantly different among each other (P < 0.01). The trend of results also showed significant increase in feed intake with an increase in floor space per bird in deep litter system of rearing.

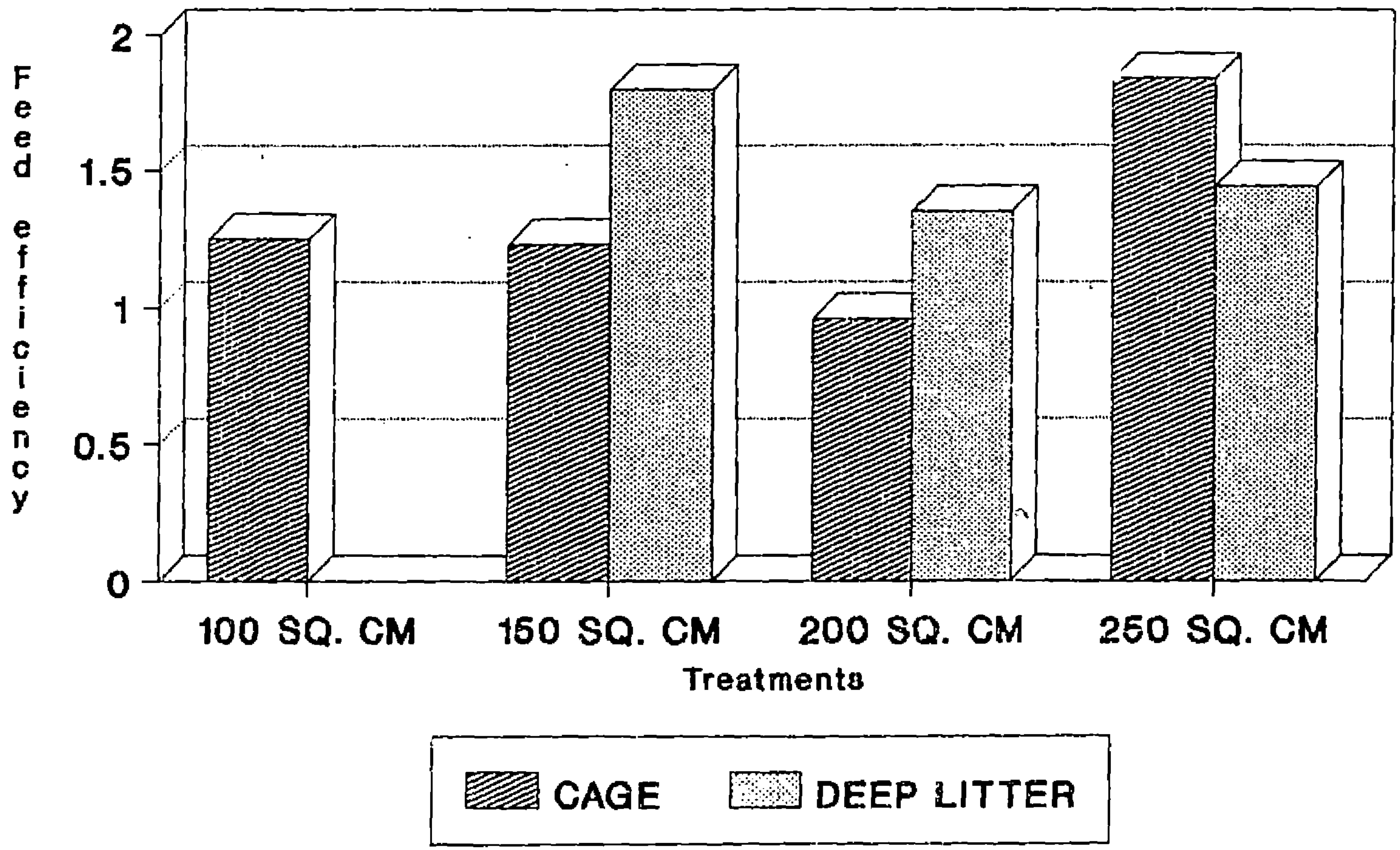
The period wise consumption in deep litter system had shown that the highest feed intake was during 36-40 weeks of age in all groups. The variation in mean daily feed intake ranged from 19.25 to 25.27, 19.86 to 25.71 and 20.45 to 25.98 g in groups given 150, 200 and 250 sq.cm per bird respectively.

Feed efficiency

The periodwise mean feed efficiency calculated as kg feed per dozen eggs as influenced by floor space and systems of rearing are presented in table 10. The average values of feed efficiency for birds reared in cages and deep litter were 1.32 and 1.34 respectively. On statistical analysis, it was observed that the two systems of housing did not differ significantly.

The feed efficiency shown by birds reared in the four treatment groups in cages are given in table 10 and depicted in fig.8 The feed efficiency shown by the Japanese quails grown in the four treatment groups I to IV averaged

Fig.8.Effect of floor space allowance on the feed efficiency (kg feed/dozen eggs) in Japanese quails in cage and deep litter system of rearing



1.25±0.63, 1.23±0.53, 0.96±0.44 and 1.84±1.25. On analysis, it was observed that the floor space allowances did not significantly affect the feed efficiency. But it is evident that the conversion efficiency was better in the group given floor space of 200 sq.cm per bird. The mean value was the lowest in this group.

Periodwise feed efficiency indicated that it ranged from 0.43 to 6.29, 0.44 to 5.41, 0.40 to 4.51 and 0.43 to 11.82 in groups I to IV. The highest numerical values were reported during 6 to 10 weeks of age in all groups and it was statistically significant ($P < 0.05$) in comparison with that in other ages.

In deep litter system of rearing, the average values of the feed efficiency shown by the three treatment groups are 1.80±1.02, 1.35±0.59 and 1.44±0.65 respectively and are depicted in fig.8. On analysis, it was seen that the treatments did not significantly affect the feed efficiency. But periods had significant effect ($P < 0.01$) on feed efficiency.

Livability

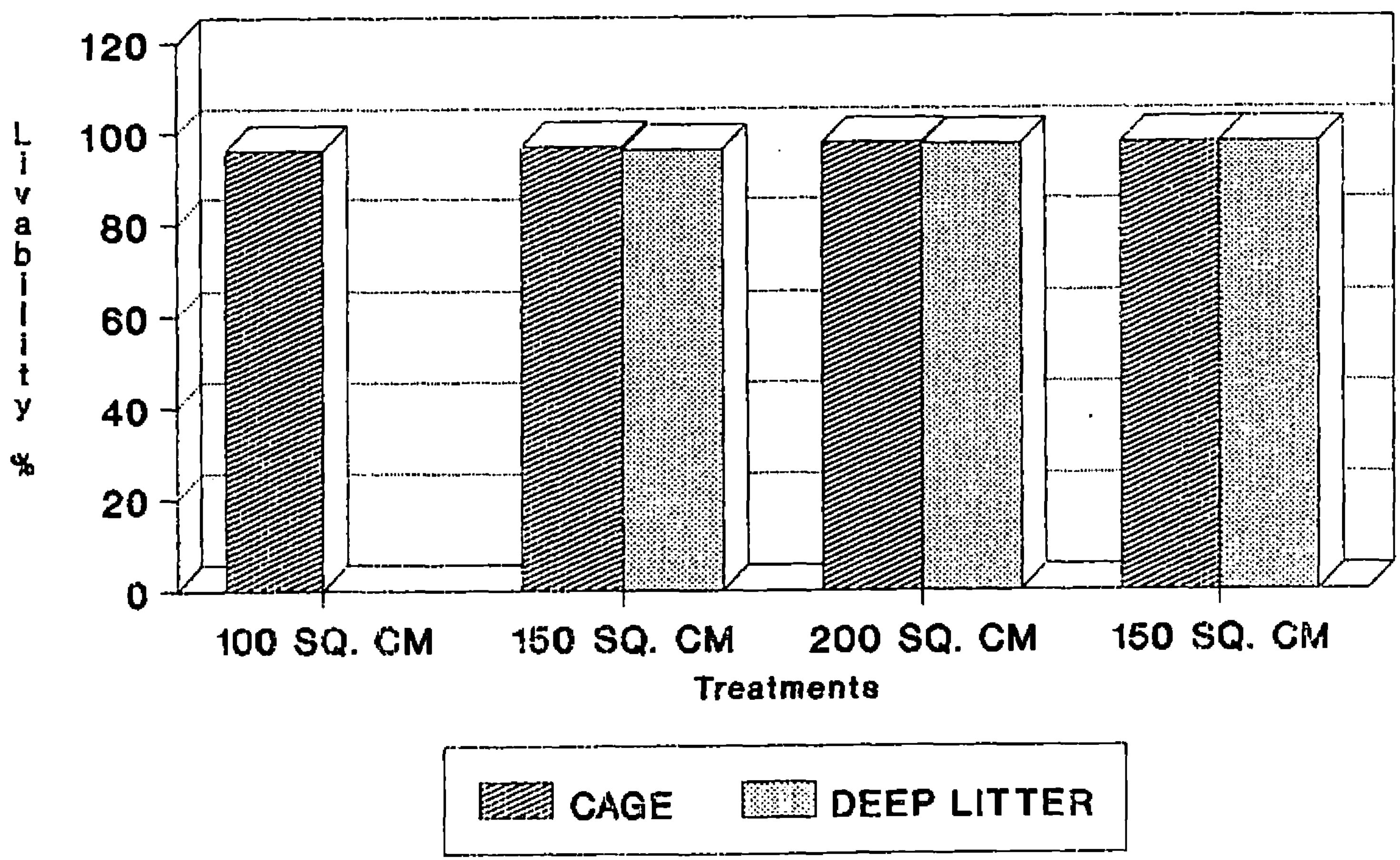
The livability per cent in Japanese quails reared in cages and deep litter are detailed in table 11. There was no statistically significant difference in the livability per cent between the two housing systems and the average values were 97.23 and 97.26 respectively in cage and deep litter systems.

The periodwise livability percentage in Japanese quails during the entire period of experimentation presented in table 11 revealed that the overall mean livability per cent for the four treatments in cages are 96.22±1.703, 97.01±0.91, 97.78±0.97 and 97.91±0.74. On statistical analysis, it was observed that floor space had no significant effect on livability. The periodwise livability percentages did not show any specific pattern in the incidence of mortality. The mean livability per cent in deep litter system for the three treatment groups averaged 96.37±1.30, 97.50±1.18 and 97.92±1.17. On analysis of the data, it was observed that floor space allowance had no significant effect on the livability of quails on deep litter. The overall mean livability of birds reared in both cages and deep litter system are depicted in fig. 9.

Egg weight

The mean egg weight as influenced by floor space allowances and system of rearing are detailed in Table 12. The cage and deep litter systems of housing had statistically significant effect ($P < 0.01$) on egg weight. The weight of eggs from birds in cages averaged 10.61 and that from deep litter averaged 10.19 g.

Fig.9.Effect of floor space allowance on the livability(%) of Japanese quails in cage and deep litter system of rearing

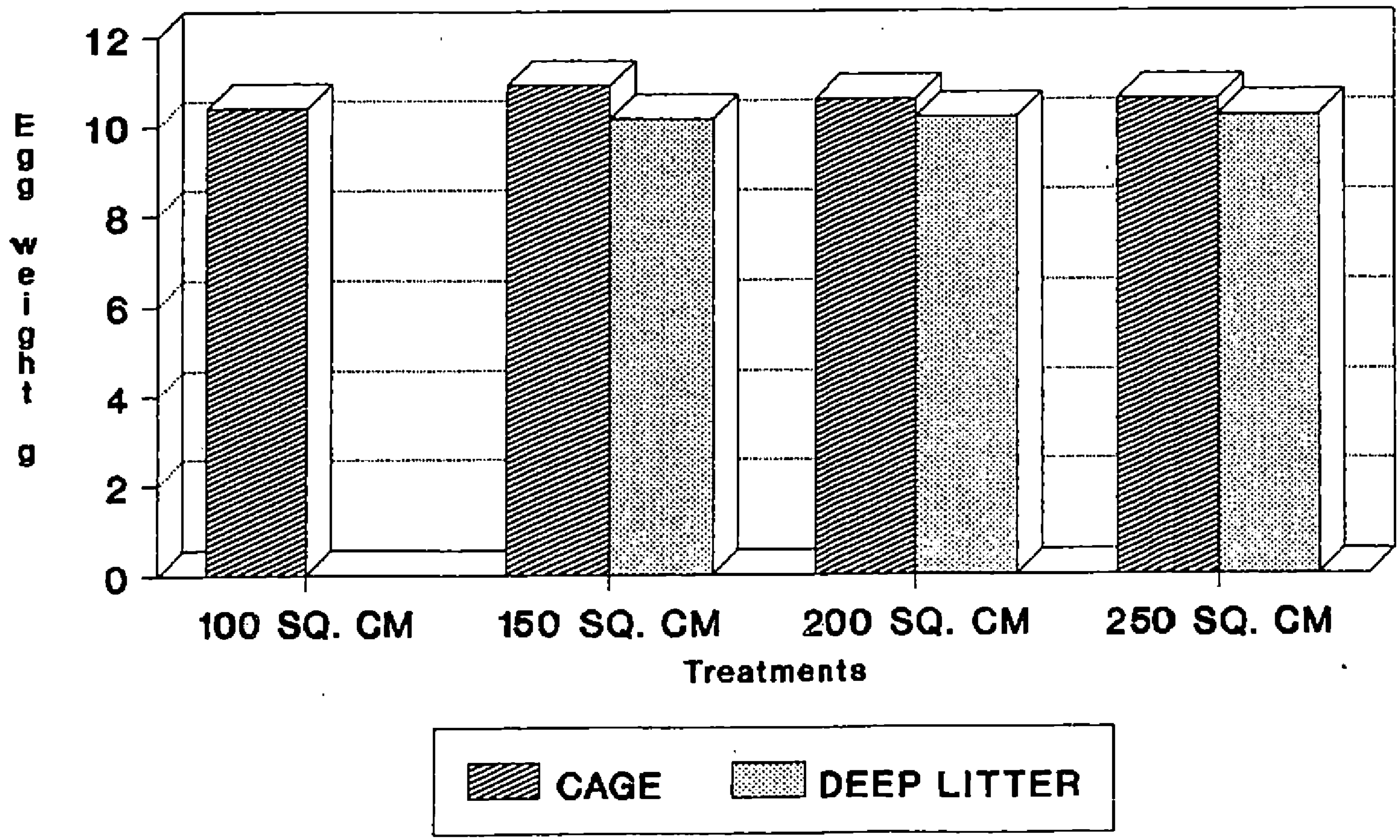


The mean egg weight in each period for the birds reared in cages in different floor densities and the overall means presented in table 12 showed that average egg weight in treatment groups I, II, III and IV are 10.40±0.22, 10.90±0.18, 10.58±0.21 and 10.58±0.16 g respectively with an overall mean of 10.61 g. Statistical analysis revealed that there is significant difference due to the variations in floor space allowance. The experimental groups given floor spaces 100, 200 and 250 sq. cm per bird (I, II and IV) were found to be homogeneous. The group II with a floor space 150 sq.cm per bird laid eggs with significantly higher weight in comparison with the other groups. The mean egg weight in the groups (III and IV) given floor space of 200 and 250 sq.cm was uniform and was 10.58 g in both groups. The difference in egg weight between groups (I and II) given floor space of 100 and 150 sq.cm per bird was marked and was 0.50 g higher in the latter than the former.

The periodwise egg weight in cage system revealed that all groups attained the highest egg weight at the age of 21 to 25 weeks. Thereafter the egg weight declined gradually and reached the lowest during the period 46 to 50 weeks of age, wherein, it was less than 10 g in all experimental groups ranging from 9.28 to 9.73 g.

The data on the effect of floor space on the egg weight in deep litter reared birds on analysis revealed that the different floor space allowances did not significantly affect the egg weight. But age of quails showed a significant effect ($P < 0.05$) on egg weight. The mean egg weights for the three treatment groups are 10.15 ± 0.21, 10.18 ± 0.15 and 10.22 ± 0.17 g respectively with an overall mean of 10.19g. In all these groups the mean egg weights recorded were lower than those in the corresponding groups of cage systems. The period wise egg weight in deep litter system of rearing showed that the maximum egg weight recorded was 10.91, 10.70 and 10.74 in groups given floor space of 150, 200 and 250 sq.cm per bird respectively at the age of 31-35, 21-26 and 41-45 weeks of age. These results did not appear to show any regular pattern in respect of egg weight in relation with age of birds. The egg weights towards the end of the experiment ranged from 9.00 to 10.36 among the groups at 46 to 50 weeks of age. In group VII, which is provided with a floor space of 250 sq.cm per bird, the sexual maturity was delayed and as such no egg production was recorded until 10 weeks of age. Hence, relatively better egg weight was recorded in this group than the other two groups. The mean egg weights of eggs obtained from the different treatment groups in cages and deep litter are depicted in fig. 10.

Fig.10 Effect of floor space allowance on the egg weight(g) of Japanese quails in cage and deep litter system of rearing



Egg quality traits

Shape Index

The average shape index for eggs obtained from quails reared in cages and deep litter are given in table 13. The overall mean values for cage and deep litter systems were 78.89 and 78.85 respectively. On analysis of the data, it was found that there is no statistically significant difference in shape index of eggs obtained from cages and deep litter.

The data pertaining to the shape indices of eggs obtained from different treatment groups in cages (table 13) showed that the mean shape indices for the four treatment groups in cages were 78.79±0.40, 78.96±0.28, 78.94±0.34 and 78.85±0.25 respectively. On analysis, the four treatment groups were found to have non significant effect on the shape index.

The data pertaining to the shape indices of eggs obtained from the three treatment groups in deep litter system had the mean values, 79.19±0.60, 79.12±0.466 and 78.25±0.34 respectively for the three treatment groups. On statistical analysis it was found that the shape indices do not differ significantly among different floor spaces.

Although the systems of rearing and the different floor spaces within the systems did not change the shape index of eggs appreciably, it is interesting to note that the age of birds in deep litter system did influence the shape index markedly ($P < 0.01$). But this phenomenon was not evident in cage system.

Albumen Index

The overall mean albumen index of eggs detained from birds in cages was found to be 0.100 and that from deep litter, 0.103 (Table 14). Analysis of the data showed that the system of housing had no statistically significant effect as far as this parameter is concerned.

From the analysis of the data, it was observed that different floor densities did not significantly affect the albumen index in cages. The mean albumen index of the eggs from the four different floor density groups are 0.098 ± 0.005, 0.99 ± 0.003, 0.101 ± 0.004 and 0.098 ± 0.004. The period wise albumen indices of eggs from the different treatment groups differed significantly ($P < 0.05$).

It was observed that the periods three, four, five, seven, eight and nine were homogeneous. However, the age of birds resulted in marked variations in albumen index at the age of 15 and 25 weeks due to cage system of rearing.

From the analysis of the data, it was observed that the three different floor densities did not significantly affect the albumen index of eggs from deep litter. The periodwise data are given in table 14. The mean albumen indices of eggs from the three treatment groups averaged 0.107±0.005, 0.1013±0.002 and 0.099±0.003 respectively. Periodwise data did not reveal any appreciable difference in albumen quality of eggs due to age of birds in deep litter system of rearing.

Yolk index

The data presented in table 15 showed that yolk indices of eggs from cage and deep litter systems of rearing did not differ significantly. The average yolk index of eggs from cages is 0.477 and that from deep litter is 0.449.

The data on the yolk index of eggs obtained from birds reared in four different floor densities in cages are given in table 15. The mean values of the yolk indices for different treatment groups are 0.474±0.005, 0.477±0.005, 0.471±0.007 and 0.486±0.007. Statistical analysis had shown that there exists no significant difference between the four treatments as far as the yolk index is concerned. But periods showed significant difference. It was observed that periods one, two, five, six, eight, nine did not show any significant difference. Same was the case with the periods two, seven and eight. This showed that the age of birds showed an influence on the yolk index when quail hens are housed in cages. The eggs from caged quails have high yolk quality at the age of 25 weeks.

The data on yolk index of eggs detained from different treatment groups in deep litter are given in table 15. The mean values of yolk indices of eggs from three different floor densities in cages averaged 0.487 ± 0.009, 0.479 ± 0.012 and 0.486 ± 0.006. Statistically, it was observed that treatments did not significantly affect the yolk index of eggs from deep litter. The periodwise data did not differ significantly among periods indicating that the age of birds had no marked influence in yolk index of eggs obtained from quails reared on litter floor.

The data pertaining to egg quality traits revealed that neither the system of rearing nor the floor space allowances within the systems influenced the quality of eggs. However, the age of birds significantly influenced the shape index in deep litter system of rearing only. While both albumen index and yolk index showed influence only in cage system indicating the peculiar effect of certain quality traits in certain system of rearing at a particular age.

Shell thickness

The data pertaining to the effect of cage and deep litter system of rearing on the shell thickness of eggs obtained from Japanese quails is detailed in table 16. The average shell thickness of eggs from cages averaged 0.224 mm and that from deep litter averaged 0.221 mm, the difference being not statistically significant.

The statistical analysis of the data on shell thickness revealed that the different floor densities did not affect the shell thickness of eggs obtained from birds in cages. The average value of shell thickness worked out to 0.227±0.004, 0.224±0.004, 0.218±0.001 and 0.226±0.006 for treatment groups 100, 150, 200 and 250 sq.cm per bird respectively.

In deep litter system of rearing, the average values of shell thickness obtained for the three different treatment groups averaged 0.220±0.004, 0.222±0.004 and 0.220±0.004 mm. Statistical analysis indicated no significant difference between the three treatments ($P < 0.05$) and also between the periods.

Haugh unit

The mean Haugh unit score of eggs obtained from cage and deep litter system averaged 52.637 and 54.190 respectively. On analysis, it was observed that they did not differ statistically.

The average Haugh Unit scores of eggs obtained from the cages were 53.18±2.18, 51.42±1.33, 53.12±1.58 and 52.67±1.71

respectively for the floor spaces 100, 150, 200 and 250 sq. cm per bird. On analysis, it was observed that the treatments did not significantly affect the Haugh Unit of eggs obtained from cages. But the various periods, significantly ($P < 0.01$) affected the Haugh Unit. The homogeneous periods were one, two, four, eight and nine, three and six, six and five and five and seven. The analysis of data for Haugh Unit score of the different treatment groups in deep litter indicated that the different floor space allowances have no significant differences on the Haugh Unit score. The mean Haugh Unit Scores were 55.01 ± 1.79, 55.01 ± 0.87 and 53.19 ± 1.13 respectively for 150, 200 and 250 sq.cm floor space per bird.

The data on the Haugh Unit Score of eggs obtained from the different treatment groups in both systems of housing and their overall means are presented in table 17.

Correlation between part year and full year productions

Tenth week to 45th week production was correlated with 50th week production considering both the systems of rearing. It was observed that except the correlation of 10th to 50th week production, all other correlations were highly significant ($P < 0.01$). But high correlations were obtained for 35th and 50th, 40th and 50th and 45th and 50th week production. So selection based on part year production upto 35th week can prove to be effective.

Considering the egg production in cages, correlations of part year productions were taken. It was observed that very high correlation started to occur from 15th week onwards and it gradually increased and reached the maximum for the correlation of 45th and 50th week production. So selection can be made when at 15 weeks of age in breeder quails in cages. In deep litter system, significant correlations were obtained only from correlation of 30th week production to 50th week production, but high correlation was observed from 35th, 40th and 45th weeks and 50th weeks total production. So selection can be done at the age of 35 weeks.

The details of the various correlations are given in table 18.

Economics

Table 19 illustrates the effect of floor density on economics of production in Japanese quails in cages and deep litter. Economics was calculated on a return over the total feed cost per bird in315 days. According to the data cages had a better effect compared to deep litter. The details are well narrated in table 19. In the cages itself, a floor space allowance of 200 sq.cm per quail was found much superior to others as far as the return over feed cost per bird per unit floor space in 315 days is concerned. So it can be calculated that a floor space allowance of 200 sq.cm per bird was found to surpass all the other treatment groups and so this can be given as a recommendation.

Table 3. Meteorological observations recorded inside the experimental house.

	Age in weeks/periods/months								
	6-10 I Apr.- May	11-15 II May- June	16-20 III June- July	21-25 IV July- Aug.	26-30 V Aug.- Sept.	31-35 VI Sept.- Oct.	36-40 VII Oct.- Nov.	41-45 VIII Nov. Dec.	46-50 IX Dec.- Jan.
Ambient Temperature (°C)									
Maximum	36.18	32.74	29.56	28.42	29.88	30.36	31.24	31.14	33.14
Minimum	24.64	24.42	23.34	22.92	23.10	22.94	23.08	22.08	20.90
Percent Relative Humidity									
Morning	81.20	87.80	93.00	95.00	93.80	92.60	85.20	70.40	74.80
Afternoon	48.20	65.60	77.20	83.80	73.60	74.00	65.80	45.6	35.60

Table 4. Mean body weights (g) up to 50 weeks in Japanese quails as influenced by system of rearing and floor space allowance.

Treatments	Age in weeks										Mean $\pm$ SE
	5	10	15	20	25	30	35	40	45	50	
CAGE											
I	98.125	148.50	174.37	160.98	179.30	189.15	190.13	183.55	174.75	168.10	166.75 ± 8.62^{a}
II	96.95	144.24	175.89	159.33	186.96	190.35	188.75	183.48	171.45	163.42	166.08 ± 8.99^{a}
III	96.25	147.88	187.40	168.07	187.35	194.10	192.70	190.10	183.00	173.65	171.05 ± 9.46^{b}
IV	96.41	149.93	190.72	166.44	184.69	189.13	186.24	179.69	184.19	175.80	171.32 ± 9.31^{b}
Mean											168.80 ± 4.38^{x}
DEEP LITTER											
V	95.00	143.85	185.31	170.00	186.58	181.18	183.96	176.92	165.50	162.65	165.10 ± 8.83^{a}
VI	95.25	145.50	186.90	174.83	190.58	183.93	180.30	180.45	169.90	169.15	167.48 ± 9.05^{ab}
VII	95.99	135.69	184.88	176.49	197.56	194.94	186.50	186.19	174.74	174.06	170.67 ± 9.93^{b}
Mean											167.79 ± 5.18^{x}

Means bearing the same superscript did not differ significantly ($P < 0.05$) within the system.

Table 5. The age at first egg (days) in Japanese quails as influenced by system of rearing and floor space allowance.

System of rearing	Floor space Sq.cm./bird	Experi-mental groups	Replications				Overall means±SE
			1	2	3	4	
A. Cage	100	I	51	60	59	58	57.00 ± 2.04^{a}
	150	II	56	60	52	54	55.50 ± 1.71^{a}
	200	III	56	54	62	55	56.75 ± 1.80^{a}
	250	IV	64	57	55	66	60.50 ± 2.66^{a}
Mean							57.44 ± 1.05^{x}
B. Deep litter							
	150	V	73	62	55	67	64.25 ± 3.82^{a}
	200	VI	53	72	62	58	61.25 ± 4.03^{a}
	250	VII	100	80	76	80	85.50 ± 5.25^{b}
Mean							70.33 ± 3.84^{y}

Means bearing the same superscript did not differ significantly ($P < 0.05$) within the rearing system.

Table 6. The age at 10 per cent production (days) in Japanese quails as influenced by system of rearing and floor space allowance.

System of rearing	Floor space Sq.cm./bird	Experi- mental groups	Replications				Overall Mean ± SE
			1	2	3	4	
A. Cage	100	I	53	61	65	62	60.25 ± 2.56^{a}
	150	II	78	87	56	57	69.50 ± 7.73^{a}
	200	III	56	54	62	55	56.75 ± 1.80^{a}
	250	IV	64	57	55	66	60.50 ± 2.66^{a}
Mean							61.75 ± 2.30^{x}
B. Deep litter							
	150	V	83	79	63	69	73.50 ± 4.57^{a}
	200	VI	53	72	62	58	61.25 ± 4.03^{b}
	250	VII	100	80	76	86	85.00 ± 5.25^{a}
Mean							73.42 ± 3.85^{y}

Means bearing the same superscript did not differ significantly ($P < 0.05$) within the rearing system.

Table 7. The age at 50 per cent production (days) in Japanese quail as influenced by system of rearing and floor space allowance.

System of rearing	Floor space Sq.cm./bird	Experi-mental groups	Replications				Overall means±SE
			1	2	3	4	
A. Cage	100	I	120	79	98	99	99.00 ± 8.38^{a}
	150	II	130	92	72	65	89.75 ± 14.59^{a}
	200	III	72	91	97	71	82.75 ± 6.61^{a}
	250	IV	76	72	93	93	83.50 ± 5.55^{a}
Mean							88.75 ± 4.55^{x}
B. Deep litter	150	V	121	109	75	109	103.50 ± 9.91^{a}
	200	VI	123	100	109	96	107.00 ± 5.99^{a}
	250	VII	103	101	100	99	100.75 ± 0.85^{a}
Mean							103.75 ± 3.59^{y}

Means bearing the same superscript did not differ significantly ($P < 0.05$) within the rearing system.

Table 8. Mean percent egg production in Japanese quails as influenced by system of rearing and floor space allowance

System of rearing	Floor space sq.cm/ bird	Experimental groups	Age in weeks/periods									Overall mean ± SE
			6-10 1	11-15 2	16-20 3	21-25 4	26-30 5	31-35 6	36-40 7	41-45 8	46-50 9	
A.Cage	100	I	3.40	27.90	42.69	62.29	61.31	68.23	61.67	40.03	30.89	44.27 ± 7.10^{a}
	150	II	4.40	26.43	40.71	63.09	65.34	56.86	54.06	33.80	24.09	41.64 ± 7.16^{a}
	200	III	5.37	40.23	54.51	62.29	69.80	57.23	68.57	51.37	42.86	51.03 ± 6.78^{b}
	250	IV	2.06	36.20	62.17	66.89	60.71	66.43	63.40	43.14	36.00	48.56 ± 7.18^{b}
		Mean	3.86	32.69	50.02	65.39	64.29	62.19	61.93	42.09	33.46	46.26 ± 3.37^{x}
B.Deep litter	150	V	2.43	24.71	39.83	57.14	55.89	55.77	45.71	21.80	19.11	35.87 ± 6.56^{a}
	200	VI	1.70	17.94	41.80	59.37	62.86	59.09	51.66	38.80	23.50	39.64 ± 7.10^{ab}
	250	VII	0.00	14.65	43.94	68.69	68.94	59.77	51.65	38.80	24.29	41.19 ± 8.06^{b}
		Mean	1.38	19.10	41.86	61.87	62.563	58.21	49.67	33.13	22.30	38.90 ± 4.25^{x}

Means bearing the same superscript did not differ significantly (P < 0.05) within the rearing system.

Table 9. Mean daily feed consumption g per bird per day in Japanese quails as influenced by systems of rearing and floor space allowance.

System of housing	Floor space sq.cm/ bird	Experimental groups	Age in weeks/periods 6-10 1	11-15 2	16-20 3	21-25 4	26-30 5	31-35 6	36-40 7	41-45 8	46-50 9	Overall mean ± SE
A. Cage	100	I	19.29	20.66	21.25	22.86	23.68	24.73	24.61	24.64	23.61	22.81 ± 0.66^{a}
	150	II	19.84	20.33	21.37	22.94	23.90	25.00	24.73	24.40	23.90	22.93 ± 0.65^{a}
	200	III	20.11	20.71	22.00	23.21	24.21	25.29	25.18	25.20	24.89	23.42 ± 0.68^{a}
	250	IV	20.27	23.13	22.37	23.53	24.64	25.67	25.45	25.13	24.64	23.87 ± 0.58^{b}
		Mean										23.24 ± 0.32^{x}
B. Deep litter	150	V	19.95	20.24	21.59	22.94	23.76	25.08	25.27	24.70	23.90	23.05 ± 0.67^{a}
	200	VI	19.86	20.23	21.68	23.11	23.96	25.68	25.71	25.20	24.86	23.39 ± 0.75^{b}
	250	VII	20.45	20.63	22.37	23.35	24.82	25.76	25.98	25.31	24.73	23.71 ± 0.71^{b}
		Mean										23.38 ± 0.40^{x}

Means bearing the same superscript did not differ significantly ($P < 0.05$) within the rearing system.

Table 10. Mean feed efficiency (kg feed per dozen eggs) in Japanese quails as influenced by system of rearing and floor space allowance.

System of housing	Floor space sq.cm/ bird	Experi-mental groups	Age in weeks/periods									Overall mean ± SE
			6-10 1	11-15 2	16-20 3	21-25 4	26-30 5	31-35 6	36-40 7	41-45 8	46-50 9	
A.Cage	100	I	6.290	0.888	0.647	0.440	0.463	0.435	0.479	0.739	0.916	1.25 ± 0.63^{a}
	150	II	5.412	0.923	0.644	0.473	0.439	0.528	0.564	0.866	1.192	1.23 ± 0.53^{a}
	200	III	4.504	0.618	0.484	0.402	0.416	0.530	0.403	0.589	0.696	0.96 ± 0.44^{a}
	250	IV	11.823	0.767	0.432	0.576	0.487	0.464	0.482	0.699	0.790	1.84 ± 1.25^{a}
		Mean										1.32 ± 0.38^{x}
B.Deep litter	150	V	9.891	0.982	0.650	0.505	0.510	0.540	0.663	0.970	1.5	1.80 ± 1.02^{b}
	200	VI	5.953	1.367	0.623	0.467	0.458	0.522	0.598	0.859	1.269	1.35 ± 0.59^{a}
	250	VII	.....	1.690	0.612	0.408	0.432	0.517	0.603	0.874	1.357	1.44 ± 0.65^{a}
		Mean										1.34 ± 0.41^{x}

Means bearing the same superscript did not differ significantly ($P < 0.05$) within the rearing system.

Table 13. Mean shape of Index of eggs in Japanese quails as influenced by system of rearing and floor space allowance.

System of housing	Floor space sq.cm/bird	Experimental groups	Age in weeks/periods									Overall mean ± SE
			6-10 1	11-15 2	16-20 3	21-25 4	26-30 5	31-35 6	36-40 7	41-45 8	46-50 9	
A.Cage	100	I	78.53	79.29	77.84	78.53	77.12	81.04	77.63	79.71	79.46	78.79 ± 0.40^{a}
	150	II	80.00	79.03	78.53	77.90	78.65	78.48	78.51	80.60	78.96	78.96 ± 0.28^{a}
	200	III	80.55	79.03	79.17	79.40	77.16	79.13	77.57	79.16	79.29	78.94 ± 0.34^{a}
	250	IV	78.38	79.49	78.19	78.43	79.27	78.40	78.58	78.48	80.45	78.85 ± 0.25^{a}
	Mean											78.89 ± 0.15^{x}
B.Deep litter	150	V	83.38	78.82	78.77	78.62	78.25	79.56	77.99	77.14	80.17	79.19 ± 0.60^{a}
	200	VI	81.75	79.40	78.77	78.41	77.59	79.62	79.19	78.57	80.31	79.12 ± 0.46^{a}
	250	VII	...	79.73	77.27	76.70	77.91	78.98	77.68	78.12	79.13	78.25 ± 0.34^{a}
	Mean											78.85 ± 0.28^{x}

Means bearing the same superscript did not differ significantly ($P < 0.05$) within the rearing system.

Table 11 Mean per cent livability in Japanese quails as influenced by system of rearing and floor space allowance.

System of housing	Floor space sq.cm/ bird	Experi-mental groups	Age in weeks/periods									Overall mean ± SE
			6-10 1	11-15 2	16-20 3	21-25 4	26-30 5	31-35 6	36-40 7	41-45 8	46-50 9	
A.Cage	100	I	100.00	98.75	83.75	100.00	100.00	95.00	95.00	97.25	96.25	96.22±1.70[a]
	150	II	100.00	98.08	94.23	96.15	96.15	92.31	100.00	100.00	96.15	97.01±0.91[a]
	200	III	100.00	92.50	100.00	95.00	95.00	100.00	100.00	100.00	97.50	97.78±0.97[a]
	250	IV	96.87	96.87	93.75	100.00	100.00	96.87	100.00	100.00	96.87	97.91±0.74[a]
	Mean											97.26±0.56[x]
B.Deep litter	150	V	100	100	90.38	98.08	94.23	98.08	96.25	100	90.38	96.37±1.30[a]
	200	VI	100	90	95.00	97.50	100.00	100.00	100.00	100	95.00	97.50±1.18[a]
	250	VII	100	100	93.75	90.62	100.00	100.00	100.00	100	96.87	97.92±1.17[a]
	Mean											97.26±0.69[x]

Means bearing the same superscript did not differ significantly ($P < 0.05$) within the rearing system.

Table 12 Mean egg weight (g) in Japanese quails as influenced by system rearing and floor space allowance.

System of housing	Floor space sq.cm/ bird	Experi-mental groups	Age in weeks/periods 6-10 1	11-15 2	16-20 3	21-25 4	26-30 5	31-35 6	36-40 7	41-45 8	46-50 9	Overall mean ± SE
A.Cage	100	I	9.98	10.57	10.40	11.67	10.87	10.32	10.04	10.41	9.30	10.40 ± 0.22^{a}
	150	II	11.03	10.96	10.89	11.58	10.74	10.96	10.89	10.46	9.66	10.90 ± 0.18^{b}
	200	III	10.30	10.55	10.69	11.58	11.19	10.46	10.71	10.48	9.28	10.58 ± 0.21^{a}
	250	IV	10.01	11.03	10.62	11.24	10.56	10.51	10.50	11.00	9.73	10.58 ± 0.16^{a}
	Mean											10.61 ± 0.09^{x}
B.Deep litter	150	V	9.79	10.56	9.52	10.78	10.65	10.91	10.24	9.92	9.00	10.15 ± 0.21^{a}
	200	VI	10.30	10.64	9.97	10.70	10.37	9.91	9.90	10.47	9.37	10.18 ± 0.15^{a}
	250	VII	.....	10.55	9.00	10.44	10.48	9.95	10.49	10.74	10.36	10.22 ± 0.17^{a}
	Mean											10.19 ± 0.11^{y}

Means bearing the same superscript did not differ significantly ($P < 0.05$) within the rearing system.

Table 14. Mean Albumen index in Japanese quails as influenced by system of rearing and floor space allowance.

System of housing	Floor space sq.cm/bird	Experimental groups	Age in weeks/periods 6-10 (1)	11-15 (2)	16-20 (3)	21-25 (4)	26-30 (5)	31-35 (6)	36-40 (7)	41-45 (8)	46-50 (9)	Overall mean ± SE
A. Cage	100	I	0.129	0.115	0.088	0.104	0.083	0.082	0.091	0.100	0.092	0.098 ± 0.005^{a}
	150	II	0.105	0.107	0.090	0.119	0.089	0.090	0.095	0.092	0.103	0.099 ± 0.004^{a}
	200	III	0.111	0.112	0.092	0.111	0.087	0.083	0.090	0.108	0.112	0.101 ± 0.004^{a}
	250	IV	0.094	0.100	0.088	0.102	0.093	0.081	0.095	0.112	0.114	0.098 ± 0.004^{a}
	Mean											0.100 ± 0.002^{x}
B. Deep litter	150	V	0.097	0.112	0.093	0.135	0.095	0.094	0.109	0.118	0.108	0.107 ± 0.005^{a}
	200	VI	0.103	0.106	0.091	0.091	0.101	0.108	0.107	0.104	0.103	0.103 ± 0.002^{a}
	250	VII	...	0.111	0.089	0.089	0.097	0.097	0.101	0.092	0.106	0.099 ± 0.003^{a}
	Mean											0.103 ± 0.002^{x}

Means bearing the same superscript did not differ significantly ($P < 0.05$) within the rearing system.

Table 15. Mean yolk index in Japanese quails as influenced by system of rearing and floor space allowance.

System of housing	Floor space sq.cm/ bird	Experi-mental groups	Age in weeks/periods 6-10 1	11-15 2	16-20 3	21-25 4	26-30 5	31-35 6	36-40 7	41-45 8	46-50 9	Overall mean ± SE
A.Cage	100	I	0.497	0.484	0.456	0.483	0.470	0.464	0.484	0.465	0.465	0.474±0.005[a]
	150	II	0.478	0.484	0.448	0.502	0.473	0.471	0.493	0.475	0.469	0.474±0.005[a]
	200	III	0.452	0.457	0.443	0.505	0.462	0.476	0.491	0.482	0.470	0.471±0.007[a]
	250	IV	0.458	0.485	0.457	0.517	0.485	0.483	0.484	0.509	0.497	0.486±0.007[a]
	Mean											0.477±0.0005[x]
B.Deep litter	150	V	0.470	0.489	0.463	0.519	0.493	0.492	0.527	0.465	0.468	0.487±0.009[a]
	200	VI	0.426	0.484	0.443	0.540	0.485	0.474	0.523	0.479	0.457	0.479±0.012[a]
	250	VII	...	0.497	0.464	0.515	0.480	0.490	0.511	0.484	0.466	0.486±0.006[a]
	Mean											0.449±0.0005[x]

Means bearing the same superscript did not differ significantly ($P < 0.05$) within the rearing system.

Table 16. Mean shell thickness (mm) in Japanese quails as influenced by system of rearing and floor space allowance.

System of housing	Floor space sq.cm/ bird	Experi-mental groups	6-10 1	11-15 2	16-20 3	21-25 4	26-30 5	31-35 6	36-40 7	41-45 8	46-50 9	Overall mean ± SE
			Age in weeks/periods									
A.Cage	100	I	0.220	0.210	0.240	0.253	0.218	0.228	0.215	0.225	0.230	0.227±0.004[a]
	150	II	0.220	0.220	0.219	0.254	0.223	0.228	0.213	0.220	0.215	0.224±0.004[a]
	200	III	0.220	0.218	0.218	0.222	0.223	0.220	0.215	0.213	0.213	0.218±0.001[a]
	250	IV	0.218	0.220	0.223	0.236	0.223	0.220	0.215	0.219	0.210	0.226±0.006[a]
	Mean											0.224±0.002[x]
B.Deep litter	150	V	0.208	0.223	0.219	0.240	0.228	0.230	0.218	0.202	0.208	0.220±0.004[a]
	200	VI	0.215	0.233	0.222	0.245	0.220	0.225	0.215	0.220	0.205	0.222±0.004[a]
	250	VII	...	0.220	0.224	0.246	0.220	0.215	0.215	0.214	0.210	0.220±0.004[a]
	Mean											0.221±0.008[x]

Means bearing the same superscript did not differ significantly ($P<0.05$) within the rearing system.

Table 17. Mean Haugh unit scores in Japanese quail as influenced by system of rearing and floor space allowance.

System of housing	Floor space sq.cm/ bird	Experi- mental groups	Age in weeks/periods 6-10 1	11-15 2	16-20 3	21-25 4	26-30 5	31-35 6	36-40 7	41-45 8	46-50 9	Overall mean $\pm$ SE
A.Cage	100	I	64.82	59.65	45.65	52.93	48.97	44.28	52.29	56.33	53.72	53.18 ± 2.18^{a}
	150	II	53.68	55.52	45.54	58.19	49.99	47.24	47.99	51.45	54.25	51.42 ± 1.33^{a}
	200	III	55.47	56.55	46.45	56.93	47.18	48.71	51.45	56.19	59.13	53.12 ± 1.58^{a}
	250	IV	55.82	52.14	46.54	53.48	49.49	45.57	51.56	60.32	59.12	52.67 ± 1.71^{a}
	Mean											52.64 ± 0.82^{x}
B.Deep litter	150	V	51.51	56.29	50.09	58.67	50.76	48.51	56.30	63.93	59.05	55.01 ± 1.79^{a}
	200	VI	57.84	56.07	49.17	57.00	53.04	55.57	56.34	54.44	55.64	55.01 ± 0.87^{a}
	250	VII	...	57.16	51.45	59.06	47.94	51.98	53.55	50.11	53.46	53.19 ± 1.13^{a}
	Mean											54.19 ± 0.77^{x}

Means bearing the same superscript did not differ significantly ($P < 0.05$) within the rearing system.

Table 18. Correlations between part year and full year egg productions

Correlation-50th week with	Age in weeks							
	10th	15th	20th	25th	30th	35th	40th	45th
Cage & Deep litter combined	0.2459 NS	0.5561**	0.7081**	0.7863**	0.8672**	0.9206**	0.9659**	0.9913**
Cage	0.1137 NS	0.9536**	0.9247**	0.9539**	0.9367**	0.9829**	0.9956**	0.9997**
Deep litter	-0.8920	-0.9927	-0.9985	0.2049	0.8484**	0.9105**	0.9687**	0.9998**

** Significant 1% level ($P < 0.01$)

NS Non-significant

Table 19. Effect of floor space on the economics of production in Japanese quails in cages and deep litter

	Cages				Deep litter		
	I	II	III	IV	V	VI	VII
Floor space bird (Sq.cm)	100	150	200	250	150	200	250
Total number of eggs/bird in 315 days	139.56	129.72	160.68	151.32	112.98	124.86	129.72
Cost of eggs @ Rs.40/egg	55.82	51.89	64.27	60.53	45.192	49.94	51.89
Total feed/ bird in 315 days (kg)	7.187	7.223	7.377	7.519	7.261	7.368	7.469
Feed cost @ 6.5/kg	46.71	46.95	47.95	48.87	47.20	47.89	48.56
Returns over feed cost/ bird in 315 (days)	9.11	4.94	16.32	11.66	-2.01	2.05	3.33
Return over feed cost/ bird/unit floor space (sq.cm) in 315 days (Rs)	0.09	0.05	0.16	0.12	-0.02	0.02	0.03

Table 20. Summary of performance of birds reared under different floor densities in cages.

Parameter	Floor Densities				
	100 sq.cm/ bird	150 sq.cm/ bird	200 sq.cm/ bird	250 sq.cm/ bird	Overall mean
1. Body weight (g)	166.75±8.62	166.08±8.99	171.05±9.46	171.32±9.31	168.80±4.38
2. Age at first egg (days)	57.00±2.09	55.50±1.71	56.75±1.80	60.50±2.66	57.44±1.05
3. Age at 10 per cent production (days)	60.25±2.56	69.50±7.73	56.75±1.80	60.50±1.80	61.75±2.30
4. Age at 50 per cent production (days)	99.00±8.38	89.75±14.59	82.75±6.61	83.50±5.55	88.75±4.55
5. Per cent egg production	44.27±7.10	41.64±7.16	51.03±6.78	48.56±7.18	46.71±3.37
6. Mean daily feed consumption/bird (g)	22.81±0.66	22.93±0.65	23.42±0.68	23.87±0.58	23.24±0.32
7. Feed efficiency (kg feed per dozen eggs)	1.25±0.63	1.23±0.53	0.96±0.44	1.84±1.25	1.32±0.38
8. Livability (%)	96.22±1.70	97.01±0.91	97.78±0.97	97.91±0.74	97.23±0.56
9. Mean egg weight (g)	10.40±0.22	10.90±0.18	10.58±0.21	10.58±0.16	10.61±0.09

Contd....

10. Shape Index	78.79±0.40	78.96±0.28	78.94±0.34	78.85±0.25	78.89±0.15
11. Albumen Index	0.098±0.005	0.099±0.003	0.101±0.004	0.098±0.004	0.100±0.002
12. Yolk Index	0.474±0.005	0.474±0.005	0.471±0.007	0.486±0.007	0.477±0.0005
13. Shell thickness (mm)	0.227±0.004	0.224±0.004	0.218±0.001	0.226±0.006	0.224±0.002
14. Haugh unit	53.18±2.18	51.42±1.33	53.12±1.58	52.67±1.71	52.64±0.82
15. Return over feed cost/ bird in 315 days (Rs)	9.11	4.94	16.32	11.66	
16. Return over feed cost/ bird/unit floor space(sq.cm) in 315 days (Rs.)	0.09	0.05	0.16	0.12	

Table 21. Summary of performance of birds reared under different floor densities in deep litter.

Parameter	Floor Densities			
	150 sq.cm/ bird	200 sq.cm/ bird	250 sq.cm/ bird	Overall±SE mean
1. Body weight (g)	165.10±8.83	167.48±9.05	170.67±9.93	167.79±5.18
2. Age at first egg (days)	64.25±3.82	61.25±4.03	85.50±5.25	70.33±3.84
3. Age at 10 per cent production (days)	73.50±4.57	61.25±4.03	85.00±5.25	73.42±3.85
4. Age at 50 per cent production (days)	103.50±9.91	107.00±5.99	100.75±0.85	103.75±3.59
5. Per cent egg production	35.87±6.56	39.64±7.10	41.19±8.06	38.90±4.25
6. Mean daily feed consumption/bird (g)	23.05±0.67	23.39±0.75	23.71±0.71	23.38±0.40
7. Feed efficiency (kg feed per dozen eggs)	1.80±1.02	1.35±0.59	1.44±0.65	1.34±0.41
8. Livability (%)	96.37±1.30	97.05±1.18	97.92±1.17	97.26±0.69
9. Mean egg weight (g)	10.15±0.21	10.18±0.15	10.22±0.17	10.19±0.11
10. Shape Index	79.19±0.60	79.12±0.46	78.25±0.34	78.85±0.28

11. Albumen Index	0.107±0.005	0.103±0.002	0.099±0.003	0.103±0.002
12. Yolk Index	0.487±0.009	0.479±0.012	0.486±0.006	0.449±0.0005
13. Shell thickness (mm)	0.220±0.004	0.222±0.004	0.220±0.004	0.221±0.008
14. Haugh unit	55.01±1.79	55.01±0.87	53.19±1.13	54.19±0.77
15. Return over feed cost/ bird in 315 days (Rs)	-2.01	2.05	3.33	
16. Return over feed cost/ bird/unit floor space(sq.cm) in 315 days (Rs.)	-0.02	0.02	0.03	

Discussion

DISCUSSION

The results obtained in the present study carried out to evaluate the production performance of Japanese quails in cage and deep litter systems of rearing under different floor densities are discussed in this chapter.

Meteorological observations

The meteorological data obtained during the experimental period from April 1992 to February 1993 presented in table 3 revealed that the mean daily maximum temperature was highest (38.18°C) during the first period of the experiment ie., during April-May 1992. During this period, the experimental birds were six to ten weeks of age and were at the point of lay. The temperature was high during this period since it coincided with the peak summer in Kerala. Somanathan (1980) also reported a high mean maximum temperature during April in Kerala.

From the second period of the experiment onwards, the mean maximum temperature showed a gradual reduction till the end of the fourth period (July-August) when the temperature was only 28.42°C and it coincided with termination of 25 weeks of age of quails. Subsequently, the maximum temperature again rose to 33.14°C towards the end of the experiment (January 1993) when quails were at 50 weeks of age. Thus, the quails were under a high mean maximum temperature during the initial and final periods of production. The maximum temperature during the first period of the experiment was 36.18°C and at the end of the experiment was 33.14°C. The mean values of maximum and minimum temperature recorded during the period of experiment were similar to those reported by Somanathan (1980) for the corresponding periods.

The mean per cent relative humidity in the morning showed an increasing trend from first period onwards and reached a highest value of 95 per cent during the fourth period (July-August). The relative humidity was more than 90 per cent during the periods three to six ie. from June to October, corresponding to heavy rainfall period in Kerala. During these periods, the relative humidity per cent in the afternoons were also higher than the other periods. It was also highest during the fourth period (July-August) with a value of 83.80 per cent. The temperature and the relative humidity recorded at various periods followed the same trend reported by Somanathan (1980).

Body Weight

The mean body weights of Japanese quails presented in table 4 revealed that the mean body weights were not significantly influenced by the two systems of rearing. However, from the data it could be seen that the birds in cages had a tendency to achieve more body weight than those in deep litter.

Contrary to the above findings Sharma and Panda (1978) reported a higher eight week body weight in cage reared quails compared to litter reared ones. Chidananda et al (1986) and Viswanathan (1992) also observed that cage reared birds had significantly higher body weights compared to deep litter reared ones. These variations in the results could possibly be due to different floor space allocations, strain differences or microclimatic conditions.

In cage system of rearing birds given a floor space allowance of 200 and 250 sq.cm per bird showed significantly higher body weights compared to the birds given 100 and 150 sq.cm floor space. Similar results were observed by Okamoto et al. (1989), Bandyopadhyaya and Ahuja (1990), Nagarajan et al. (1990) and Viswanathan (1992). On the contrary, Ernst and Coleman (1964) reported that the different floor densities had no significant effect on the body weight of quails.

In deep litter also, when the floor space per bird was increased a trend of increase in body weight could be observed. Viswanathan (1992) also was of the same opinion.

The decrease in body weights in groups with lower floor space allowance may probably be due to peck order and other factors which cause a reduction in feed intake or feed efficiency.

Age at first egg

The results revealed that housing systems had a significant effect on the age at first egg in Japanese quails. It was observed that cage reared birds laid their first egg at a much earlier age (57.44 days) compared to litter reared birds (70.33 days). The trend of these findings was similar to the observations of Chidananda et al. (1986). But Viswanathan (1992) observed that system of housing did not exert any significant effect on the age at first egg.

Wilson et al. (1961), Howes and Ivy (1962), Krazewska - Doman'ska et al. (1969) and Jones and Hughes (1978) observed that the quail hens laid their first egg at a much earlier age (five or six weeks) than the present observations. But Tiwari and Panda (1978) and Kohler (1987) observed the age at first egg as 51 days and 56.2 days respectively; which coincides with that of the present study. The differences observed by different researchers on this trait could be due to the effects of strain and climate. In cage system of rearing the different floor densities did not significantly affect the age at first egg. This finding is in agreement with that of Nagarajan et al. (1990) and Viswanathan (1992).

The results in deep litter system showed a different trend in comparison to cages. The age at first was delayed very much in the group provided with 250 sq. cm floor space per bird (85.50±5.25) and this was significantly higher than the other two treatment groups studied.

Age at 10 per cent production

Birds reared in cages reached the age at 10 per cent production significantly earlier compared to deep litter reared ones; the corresponding values being 61.75 and 73.42 days respectively.

In cage system, different floor densities provided did not significantly affect the age at 10 per cent production.

In deep litter system, the age at 10 per cent production was significantly earlier (61.25±4.03) in the group given a floor space allowance of 200 sq.cm per bird compared to groups given 150 and 250 sq.cm per bird (73.50±4.57 and 85.00±5.25). There was no literature information regarding the effect on this trait.

Age at 50 per cent production

Significantly lower age at 50 per cent production was observed in caged birds (88.75 days) than in deep litter (103.75 days) reared birds. The results are in agreement with that of Chidananda et al. (1986), who observed a numerically lower age at 50 per cent production in cage reared birds (77.62 ± 2.12) compared to litter reared ones (80.12 ± 1.79) although the difference was not statistically significant. Viswanathan (1992) also had a similar observation.

In cage system of rearing, the different floor spaces did not significantly affect the age at 50 per cent production. But the observations of Nagarajan et al. (1991) and Viswanathan (1992) contradict this finding. They observed a significantly lower age at 50 per cent production with proportionate increase in cage space per quail layer.

In deep litter system also, there was no significant difference among the three treatment groups. However Viswanathan (1992) observed that difference in floor space allowance influenced this trait.

In the present study, the age at 50 per cent production was generally higher. Tiwari and Panda (1978) reported a lower value of 67 days. But in the present experiment, the age at 50 per cent production is well above 85 days. This may be due to the genetic difference and environmental influence. Gildersleeve et al. (1987) studied four generations of paired Japanese quails and observed that the age at 50 per cent production increased from first to fourth generation.

Per cent Egg Production

The over all mean per cent egg production during the periods from five to fifty weeks of age in cage and deep litter systems of rearing were 46.21 and 38.90 respectively and were found to be statistically non-significant. Even though the magnitude of differences were statistically non-significant, the results revealed a numerical superiority for cage system over deep litter.

Chidananda et al. (1986) opined that birds in deep litter produced lower ($P<0.05$) number of eggs than cage reared birds. They confirmed that the cage system of rearing had marginal advantage over deep litter system of rearing. Viswanathan (1992) also was of opinion that both the hen-day and hen-housed production percentage was better in cage reared birds.

Wilson *et al*. (1961), Krazewska - Doman'ska *et al*. (1967), Panda *et al*. (1980), Sato *et al*. (1983) and Gildersleeve *et al*. (1987) reported higher per cent egg productions than that obtained for the stock used in this study. This may be due to the fact that the stock used in the study has not been subjected to any selection for higher egg production.

In cage system of rearing, the percent egg production increased significantly with increase in floor space allowance provided. Quails provided with 200 and 250 sq.cm. in cages showed superior production than the two lower levels of floor spaces provided, the highest being the groups provided with 200 sq.cm. per bird.

The results of this study are in agreement with those of Ernst and Coleman (1964); Bandyopadhyaya and Ahuja (1990) Nagarajan *et al*. (1990) and Viswanathan (1992). These authors observed that the egg production increased, as the floor space per bird increased. The reduced egg production in higher floor densities may be due to peck order, cannibalism or stress factors to which birds are subjected to.

In deep litter system also, an increased floor space allowance caused a hike on the egg production. The highest mean per cent egg production in deep litter system was

49.19$\pm$8.06, which was recorded in the groups provided with 250 sq.cm. per bird. But Viswanathan (1992) observed statistically similar egg production in the three different floor space allowances studied in deep litter.

Feed consumption

The over all average feed consumption(g) in cages was found to be 23.24g and that in deep litter 23.38g per bird per day during the period from five to fifty weeks of age. The difference between the mean values were statistically non-significant. The feed consumption values obtained in the present study is similar to those observed by Panda et al. (1977)and Viswanathan (1992). The latter reported that the average feed consumption (per bird per day) is lesser in cage reared quails than in litter reared ones and the results were found to be significant. In the cage system of rearing, the different floor densities had significantly affected the feed consumption. The feed consumption in quails given floor space 100,150 and 200 sq.cm per bird were statistically comparable, whereas quails reared with floor space of 250 sq.cm per bird consumed significantly higher quantities of feed than those given lesser space. This indicated that an increase in floor space resulted in an increase in the feed consumption; but this did not subsequently result in the increase in production. But

Viswanathan (1992) had an opposing view and reported that the different floor space allowances did not significantly affect the feed consumption of birds in cages.

In deep litter system also the trend of results were more or less similar. Quails provided with 150 sq.cm per bird consumed significantly lower quantity of feed. Eventhough feed consumption showed a numerical increase between the quails provided with 200 and 250 sq.cm. per bird, the difference was not statistically significant. Viswanathan (1992) observed that feed intake was not influenced by floor space variations in deep litter.

Feed Efficiency

The average feed efficiency (kg feed per dozen eggs) in cage and litter reared birds were 1.32 and 1.34 and were statistically non-significant. The observations of Ernst and Coleman (1964) and Chidananda et al. (1985) are comparable with the present study. But observations of Narahari et al. (1986) and Viswanathan (1992) were at variance. Narahari et al. (1986) observed that cage reared birds had better food conversion indices at five, six, seven, and eight weeks of age. According to Viswanathan (1992) there is highly significant difference in feed efficiency between cage and deep litter reared quails.

It was observed in the present study that floor space allowances did not significantly affect the feed efficiency in cage system of rearing.

Das et al. (1990) observed an improvement in the feed efficiency as the floor space per bird increased. Viswanathan (1992) also observed a significant difference in feed efficiency between the different density groups.

In deep litter system of rearing also it was seen that the treatments did not significantly affect the feed efficiency. The observations of Viswanathan (1992) differed from the present study.

The differences between the values obtained and those reported by others could be due to the differences in the genetic make up of the stock used. The stock used in the present study has not been subjected to selection procedures for improvement of egg production. Therefore, a comparison between values observed in a flock specifically selected for egg production and that subjected to dual performance is not meaningful.

Livability

Rearing systems have failed to exert any significant influence on the livability per cent in Japanese quails. The average livability per cent for birds reared in cages and deep litter are 97.23 and 97.26 respectively.

Chidananda et al. (1985) was also of the same opinion. Viswanathan (1992) observed that per cent mortality of quails (7-30 weeks) in cages averaged 14.33 and that as litter averaged 20.33.

It was observed in the present study that floor space had not significantly influenced this parameter both in cages and deep litter.

Wilson et al. (1978) observed that mortality was increased by floor space allowance less than 232 sq.cm per bird. Bandyopadhyaya and Ahuja (1990) in their studies on Japanese quails observed that mortality was not influenced by cage density. Nagarajan et al. (1990) reported that with increasing space allowance in cages, mortality was reduced in quail hens.

Egg weight

The caged quails laid significantly heavier eggs with a difference of 0.42 g per egg in comparison to those on deep litter. The weight of eggs from birds in cages averaged 10.61 g and that from deep litter averaged 10.19 g. This finding is in agreement with those of Chidananda et al.

(1986) and Mahapatra et al. (1988). The latter reported that the weight of eggs averaged 10.30±0.09 and 10.62±0.07 g for both deep litter and caged birds.

Viswanathan (1992) reported that the cage reared birds laid eggs with a mean weight of 9.67±0.05 g and litter reared quails had a mean egg weight of 9.75±0.05 g.

In cage system of rearing, statistical analysis revealed that there is significant difference due to the variations in floor space allowances. The group with a floor space of 150 sq.cm per bird laid eggs with significantly higher weight (10.9g) in comparison with the other groups. However the egg production in this group was the lowest (41.64 per cent) among the experimental groups tested under cage system. Therefore, on egg mass basis this floor space will not be advantageous over the allowance of 200 sq.cm per bird. The mean egg weight in the group given floor space of 200 sq. cm per bird was 10.58g and was next below the highest egg weight recorded in this study.

The periodwise egg weight revealed that there occurred a slight drop in egg weight during the period from 16-20 weeks of age in relation with the egg weight during the period 11-15 weeks of age. This was possibly due to the reduction in body weight which occurred during 16-20 weeks of age.

Bandyopadhyaya and Ahuja (1990) had observed that the egg weight remained unaffected with the different floor densities, whereas Nagarajan et al. (1990) reported that there was no significant difference in weight of egg among birds reared in the different densities.

But in deep litter system of rearing, the analysis revealed that the different floor space allowances did not significantly affect the egg weight. Moreover, in all these groups, the egg weight was lower than those recorded under cage system. Thus, in terms of egg weight and also egg number, the floor space allowances tested in deep litter system were inferior to those studied under cage system.

Egg Quality Traits

Shape Index

The observations of this experiment had shown that the average shape index of eggs from cage and litter reared birds were 78.89 and 78.85 respectively and were statistically not significant. Mahapatra et al. (1988) were also of the same opinion. They reported that the shape index of eggs in Japanese quails was not influenced significantly by the type of housing. The average shape index of eggs in this experiment was within the range of the standard figure of shape index of quail eggs which is 79.10.

In both cage and deep litter system, the different floor space allowances provided did not significantly affect the shape index of eggs. Bandyopadhyaya and Ahuja (1990) had observed similar findings in which they reported that cage density had no significant effect on the egg shape in Japanese quails.

Albumen Index

The mean albumen index of eggs of Japanese quails in cages was found to be 0.100 and that from deep litter 0.103. Analysis showed that the system of housing did not significantly influence this parameter. The standard value for albumen index in quail eggs is 0.100 which is in agreement with the present study. Mahapatra et al. (1988) had also observed that this parameter was not significantly influenced by the type of housing.

The different floor space allowance provided in this study either in cages or deep litter had also not affected albumen index of eggs. Similar result was reported by Viswanathan (1992). On the contrary, Bandyopadhyaya and Ahuja (1990) observed that cage densities influenced albumen index of eggs from Japanese quails.

Yolk Index

The average yolk indices of eggs from cages and deep litter were 0.477 and 0.449 respectively and on analysis, it was observed that they did not differ significantly. The average yolk index in this experiment is slightly below the standard value, which is 0.490. Mahapatra et al. (1988) also observed that the yolk index of quail eggs was not significantly influenced by the type of housing.

Viswanathan (1992) differed from this finding. He observed that the yolk index of quail eggs was significantly influenced by the type of housing. He reported that yolk index values for the cage reared birds were superior.

In both cage and deep litter system of rearing, the different treatments did not significantly affect the yolk index of eggs. But Nagarajan et al. (1991) observed highly significant ($P < 0.01$) differences in the yolk index values between the different cage floor space allowances studied. They reported that the yolk index values were found to be negatively correlated with stocking density. Viswanathan (1992) also observed that the different floor densities in cage and deep litter had a significant effect ($P < 0.01$) on the yolk index. He studied floor space allowances of 150, 175 and 200 sq. cm per bird in both the systems and observed that the yolk index values for the cage reared birds under the floor space allowance of 175 cm^2 were found to be superior (0.47 ± 0.0028) than the rest. The lowest value of 0.42 ± 0.0059 was observed in a floor space of 200 cm^2 under deep litter system.

Shell Thickness

The shell thickness of eggs from cages and deep litter averaged 0.225 mm and 0.221 mm respectively and they were not statistically significant. The results obtained in this study concurs with those reported by Mahapatra et al. (1988) and Viswanathan (1992). But the shell thickness values in this experiment is above the standard value which is 0.19 mm.

The different floor density treatments in cages did not significantly affect the shell thickness. In deep litter also, the same was the case observed. Bandyopadhyaya and Ahuja (1990) and Nagarajan et al. (1991) also reported that the shell thickness of Japanese quail eggs was not influenced by stocking density. But Viswanathan (1992) reported that difference in floor densities in cages significantly affected the shell thickness, but not in deep litter.

Haugh Unit

Neither the system of housing nor the different floor space allowances significantly affected the Haugh Unit score of Japanese quail eggs. However numerical differences in the score were noticed viz., 52.64 and 54.19 respectively for cage and deep litter. Viswanathan (1992) was also of the same opinion, wherein he also noticed numerical difference between cage and deep litter system of rearing (64.66±8.58 Vs 65.73±0.35). But the observations of the present study is in variance with those reported by Bandyopadhyaya and Ahuja (1990) who observed that cage density did significantly affect Haugh Unit score. This can possibly be explained by the strain x housing density interactions

Correlation between part year and full year productions

Considering the production as a whole for both cage and deep litter systems of rearing correlations between 50th week production and 10th, 15th, 20th, 25th, 30th, 35th, 40th and 45th week of production were worked out. Higher magnitudes of correlation were obtained from 35th week onwards. Therefore, it can possibly be surmised that selection for better egg production can be effected at 35th week.

When cage system of rearing alone was taken into consideration, it was observed that high correlations with 50th week production existed from 15th week onwards. Therefore, if cage system of rearing is practiced in managing breeders, selection of breeder quails may be carried out at 15 weeks of age.

In deep litter system a statistically significant correlation was obtained from 30th week only. But high correlations with 50th week production were obtained from 35th, 40th and 45th week of age. So selection in deep litter reared birds may be practiced at the age of 35 weeks.

Due to the scarcity of published work on the correlations between part year production and full year production, no comparisons could be made.

Economics

The economic advantage and productivity of birds reared under different floor density levels both in cages and deep litter is detailed in Table 19. The cage system was found far superior to deep litter in all floor densities. The highest production and net return over feed cost was highest in the group provided with a floor space of 200 sq.cm per bird in cage system of rearing. In deep litter, the same was for the group with 250 sq.cm per bird. From this study it is apparent that the group which was provided with 200 sq.cm per bird showed superior values of return over feed cost per bird, as well as per square metre floor area. This has an important implication in economic quail production, which will benefit the farmer.

Summary

SUMMARY

An experiment was carried out at the Department of poultry science, College of Veterinary and Animal Sciences, Kerala Agricultural University, Mannuthy to evaluate the production performance of Japanese quails in different floor densities under cage and deep litter system of rearing and recommend a suitable housing system and floor space allowance.

Japanese quails were housed in cages providing 100, 150, 200 and 250 sq. cm per bird and in deep litter providing 150, 200 and 250 sq. cm. For each treatment group, four replicates were provided. A standard quail mash was provided throughout the experimental period. Feed and water were given ad lib and standard managemental practices were followed throughout the experimental period.

Body weight, egg production parameters, feed consumption, feed efficiency, livability, egg weight and egg quality traits were the major criteria considered for evaluation. In addition, attempts were also made to estimate the correlation between part year production and annual production. The birds were housed at five weeks of age and reared up to 50 weeks. The data were collected for nine 35-day periods and were subjected to appropriate statistical analysis. The results obtained during the entire study are summarised (Table 20 and 21) as follows.

1. The body weight of layer quails was not affected by the housing system employed.

2. The age at sexual maturity, as measured by age at first egg and age at 10 per cent production, was earlier in cage than on litter. However when age at sexual maturity was reckoned as at 50 per cent production, cage : rearing was found to be superior.

3. By and large, the floor density allowances provided either under deep litter system or in cages had very little effect on the age at sexual maturity arrived at by any three yardsticks used.

4. The egg production, feed intake, feed efficiency, egg quality parameters such as shape index, albumen index, yolk index, shell thickness and Haugh Unit score were not influenced by the system of housing, namely cage or deep litter.

5. Egg weight was heavier from birds reared in cages than those reared on deep litter system.

6. Among the four levels of floor space allowance provided in cages namely 100, 150, 200 and 250 sq. cm per quail, the space allowance of 200 and 250 sq.cm per bird elicited better response in respect of body weight, egg

production, feed intake and egg weight while the other parameters studied were not influenced by the differences in floor space allowances.

7. In deep litter among the three floor allowances studied namely 150, 200 and 250 sq. cm per bird, favourable responses were obtained in respect of body weight and egg production with 200 and 250 sq.cm per bird. The other parameters were not influenced by the three floor allowances studied. However, in most cases the differences in performance between 200 and 250 were not very much different.

8. Economics workedout as net return over feed cost revealed that cage system is superior to deep litter system. However, capital investments have not been reckoned.

9. The attempt to workout correlation between part year egg production and annual egg production revealed that highly significant ($P<0.01$) correlation is obtained from 15th week of age, when egg production data was pooled. However, when egg production in cages and deep litter were considered separately, highly significant correlation ($P < 0.01$) was obtained for egg production at 15th week of age in cages and at 35th week of age in deep litter. Considering possible advantage of using

part year production in selection procedure, the present study indicated that breeders should be reared in cages and selection of parents done based on egg production at 15th week of age.

Assessing the overall results obtained, it is concluded that layer quails can be raised with advantage either in cages or in deep litter not withstanding the slight edge that cage system has with a floor space allowance of 200 sq.cm per bird. It would be advantageous to rear breeders in cages so that selection can be effected based on egg production upto 15th week of age.

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EFFECT OF FLOOR DENSITY ON PRODUCTION PERFORMANCE IN JAPANESE QUAILS REARED IN CAGES AND DEEP LITTER

By

B. PADMAKUMAR

ABSTRACT OF A THESIS

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Faculty of Veterinary and Animal Sciences
Kerala Agricultural University

Department of Poultry Science
COLLEGE OF VETERINARY AND ANIMAL SCIENCES
Mannuthy, Thrissur

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ABSTRACT

To suggest a suitable system of rearing and optimum floor space allowance for Japanese quail rearing, so as to reduce housing cost and to achieve better efficiency, a study was carried out to evaluate the production performance of quails reared in cages and deep litter with different floor densities.

In cage system of rearing the floor densities evaluated were 100, 150, 200 and 250 sq. cm and in deep litter system, 150, 200 and 250 sq. cm per bird. The experiment was carried out from the fifth week of age to 50th week of age; each group with four replications. Except for the difference in floor densities, all the managemental practices followed were the same and the data was recorded for nine, 35-day periods.

The system of housing had no effect on the body weight, but an increase in floor space resulted in a hike in the body weight. Age at first egg, 10 per cent production and 50 per cent production were not influenced by the type of housing. In deep litter system, they were significantly affected by the different floor densities, but not in cage system of rearing.

System of housing did not affect the egg production. But in cages, different floor densities significantly

affected the egg production. This was not seen in deep litter system of rearing. The mean daily feed consumption was not affected by the system of housing. But the different floor densities in cages and deep litter had significant effect on feed consumption. System of housing and floor density variation had no effect on feed efficiency. The percent Livability also has shown a similar trend.

System of housing significantly affected the weight of eggs. The treatment groups in cages significantly affected the egg weight, but not in deep litter. Egg quality traits were neither affected by system of housing nor the floor density variations.

Based on correlation of part year and full year productions, 35 weeks of age was found advantageous for selection of breeders. In cage system, it was found to be 15 weeks and in deep litter 35 weeks . The returns over feed cost was found to be better in cage system of rearing compared to deep litter. Between the different floor density allowances, 200 sq.cm floor space per bird surpassed all the other treatments. So it is concluded that the floor space allowance of 200 sq. cm per bird in cages is ideal for Japanese quail rearing.