CHAPTER 5

STUDIES ON FLOOR-LAYING AND NEST USAGE HABITS OF BROILER BREEDER HENS

5.1 Introduction

A third objective of this investigation into nesting behaviour and nest site selection was to examine nest selection and usage habits of large flocks of hens and to study, more fully, the phenomenom and occurrence of floor-laying in such situations. In addition, it was intended that this study should be used to implicate the possible effectiveness of modification of nest types in changing relative proportions of nest and floor usage in such flocks. It was not the objective of this study to extrapolate from the findings of nest preference studies and to design more suitable nests using this information, this was considered to be within the realms of the second stage of the overall investigation continuing on after completion of this thesis. In fact, the studies to be reported here were designed and completed in 1979, well before most of the nest preference studies had been attempted. While it would have been ideal to have initiated the present investigation after all nest preference information had been gathered, the availability of birds and facilities were such that this would have been impossible. As it was, the studies undertaken were rather opportunistic, utilising birds and facilities provided for a nutrition experiment. As a result, the author had no control over the time at which the study was initiated and was also limited in terms of the treatments that could be applied. The objectives of these studies, therefore, were to investigate how hens use nests, what they use them for and the incidence of floor-laying, and what may affect it, in flocks of hens in conditions somewhat similar to those found in commercial breeding situations.

Results presented in the previous chapters have suggested that a number of factors may influence the way in which hens go about the selection of nest sites and the types of nest sites eventually selected. Several features of the nest have been shown to influence the favourability of the site to nest-seeking hens. However, it is not possible to extrapolate from these findings and conclude that the provision of certain of the more preferred features of nest sites will ensure selection of the provided nests in preference to other possible sites in a large flock situation. Commercial breeding situations introduce an element of competition into nest selection that may not be present in the studies of nest preferences. Bird density may also influence selection of nests. It is also probable that the development of certain preferences during the first few weeks of production may be affected by social factors operating in a large flock. For example, even in the best managed flocks hens will vary with respect to day of first oviposition. This means that nest selection habits of hens just coming into lay may be influenced by those of hens already laying for some time and vice versa. Habits established in the first few weeks of lay may be difficult to alter and may interfere with predicted nest preference and usage patterns.

Another important consideration is that, although provided nests may themselves be very attractive to nest-seeking hens, their usage may be governed by their accessibility to the hens and by their siting. Hens may in fact have preferences for particular types of nesting areas and may avoid even the most attractive nests if they are located outside these areas. Accessibility of nests may be of several kinds. Hens may not use nests that are either too difficult to get to across the pen, in cases where they have to pass through feeding and/or watering areas, or across the territories of other groups of birds, or difficult to get up to, down from, into or out of. Nests may also be rendered inaccessible because they are already occupied by other nestsing or non-nesting birds.

In order to obtain some indication of how much application nest preference information may have when attempting to encourage nest usage habits in floor penned flocks, studies of floor-laying tendencies of flocks provided with nests which differed with respect to several features previously noted to have some effect on nest selection were initiated. The effects of some forms of accessibility and the provision of 'nesting areas' on floor and nest laying habits would also be worthwhile avenues of further investigation in this respect.

5.2 Materials and Methods

(a) *Birds and Their Housing*

Birds used in this study were a commercial Hyline* broiler breeder strain. They had been reared in a brooding shed to six weeks before being allotted to pens in the shed in which the present studies were conducted. The birds were reared under conditions of naturally increasing daylength (southern hemisphere) to 21 weeks of age at which point they began to receive additional lighting, increasing to a constant 16 hours light per day at the age of 27 weeks. This corresponded to the time that hens were beginning to lay. This additional artificial lighting was supplied prior to the onset of natural daylight each morning. Thus, under a 16 hour photoperiod, lights were turned on at approximately 3.30 am. The first eggs began to be laid towards the end of September, 1979.

The present experiments were superimposed over a nutritional trial being conducted on the same hens. This was a restriction feeding trial which involved three pre-production levels of restriction and four restriction levels implemented during the laying period. All levels of restriction were quite severe and it was considered unlikely that they would interfere in the present study. Each pre- and post-lay feeding possibility was represented in one pen in each of the four rows of pens in the shed.

Studies were conducted in a breeder shed at 'Laureldale', the poultry unit attached to the University of New England. The shed was divided into 48, 3.70 m x 2.65 m deep litter floor pens which were arranged in four rows running down the shed. Two service aisles ran the length of the shed and serviced two each of

* Hyline Pty. Ltd., R149 Bringelly Road, Luddenham, NSW, 2750

the rows of pens. Pens were divided from each other by wire partitions. The two outermost rows ran along the two side walls of the shed. Each pen contained three tubular feeders and an automatic waterer but no perches. In each pen was provided a double tiered nest-set which contained a total of 12 nests, each approximately 30 cm x 35 cm x 45 cm in dimension, which were constructed of sheet metal. Wood shavings were used as a nesting material in these nests and were regularly topped up to a depth of 3 cm. The nest-set was elevated 25 cm above the litter and in the original pen design was accessible at upper and lower levels by metal rungs 5 cm wide and running along the front of the nests out 25 cm and 15 cm from bottom and top levels respectively (see Plate VII). These approach rungs to bottom and top level nests were 33.5 cm and 81.5 cm above the floor respectively. Approach rungs were swung up, so as to occlude the entrance to nests, prior to the birds reaching 20 weeks of age at which point nests were opened up and both rungs and nests made available to the birds for the remainder of their stay in the pen.

Hens were fed at approximately 12.45 pm each day. Eggs were collected thrice daily from the back of the nests in the service aisle. In the original nest design the backs of the nests were constructed of wire partitions which were swung inwards from the service aisle in the collection of eggs (see Plate VII).

Forty five hens and six cockerels were housed in each pen. This gave a floor density of 5.20 birds/sq. m. and a hen to nest ratio of 3.75 hens/nest.

The conditions provided in these experiments only approximated those found in commercial breeder enterprises, unfortunately. Pens were small, as were flock sizes, in comparison to such commercial situations, and the number of nests provided per bird was higher than would normally be used. The number of potential nest sites on the floor in these pens was probably increased also, as a result of the large area of floor which was adjacent to a wall in each small pen.

For the purposes of the present study, each of the four rows consisting of 12 pens was used for each of four different experiments. Treatments applied in these studies were allocated to particular pens, in which particular nutritional treatments were applied, as elements in an incomplete Latin Square design. The three pre-production nutritional treatments became the three replicates for each treatment of the present study. This was done because, although the direct effect of restriction level was not considered to be a likely influence on floor laying patterns, the time or age at which the different hens would be coming into lay, which could be affected by pre-production restriction level, might be. Thus the allocation procedure allowed for any post-production effect on treatment differences to be minimised, while pre-production influences, if they were felt, could be detected if replication effects were evident.

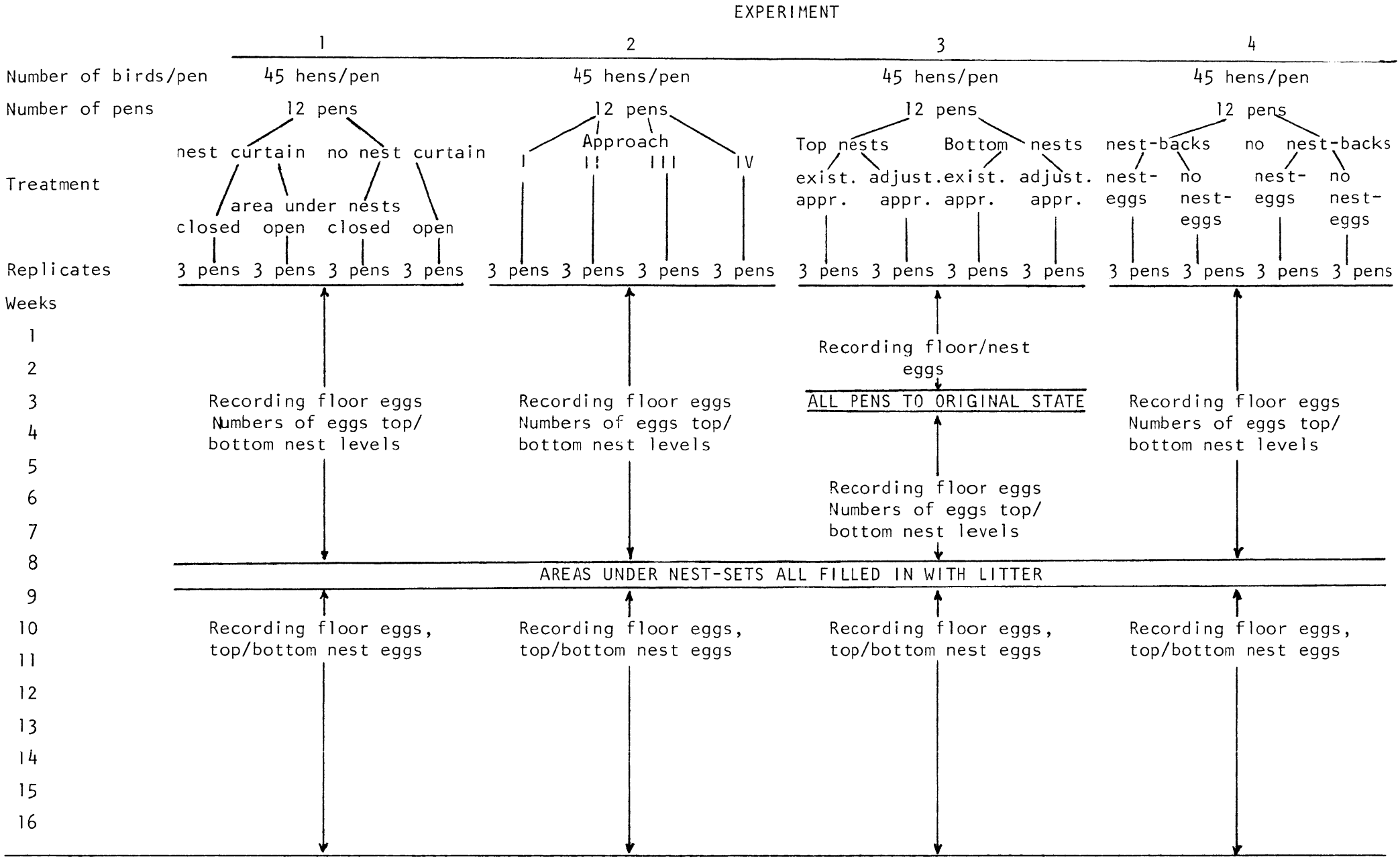
All alterations to the existing facilities were commenced as the first hens began to lay, completed within two days, and recordings commenced within one week from the appearance of the first egg, at which point the majority of hens had not laid their first egg. A summary of the treatments applied in these experiments is given in Table 5.1.

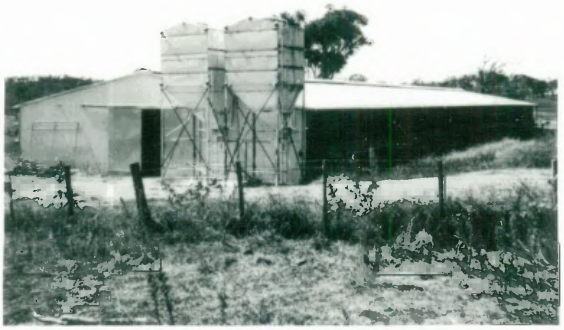
In row 1, an attempt was made to study nest usage in pens in which a complete nesting area had been created by means of a hessian surround which divided the nest-set off from the rest of the pen area. The hessian was supported from the top of the pen by means of a metal rod. The hessian fell in a continuous sheet down to within 15 cm of the floor. The surround reached from the pen wall to which the nest-set extended, which also divided one pen from an adjacent pen, to a point 30 cm from the other end of the nest-set and back to the wall along the servicing aisle, next to the door. The surround was positioned 80 cm out from the front of the nests so that there was adequate space for hens to jump to the lower level approach rung or fly to the upper level and dismount without much difficulty. To gain access to the nesting area hens had to push their way underneath the surround. This was the only means of access to the nesting area. Once in the nesting area, particularly in the nests, hens could see no other hens or the facilities of their own pen directly. They could, however, see something of the adjacent pen on the one side which the nest-set came up against. Images of their own pen and flock-mates could also be discerned through the slightly porous hessian. The bottom of the hessian surround was found to move about too much with gusts of wind and so all surrounds were anchored down in several places along their lower edges at the end of the second day of observation.

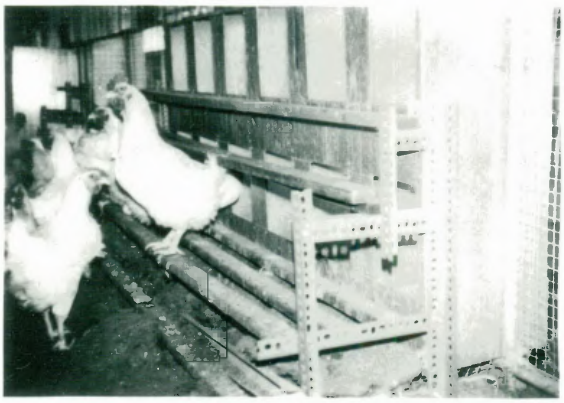
Half of all row 1 pens were equipped with these hessian surrounds and half were left in their original state with the nests facing directly out into the general pen area. Half of the 'curtained' pens and half of the 'uncurtained', or original pens without surrounds, had the floor area underneath the nest-set blocked off so that hens could not get underneath the nest-set to lay. The remaining six pens of both curtained and uncurtained treatments were not altered in this way. Thus, in row 1 (otherwise known as Experiment 1), two different factors were investigated, curtains versus no curtains, and open versus blocked off areas underneath nest-sets. Each possible combination was replicated in three pens.

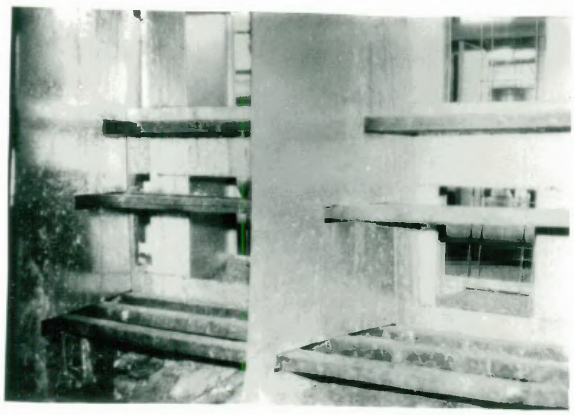
The second row of pens (row 2 or Experiment 2) was used to see if simple alterations to the approach system could be used to change nest usage patterns. Four alternative approaches were compared, with three replicates of each alternative. Alternatives are shown in Plate VII. The first alternative,

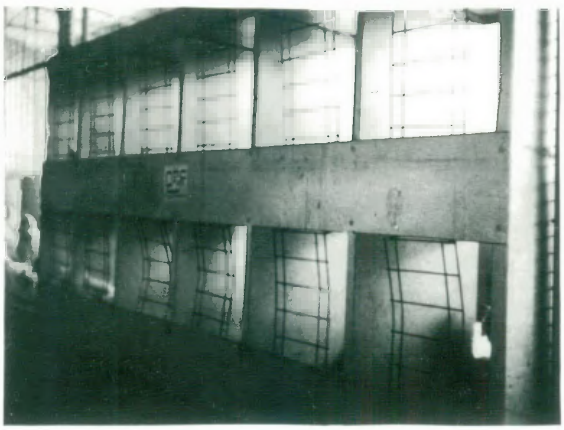
Table 5.1 Experimental design, treatments applied and observations taken - floor-laying trial











approach I, was that already in existence in the pens. It consisted simply of a single metal rung in front of top or bottom nest levels. The second alternative (approach II) consisted of a single 2 cm x 6 cm wooden rung to the upper nest level, and a three rung wooden 'platform' approach to the bottom level which extended out 30 cm from the front of the nest-set. The third alternative (approach III) consisted of a four level step-up approach constructed of wooden rungs bolted to an angle-iron frame. Each level was closer to the nest-set front than the level below it, so that hens could easily step from one level to the next without having to fly to any part of the approach or nest-set. Two levels gave access to the bottom set of nests, and a further two levels allowed hens access to the upper nests. Levels immediately adjacent to the nest entrances were runged right to the front of the nests so that hens could walk straight from the approach into the nest. Distances between the levels were spaced so that hens could step or hop from one to the next. This meant that hens had to crouch slightly in order to enter lower nests between the second and third steps of the approach.

The fourth alternative (approach IV) was similar in design to approach III. The same step-up system of levels was used, but sheet metal partitions were placed across the approaches up to the front of the nest-set, so that the approac and nest-set was effectively partitioned into three discrete four-nest blocks. This was done to discourage hens from moving along the length of the nest-level evicting other hens from all the nests in the row. Some indication of the design of this, and the other approach alternatives, can be gained from Plate VI

In the third experiment (row 3 or Experiment 3), an attempt was made to establish the importance of nest height in determining nest usage in the pen situation. Four treatments were again applied. The first, TE (top/existing), involved closing and wiring up the bottom level of nests so that hens could not get into them. The original or existing metal rung approach was the only means of access to these nests. The second treatment, TA (top/altered) again allowed hens access to the top level of nests only, but an alternative approach to the nest was provided. This consisted of a wooden runged step-up approach similar to that used in Experiment 2 except that only three levels were provided in the step-up system. In the third treatment, the top level of nests was excluded and the birds were allowed access to the nests by means of the existing metal rung. This treatment was termed BE (bottom/existing). For the final treatment BA (bottom altered), top level nests were excluded and the original metal approach replaced with a three board wooden platform in front of the nests, similar to that provided in approach II, Experiment 2.

In the fourth and final row (Experiment 4), it was intended that a study of the influence of several factors, for which very obvious preferences had been previously established on nest usage patterns, be conducted. One such factor had been the presence or absence of a nesting material. While this would have been an ideal factor to have studied, the economic conditions under which the experiment was conducted necessitated that the treatments applied did not exacerbate the existing floor-laying problem in the shed. Since removal of nesting material from some pens may have done this, it was decided to investigate the effect of provision of additional confinement to the nests and the inclusion of nest-eggs in nests instead.

To provide a sense of additional confinement to the nests, sheet metal nest backs were wired to the swinging wire back of each nest in the allotted pens. These backs prevented hens from seeing out into, or being seen from, the service aisle, except through a 3 cm gap at the top of the nest back which was included to allow adequate ventilation through the nest. Half of the row 4 pens had all of the nests provided in them fitted with these backs. Nests with and without these backs are shown in Plate VII.

In addition, half of the pens with and half of the pens without nest-backs had nest-eggs placed in all nests in the provided nest-sets. The nest-eggs were hard boiled bantam eggs. One of these was placed in each nest in the allocated pens. Nest-eggs which were broken and eaten were replaced as soon as possible. Nests in the remaining six pens were not equipped with nest-eggs. Thus, this was another two by two factorial design experiment, investigating the influence, if any, of nest confinement, the presence of eggs in provided nests and the interaction of these factors on nest usage and floor-laying patterns.

As was the case for Experiments 1 and 2, all treatments, or possible combinations of treatments, were replicated in three pens.

During the eighth week of recordings, while the observer was away for a period of several days, one of the workmen at the poultry farm unwittingly interfered in the experiments by shovelling litter into, and therefore blocking off, the area underneath the nest-set in a number of pens in which floor-laying in these areas was particularly rife. When this was discovered, there was no alternative but to do the same to all pens since it was possible that hens, having been forced out of these laying sites and possibly into nests, may have learnt to use nests which they otherwise might not have used. This could have interfered quite significantly with results, particularly since it tended to be those treatments which gave rise to high levels of floor-laying which the

workman had altered. Since all pens in the shed were dealt with in this way during the last few days of week 8 of recordings, all weekly data up to and including that of week 8 were analysed separately from data from weeks later than week 8.

(b) *Floor-Laying Recordings and Behavioural Observations*

(i) Floor egg/nest egg recordings

In order that rates of floor-laying could be determined, the following procedure was followed. Eggs were collected and recorded from each pen three times daily, seven days a week. The first collection took place at 9.00 am, the second at approximately 11.00 am and the third at approximately 1.00 pm, shortly after feeding time. During each collection the numbers of eggs found in either top or bottom level nests were recorded as were the numbers of eggs found on the floor of the pen. Data recorded in each of these collections on each day were then used to calculate weekly floor egg percentages and per cent nest eggs laid in bottom level nests according to the following formulae:

$$\text{Floor egg \%} = \frac{\text{Number of floor eggs} \times 100}{\text{Total number of eggs (floor + nest eggs)}}$$

$$\text{\% Bottom level eggs} = \frac{\text{Number of eggs from bottom level nests} \times 100}{\text{Total number of nest eggs (top + bottom nests)}}$$

Week 1 recordings commenced the day after all alterations to the existing shed facilities had been completed and, as previously mentioned, this occurred within a week after the first eggs were dropped in the shed. Data were recorded each day for a period of 12 consecutive weeks, and again for a further week 16 weeks after the commencement of recordings.

During the sixth week, records were taken of where in the pen floor eggs were being laid in Experiment 1 pens only. Floor eggs were classified as either from the floor area behind the curtain or from elsewhere in the pen in the case of 'curtained' pens, or from corresponding areas in 'uncurtained' pens.

(ii) Behavioural observations

During the 10th, 11th and 12th weeks of the experiment, a number of observations were made on the activities of hens in nests. Records of activities of all hens in nests were recorded at hourly intervals throughout the day for five days. Commencing five or ten minutes before 5.00 am, each pen would be visited and the activities of hens in nests recorded. Visits were made in a strict order, running first up row 1, then down row 2, up row 3 and finally down row 4. All observations were taken from the service aisles and took

approximately 12 to 20 minutes in total to complete each hour, depending on the time of day. The visits and recordings were repeated every hour throughout the day to 4.00 pm.

Activities of hens on the nest were classified into those which took place in top or bottom nests and also according to whether the hens performing them were facing into the pen, out into the servicing aisle or across the nest. The number of hens that were sleeping, sitting and inactive, sitting but actively engaged in some activity, or in the laying stance were recorded for each of these categories. The number of hens standing was also recorded for top and bottom level nestings, but this was not classified according to orientation of the hen in the nest since standing hens were often in the process of changing their direction in the nest. Definitions of these activities as applied in this study were as follows:

'sleeping' = hen in a sitting or lying position in the nest with eyes closed, or, hen standing in nest with head tucked under the wing (rarely seen).

'sitting-inactive' = hen sitting or lying with legs bent and the breast in contact with the floor of the nest. The hen's eyes are open and the hen alert, although she is not performing any other activity.

'sitting-active' = hen sitting or lying with legs bent and the breast in contact with the floor of the nest. The hen is actively engaged in some activity, such as nest building activities or preening.

'laying stance' = hen raised up in stance typical of hen about to lay and usually straining.

'standing' = hen standing with legs and back straight; may or may not be performing any other activity.

Over the days that these activity recordings were taken, hourly records of numbers of eggs laid were also collected. Commencing at approximately 4.30 am each morning, the numbers of eggs in each nest-set were recorded and removed. Pens were visited in the same order as they were for the activity recordings. These visits were repeated each hour to 3.30 pm. The number of eggs collected represented the number of eggs laid during the hour in which the previous activity observations had been recorded.

In an additional study, pens were visited regularly at 30 minute intervals, and the orientation of hens which were found to be in the laying stance recorded. Five orientations were recognised:

A = hen's body facing out towards the pen, but head averted so that it was in a corner created by the front panel of the nest and the side wall of the nest -

B = hen's body and head facing out into the pen -

C = hen's body directed across the pen -

D = hen's body and head facing directly out into the service aisle -

E = hen's body facing out into the service aisle, but head averted into either of the back corners of the nest.

An attempt was made to follow the nesting habits of individual hens over a number of successive nestings during weeks 11 and 12. In order to do this, a number of hens from each pen were marked with different coloured spray paints on back, tail, or left or right wing areas of the body. Initially it was hoped that six hens found nesting in bottom nests and six hens found nesting in top nests in each pen would be marked in this way. However, in a number of pens insufficient top or bottom level nesters could be found, so the number of hens marked in each pen varied slightly.

Hens were marked in each pen over a period of several days. On subsequent days, all nest-sets were visited at half hourly intervals and a note made of when marked hens first appeared in nests and when they left the nest-set after laying. Whether a hen was, in fact, going to lay, and whether it had laid during the 30 minute interval between visits were determined by palpation of the hens and egg counts on eggs present in the nests. Hens rarely appeared disturbed by the handling involved in this procedure and only very occasionally left the nest that they occupied as a result of it, although they were quite free to do so. A note was also made during these visits of which level and which nest each marked hen occupied, and whether several nests or levels were occupied on the one day. Individual nests were named A, B, C, D, E and F, A being the nest closest to the door and F the nest furthest from the door in each pen. Nestings were discarded in cases where the hen performing them gave any indication of brooding behaviour.

(c) *Analysis of the Data*

All weekly floor egg percentages and percentage nest eggs in bottom level data were transformed by arc sine $\sqrt{\text{percentage}}$ to stabilise the variance. The data were then analysed on a weekly basis, using analysis of variance. The replicate component of the total sum of squares was examined at each week and in all cases the variance ratio was not significant and in most cases was less than unity. The replicate sum of squares was thus combined with the residual sum of squares to give a residual mean square on eight degrees of freedom for each

experiment and thus a more powerful test. Each experiment was analysed separately. All weekly data for the periods from week 1 to week 8 and from week 9 to week 16 in each experiment were then analysed as an overall split plot in time. It was recognised that some caution should be exercised in applying this analysis because of possible serial correlation in the errors in the sequential observations.

By the third week of recording it became obvious that floor-laying levels were extremely high and not going to improve greatly in pens involved in Experiment 3. This may have jeopardized the results of the nutritional trial being conducted on the same birds and so nest-sets were returned to their original state in all Experiment 3 pens at the end of week 3. Thus, Experiment 3 was analysed over three periods, from week 1 to week 3, when all the described treatments were present in the pens, from week 4 to week 8, when all pens had been altered to their original state, and from week 9 to week 16, when all pens were still in their original state but all the areas underneath nest-sets had been filled in and were not available as nesting sites.

For each of the experiments, the number of hens found to be performing the five alternative activities in nests were tabulated for each hour of the day. Regression equations predicting the number of hens performing each of the activities at different times in the day were calculated using the BAR3 programme (Burr, 1975) for regression analysis available on the DEC20 computer system at the University of New England. Polynomial models up to the third degree were fitted to the data pertaining to each row, and also to the pooled data from all rows. For each activity, tests were carried out to find if there were differences among regression coefficients for different rows.

Pairwise correlation coefficients, pooled over all rows, for the numbers of hens engaged in each activity and the number of eggs laid during each time period throughout the day were calculated. For each experiment, the interactions of treatment, nest level, activity and orientation of the hen in the nest when performing each activity were investigated by multi-way Chi-square analysis. Since the activity 'standing' was not classified according to orientation, one Chi-square analysis considered the other four activities and the orientations associated with them, and another Chi-square analysis dealt with all five activities with no reference to orientation. All analyses were performed using the BMDP4F programme on the DEC20 computer.

Orientations of hens when about to lay were tabulated for each treatment in each experiment and for each of four days on which these recordings were taken. Overall tendencies for orientation at oviposition were tested by Chi-square

analysis of numbers of hens recorded in each of the five alternative orientations totalled over all pens, assuming equal probabilities of each occurring at random. For Experiment 1, the observed numbers of types A, B and C orientations were compared for curtained and uncurtained treatments by Chi-square analysis, types D and E orientations being so infrequently recorded that they were omitted from this analysis. Similarly, analyses were performed on the data from other experiments to compare the frequencies of observed types A, B, C and D orientations for each treatment in Experiments 2 and 3 and to compare the frequencies of observed types A, B, and C orientations for pens with or without backs in Experiment 4. Total numbers of all five orientation types recorded on each of the four days of observations were analysed after square root transformation by analysis of variance using the NEVA programme (Burr, 1980) on the DEC20 computer.

For each individually marked hen, the numbers of times each nest of the one level was eventually laid in was recorded, but these data could not be analysed due to low expected values. The numbers of hens which selected the same nest for at least half of their recorded eggs in the same nest in either top or bottom level nests were then analysed by Chi-square analysis. The most commonly selected nest option was determined for each hen and the total number of hens predominantly selecting each nest tabulated for top or bottom level marker hens in all experiments. These results were then subjected to Chi-square analysis.

Times spent in final nests, which incorporated time on the final nest before and after oviposition and which was only accurate to within 30 minutes, were determined for each hen during each observed nesting. Mean times spent on the final nest by all marked hens on all occasions were determined for top and bottom nest levels in all pens. These data were then subjected to analysis of variance to test for differences attributable to experiment, pen and nest level. Due to non-significance of the between pens within experiments variance found in this original analysis, further comparisons between pens and treatments were not carried out.

5.3 Results

(a) Floor Egg/Nest Egg Recordings

Levels of Floor Laying

.Experiment 1

The weekly floor egg percentages calculated for all four types of pen in Experiment 1 are shown in Figure 5.1. As previously noted, no replication effect was found in these data or the data pertaining to any of the other three experiments. All percentage data shown for this and all other experiments have therefore been calculated from total floor egg and nest egg numbers from all three replicate pens. Original data are available from the Physiology

Department, UNE. No significant differences were detected between treatments at any one week during the study. Overall analysis revealed no significant effect of either the curtaining treatment or of eliminating the floor area underneath the nest-set on the rate of floor-laying. However, in both the first eight week period, before all areas under nest-sets were filled in, and in the subsequent time period, a significant effect of week was found. Mean floor egg percentages recorded for weeks 1 and 16 were 41.2% and 7.7% respectively. The analyses of variance for both time periods are shown in Appendix 5.1. The decline in floor egg percentages over time in both periods shows significant linear and quadratic trends . The tendency for floor egg percentages to decline over time in both periods is not significantly different for different treatments. The substantial decline in floor-laying rates during the two weeks following exclusion of the area underneath the nest-set is apparent in all treatments, despite the fact that these areas were supposed to be excluded from the hens from the very beginning of the experiment. Numbers of floor eggs dropped from 25.1% to 8.2% of all eggs laid between weeks 8 and 10.

The number of floor eggs, summed over all days and replicates, which were laid in the area behind the curtain, or in the corresponding area in uncurtained pens, during week 6 are given in Table 5.2.

Table 5.2 Numbers of floor eggs collected from floor areas behind the curtain, or in equivalent areas in uncurtained pens, and in other areas of the pen in Experiment 1 pens during week 6

Treatment	Number of Floor Eggs Collected: Behind Curtain	Elsewhere in Pen
Curtains + Area Under Nests Closed	163	55
Curtains + Area Under Nests Open	135	25
No Curtains + Area Under Nests Closed	84	90
No Curtains + Area Under Nests Open	112	82

Chi-square analysis revealed that sites of floor-laying are significantly different in curtained pens as compared with uncurtained pens ($\chi^2_{1df} = 54.5$ Approximately 85% of all floor eggs were laid in the area behind the curtain in curtained pens, whereas only 53% were laid in equivalent areas in uncurtained pens

.Experiment 2

Weekly floor egg percentages of the various approach alternatives are shown in Figure 5.2. Even early in the experiment rates of floor-laying were markedly higher in pens with the existing metal rung approaches. Floor egg percentages associated with pens with altered approaches were considerably lower (34.5% on average, as compared with 50.4% for approach type I in week 1). Floor-laying rates for these three alternatives were similar except perhaps for pens fitted with approach type III, which seemed to have a slightly lower incidence of floor eggs.

.Experiment 3

Overall analysis presented in Appendix 5.2 indicated significant differences between approach treatments in both the first eight week period and the subsequent period. Significant effects of week were also felt in both periods. The decline in floor-laying over time during the first eight week period again showed significant linear and quadratic components, as the rate of decline in floor-laying slowed down towards the end of this period. After this period, changes in floor egg percentages followed a less obvious pattern.

Floor egg percentages throughout the study are shown for Experiment 3 treatments in Figure 5.3. Floor laying rates were extremely high in this experiment (58.8% floor eggs decreasing to 47.5% from week 1 to 3), and as previously noted, both levels of nests had to be made available to hens in these pens after the third week of recording because of this. Results of weekly analyses of variance are given in Appendix 5.3. Also shown in this Appendix are the overall analyses for the periods covering weeks 1-3, weeks 4-8 and weeks 9-16. Largest differences were found in the third week. Highest floor-laying rates at this stage were found in the two treatments in which hens only had access to the top level of nests (mean of 61.4% floor eggs at week 3). Lowest numbers of floor eggs were collected from the pens in which hens had access to the lower level of nests via an altered, wooden platform approach.

The decline in floor egg percentages over the first three weeks exhibited a significant linear trend. However, during the subsequent five week period after all pens had been returned to their original state, no significant week effect was felt. After areas underneath all nest-sets were filled in, percentages of floor eggs dropped further, particularly in the case of the top/adjusted, top/existing and bottom/existing treatments which had previously

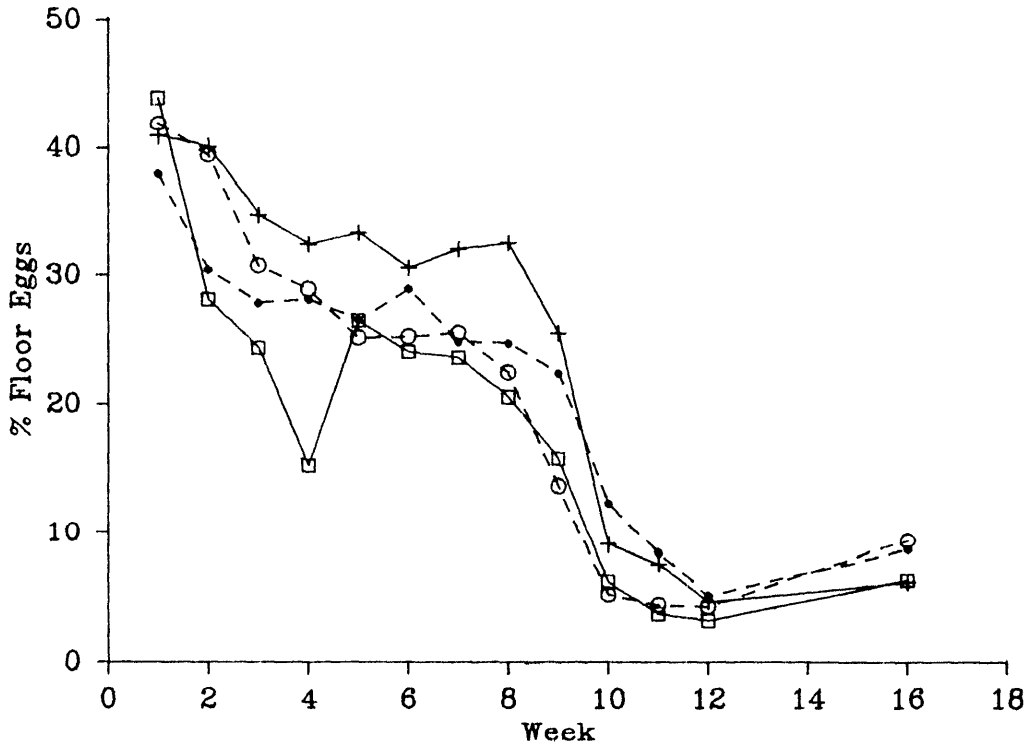


Figure 5.1 Weekly floor egg percentages - Experiment 1 (+——+ = curtains/area under nest-set blocked off; □——□ = curtains/area open; o---o = no curtains/area blocked off; •— — —•= no curtains/area open)

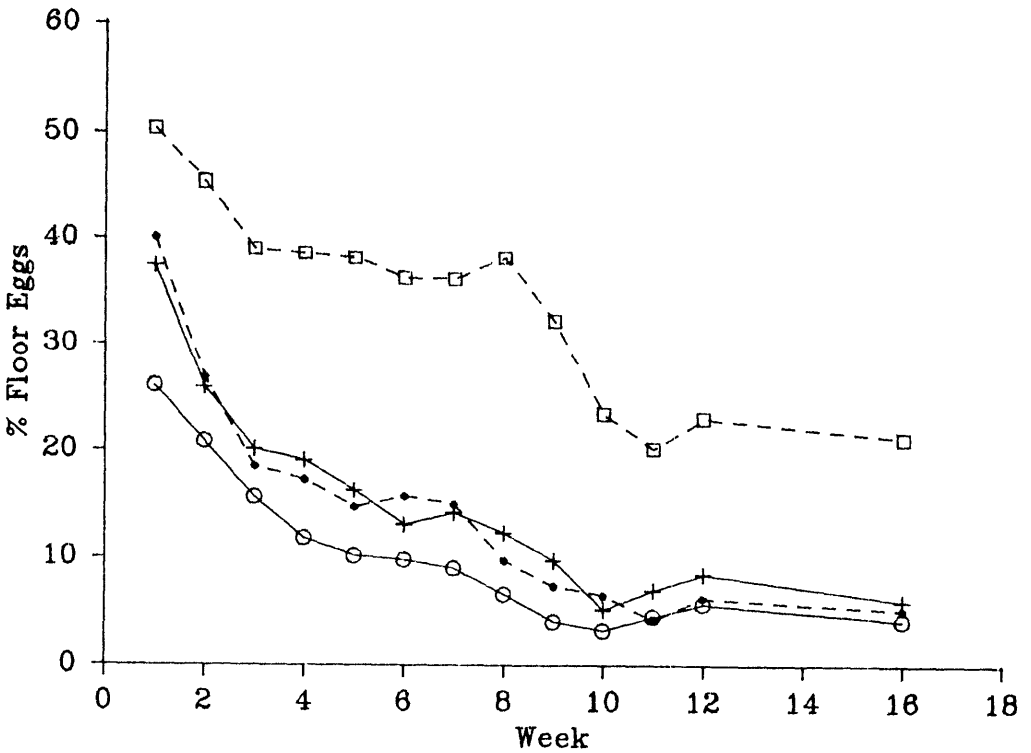


Figure 5.2 Weekly floor egg percentages - Experiment 2 (□--□ = Approach I (existing); +——+ = Approach II (wooden platform); o——o = Approach III (wooden step-up); •— — —• = Approach IV (step-up with divides)

produced the largest floor-laying levels. This decline in floor-laying level followed a linear trend during the final period of recordings. Differences between the treatments decreased to non-significant levels during the last month of continuous recording and were even smaller when pens were again recorded at 16 weeks.

Although no direct comparisons can be made, it certainly appeared that floor-laying levels in Experiment 3 were considerably higher throughout the study than they were in any of the other experiments. It was therefore interesting to note that top level nests were not used, or only used by one or two hens, in a number of pens involved in other experiments throughout most of the study. In the individual pens in which this was noted, no marked differences in numbers of floor eggs collected were obvious when compared to replicate pens in which both nest levels were well used.

.Experiment 4

Weekly floor egg percentages of the four possible pen types studied in Experiment 4 are shown in Figure 5.4. Results of the analyses of variance carried out on the data pertaining to each week in the study, and overall analysis for the first eight week period are shown in Appendix 5.4. Analysis of variance for the period from 9 to 16 weeks is not shown since this analysis revealed no significant differences.

During week 3, significant differences between treatments with, as compared with those without, nest-backs began to appear. This trend was most evident at week 5, becoming less obvious and disappearing during later weeks of recording. Floor-laying levels in all four possible nest types were very similar during the final weeks of recording. Overall, the trend towards lower floor-laying rates in pens with nest-backs only approached significance in the first eight week period ($P < 0.1$). Mean floor egg percentages for pens with or without nest-backs over this period were 20.0% and 26.9% respectively. At no stage was any trend regarding an effect of nest-eggs apparent.

Significant linear and quadratic trends were shown in the decline in floor egg percentages over time during the first eight weeks in Experiment 4, although considerable variation about this was also found. As was the case in the other experiments, floor-laying dropped considerably during the week after all areas under nest-sets were excluded. This is indicated by the sudden and steep decline in graphs of floor egg percentages between weeks 8 and 9. Generally, floor egg percentages appeared to have stabilised by week 16.

Although records were not taken, it was thought that a large number of eggs laid in pens with nest-eggs were eaten. This was evidenced by a high level of broken eggs in such pens or of yolk stained eggs found in nests.

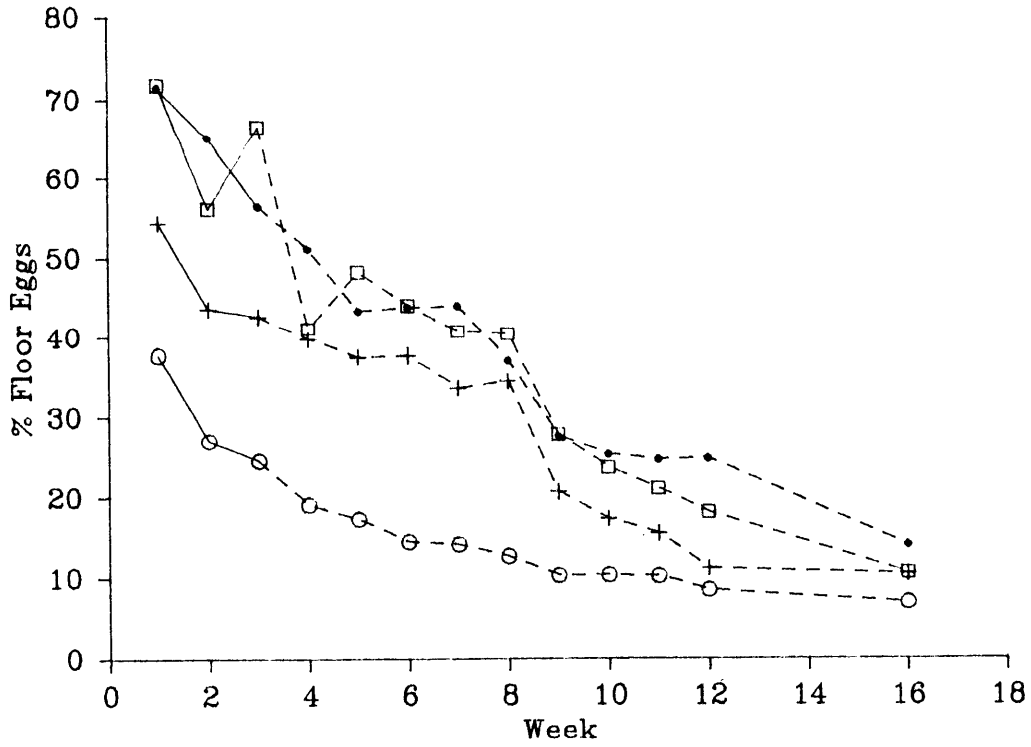


Figure 5.3 Weekly floor egg percentages - Experiment 3 (• = top nests/existing approach; □ = top nests/adjusted approach; + = bottom nests/existing approach; o = bottom nests/adjusted approach; —— = while treatments operating; --- = after all returned to original state)

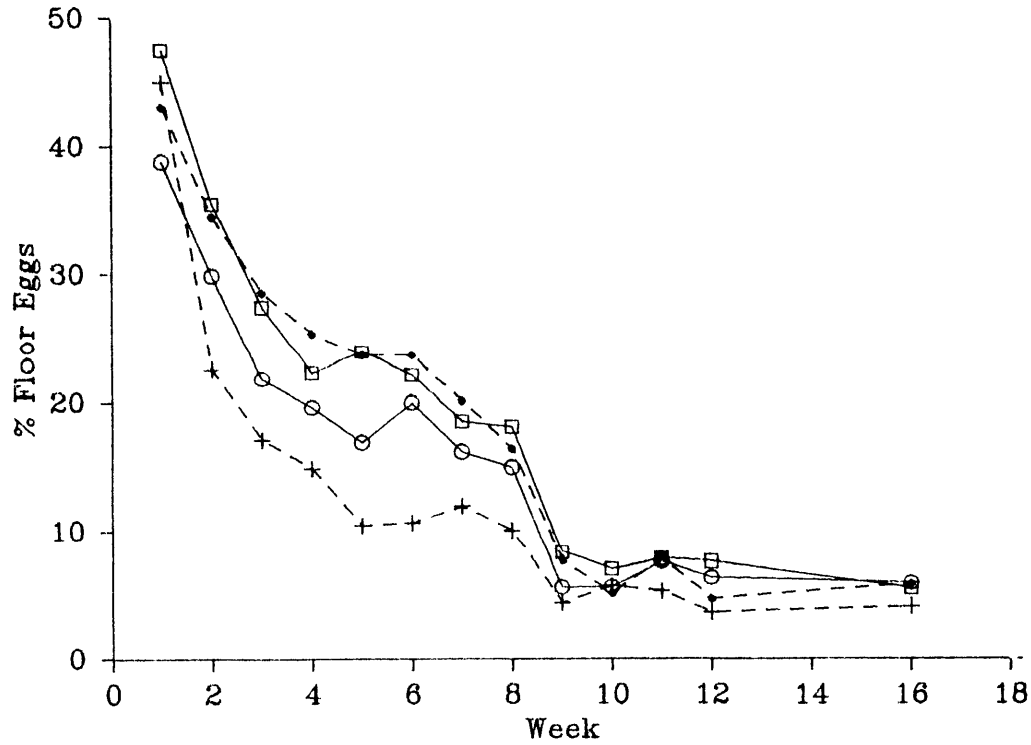


Figure 5.4 Weekly floor egg percentages - Experiment 4 (•---• = no nest-back/no nest-egg; o——o = nest-back/no nest-egg; □——□ = no nest-back/nest-egg; +---+ = nest back/nest egg)

.Overall

Mean floor egg percentages throughout the study for all pens in all rows are shown in Figure 5.5. Since these figures were from all four experiments,

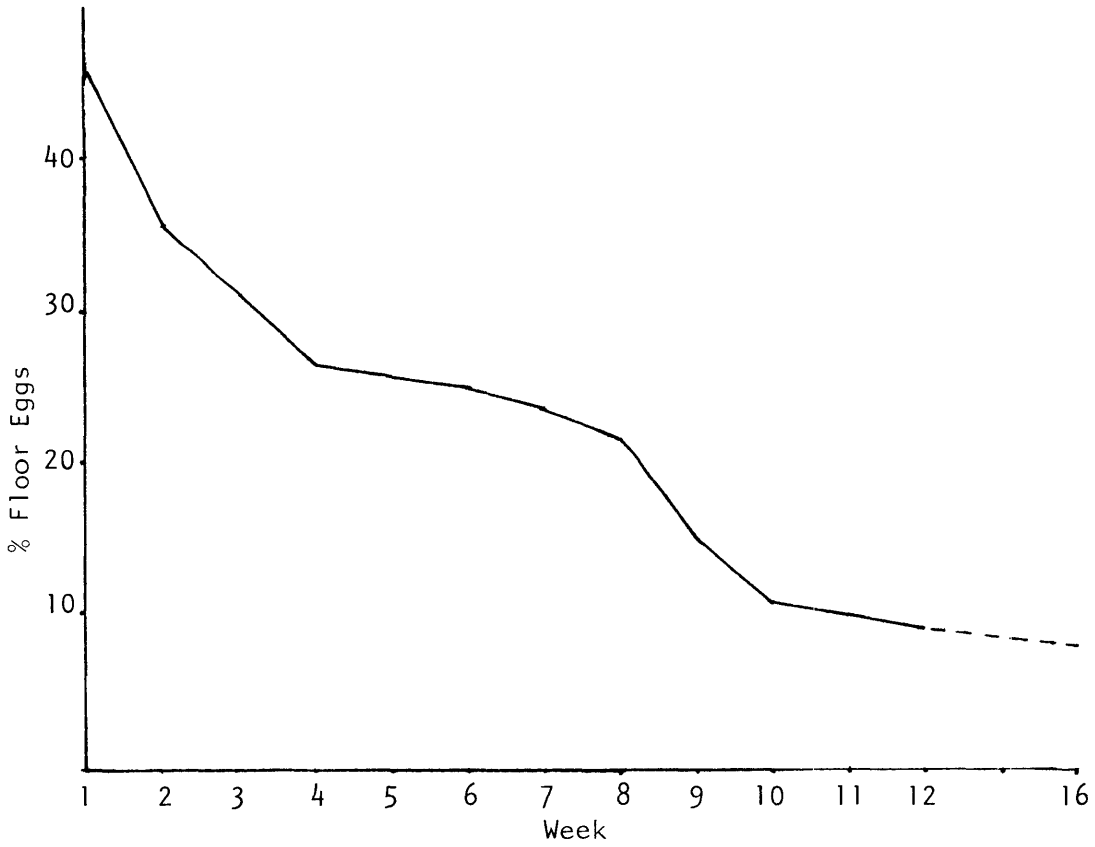


Figure 5.5 Mean floor egg percentages throughout the study for all pens and all rows

no analysis of the data was attempted. However, this figure does indicate the overall trend in floor-laying over time. Levels of floor-laying tended to decline quite dramatically during the first two weeks of recording. The rate of decline in floor-laying levels decreased during the final few weeks of the first eight week period. At the end of this period, floor egg percentages had stabilised somewhat. After the elimination of floor areas under all nest-sets, or at least from the ninth week, floor-laying levels once again dropped markedly (approximately 24% to 11% between weeks 8 and 10). This decline again lessened with time and floor egg percentages tended to stabilise once more towards the end of the study.

Usage of Nest Level

Weekly values of percentage nest eggs which were laid in bottom nests for all treatments in Experiments 1, 2, 3 and 4 are represented in Figures 5.6, 5.7, 5.8 and 5.9 respectively. These are mean values of the three replicates. Original data are available from the Physiology Department, U.N.E. Results of weekly analyses of variance and overall analyses for which significant differences were revealed are shown in Appendix 5.5.

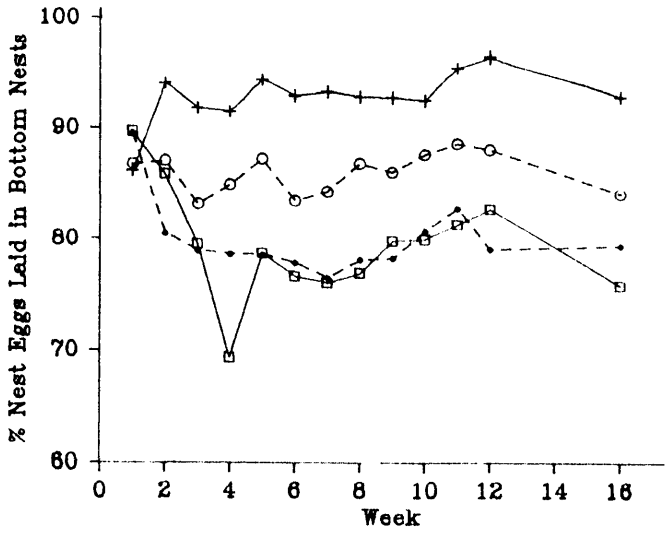


Figure 5.6 Weekly percentage nest eggs laid in bottom nests-Experiment 1 (+—+=curtains/area blocked off;□—□ =curtains/area open; o--o=no curtains/area blocked off;•---• =no curtains/area open)

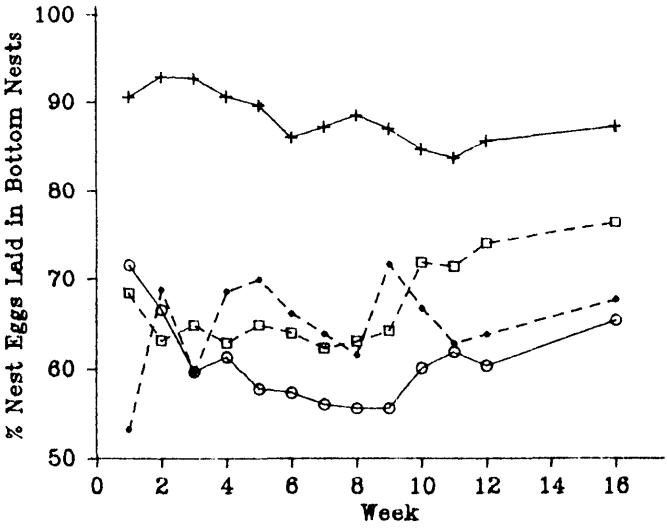


Figure 5.7 Weekly percentage nest eggs laid in bottom nests-Experiment 2 (□--□ =Approach I; +—+=Approach II; o—o= Approach III; •---• =Approach IV)

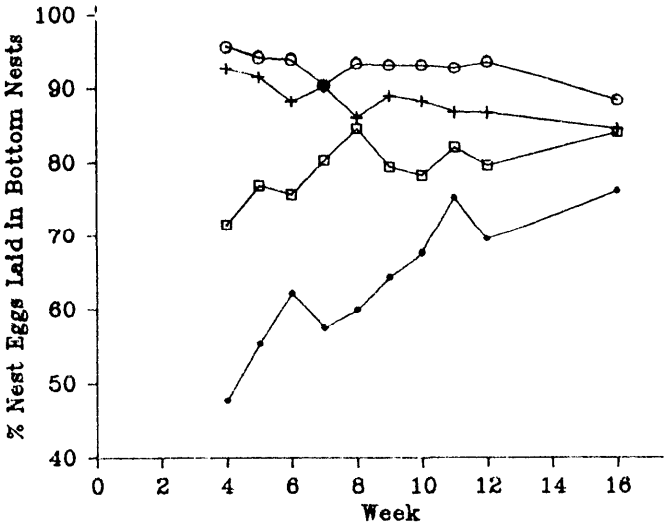


Figure 5.8 Weekly percentage nest eggs laid in bottom nests-Experiment 3 (•—•=top nests/existing approach; □—□ =top nests/adjusted approach; +—+=bottom nests/existing approach; o—o=bottom nests/adjusted approach)

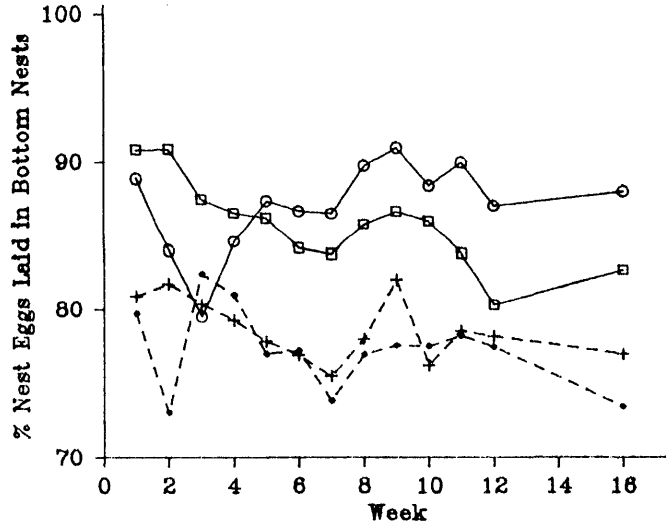


Figure 5.9 Weekly percentage nest eggs laid in bottom nests-Experiment 4 (•---• =no nest-back/no nest-egg; o—o=nest-back/no nest-egg; □—□ =no nest-back/nest-egg; +--+=nest-back/nest-egg)

.Experiment 1

Although no significant differences were found between treatments in the first eight week period in Experiment 1, the proportion of nest eggs that were found in bottom level nests varied significantly over time in the following period. An overall increase in bottom level eggs was evident between weeks 9 and 16, although this had dropped again by week 16. Although Figure 5.6 gives the impression that bottom nest usage in pens in which the area underneath the nest-set had initially been excluded was greater than it was in pens in which which that part of the floor area had been available, this only proved to be signi icantduring week 12. Overall, this trend in bottom nest usage between pens with or without areas under nest-sets available, only approached significance in the period after all such areas had been excluded from all pens.

.Experiment 2

Results presented for Experiment 2 in Figure 5.7 and Appendix 5.5 indicate that large differences existed in levels of bottom nest usage throughout the study. The most obvious tendency was for bottom nests in approach type II pens to be used to a greater extent (mean of 89.1% of nest eggs) than they were in pens in which the other three types of approaches were provided (mean of 64.7% of nest eggs). All of the other approach alternatives produced bottom nest usage figures which were very similar to each other, except perhaps for the slightly lower values found for approach III, the step-up approach without divisions. A significant effect of week was apparent in the period from week 9 to 16, but the trend exhibited tended to be somewhat different for different treatments.

.Experiment 3

Percentage nest eggs laid in bottom nests are only available from week 4 onwards in Experiment 3, because only top or bottom level nests were available to hens up to that point. Treatments were found to differ significantly with respect to bottom nest usage during the first eight weeks in Experiment 3. Results of weekly analyses indicate that these differences were greatest during the first two weeks after all nests were made available to hens. Usage of bottom nests was greatest (mean of 93.4% of nest eggs in weeks 4 and 5) in pens in which bottom nests had previously been the only nests available. Bottom nests were used least (mean of 62.9% of nest eggs in weeks 4 and 5) in those pens in which hens had previously had access only to upper nests via the existing approaches.

The data presented in Figure 5.8 suggest that bottom nest usage in pens in which top level nests only had been available tended to increase over time, while bottom nest usage stayed much the same in those pens which had previously only had bottom level nests. However, analysis revealed that this trend only approached significance ($P < 0.1$) in both time periods.

.Experiment 4

Weekly percentage nest eggs laid in bottom level nests in Experiment 4 as shown in Figure 5.9, did not show any consistent trends over time. The only significant differences found were for different nest-back/nest-egg combinations during week 9. Bottom nest usage remained fairly constant throughout the study otherwise.

Overall, bottom nests tended to be used much more heavily than top level nests. On average, approximately 80% of all eggs were laid in bottom level nests.

(b) Behavioural Observations

Occurrence of Activities on the Nest Throughout the Day

Regression equations describing the changes in numbers of hens performing particular activities throughout the day in each experiment are given in Table 5.3. Analyses indicated that differences between regression coefficients determined for different experiments were not significant in the case of any of the activities recorded and so the regression equations for all data pooled were also calculated for each activity.

Total numbers of hens observed to be engaged in each of the activities at different times of the day on all days of observation are illustrated in Figure 5.10. These data are results for all pens and all rows pooled. Also shown in this figure are the total numbers of eggs laid in all pens, rows and days during each hour of the day from which the activity data came. Correlation coefficients, pooled over experiments, calculated for activities and numbers of eggs laid in each time period are given in Table 5.4.

The activity most commonly recorded at all times of day was sitting while inactive or 'resting'. Numbers of hens recorded in this activity increased up to a peak at about 7.00 am or a little later. From this time onwards each day, numbers of hens sitting, inactive, declined markedly, the rate of decline decreasing gradually as the afternoon progressed. These trends for numbers of hens sitting, inactive or resting, throughout the day closely parallel the trends in numbers of eggs laid. This is reflected in the high correlation between number of eggs laid and number of hens sitting, inactive, shown in Table 5.4.

Number of eggs laid during hourly periods throughout the day increased steadily and dramatically from 4.00 am to about 8.00 am. A peak value was obtained at 9.00 am. Thereafter, numbers of eggs laid in each hour dropped off quite sharply, the decline tapering off later in the afternoon.

Table 5.3 Regression equations of the form $y = \hat{\beta}_0 + \hat{\beta}_1 x + \hat{\beta}_2 x^2 + \hat{\beta}_3 x^3$ (i.e. up to the third degree)' calculated for number of hens performing each activity, or eggs laid (x) over time of day (y)

Activity	Row	$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	Significance of Equation
Sleeping	1	41.31***	-2.93			***
	2	106.43***	-15.04**	0.527		*
	3	60.98***	-9.39***	0.354		***
	4	102.31***	-13.59***	0.454		***
	All	332.12***	-45.45***	1.550		***
Resting	1	-1100.31***	416.38***	-41.425***	1.2371	***
	2	-692.98*	331.43**	-36.084**	1.1368	**
	3	-394.68**	184.84***	-19.622***	0.6038	***
	4	-1283.44***	501.21***	-51.186***	1.5647	***
	All	-3473.92***	1434.75***	-148.416***	4.5456	***
Active	1	-238.33***	79.38***	-7.308**	0.2053	**
	2	-340.35**	117.25***	-11.264***	0.3301	**
	3	-144.92**	50.49**	-4.788**	0.1381	**
	4	-242.47**	83.26**	-7.815**	0.2234	**
	All	-966.07***	330.39***	-31.175***	0.8968	***
Laying	1	-24.72**	9.07**	-0.802**	0.0209	**
	2	-54.59*	20.68*	-2.102*	0.0642	*
	3	-60.81**	21.12***	-2.044**	0.0604	**
	4	-27.65*	10.06*	-0.947*	0.0269	*
	All	-167.78**	60.92***	-5.897**	0.1724	**
Standing	1	-10.14	6.02~	-0.335		**
	2	-7.70	5.97~	-0.334		*
	3	18.51***	-0.96			***
	4	-10.79	5.95*	-0.328		*
	All	-13.38	17.71*	-1.035		**
Total Eggs Laid	1	-1215.19*	421.13*	-39.192*	1.1056	*
	2	-1601.60***	596.33***	-59.998***	1.8275	***
	3	-893.34***	335.53***	-33.479***	1.0091	***
	4	-1616.59***	576.02***	-55.967***	1.6539	**
	All	-5074.47***	1854.53***	-181.721***	5.3915	**

' Blanks in table indicate that this and higher order terms are not significant

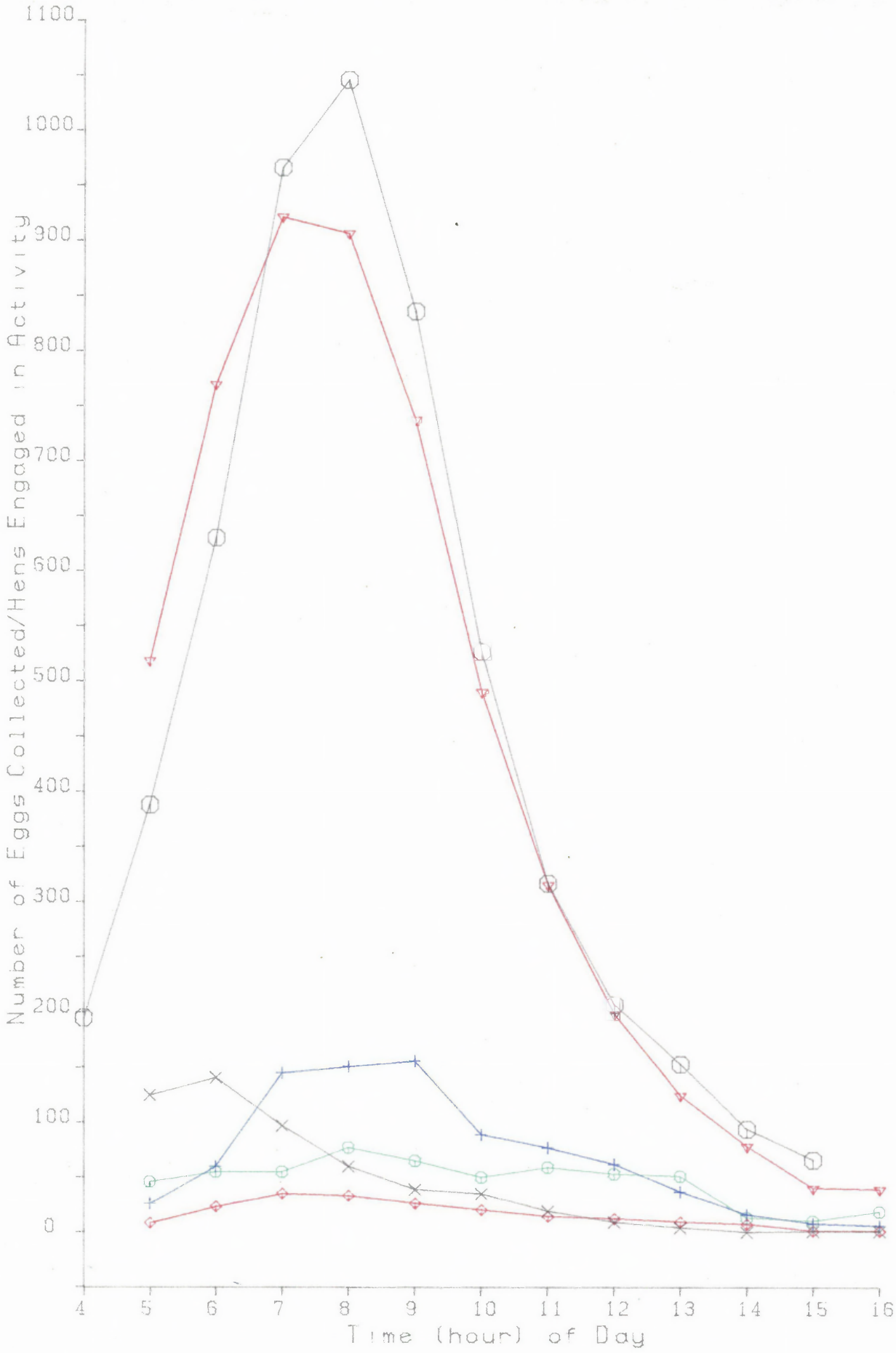


Figure 5.10 Total numbers of hens engaged in the activities sleeping (x——x black), sitting, active (+——+ blue), sitting, inactive or resting (▽——▽ red), laying stance (◇——◇ red) or standing (o——o green) and total numbers of eggs laid (0——0 black) at different times of day on all days of observations in all pens

Table 5.4 Pairwise correlation coefficients for numbers of hens recorded in particular activities in nests throughout the day and numbers of eggs laid during the same periods

	Activity on the Nest				
	Sleeping	Sitting (Active)	Sitting (Inactive)	Laying Stance	Standing
Number of Eggs Laid	.557***	.879***	.957***	.837***	.625***
Sleeping		.227 N.S.	.695***	.430**	.279⁻
Sitting (Active)			.779***	.819***	.625***
Sitting (Inactive)				.789***	.580***
Laying Stance					.521***

The number of hens recorded to be sitting whilst actively involved in some other form of action or movement also increased during the morning, reaching a peak value between 7.00 am and 9.00 am. Numbers of hens engaged in this type of activity on the nest dropped through the remainder of the day. Numbers of hens sitting but active was highly correlated with number of eggs laid also. It was also highly correlated with the number of hens sitting, inactive, in the laying stance and standing in nests.

The number of hens actually recorded whilst in the laying stance was quite low, but showed a significant tendency to increase up to about 7.00 am to 8.00 am, and then to decline again through the remainder of the day. A highly significant correlation existed between this parameter and number of eggs laid. It was also highly correlated with incidences of sitting, standing to a lesser extent, and also with sleeping.

The numbers of hens found to be sleeping in the nestswere highest in the first two hours of observation and then declined throughout the day. As for previously described activities, the rate of decline in the numbers of hens sleeping decreased throughout the rest of the day. Although still highly correlated with number of eggs laid during the day, sleeping was not so highly correlated with eggs laid as were the other five possible activities. Correlation coefficients determined for sleeping frequency with sitting, active, and standing frequencies were not significant.

Of all the activities, standing followed the most irregular pattern over time. Overall, a quadratic equation was found to describe the change in

numbers of hens standing in nests more satisfactorily than linear or cubic models. However, the results as presented in Figure 5.10 suggest that the peak in standing numbers which occurred around 8.00 am may have been followed by another peak several hours later. Unfortunately, a quartic model was not fitted to this data so this is not shown statistically. Between 1.00 pm and 2.00 pm numbers of hens standing in nests decreased markedly. The numbers of hens standing throughout the day correlated well with numbers of eggs laid and numbers of hens sitting and in the laying stance.

While not actually recorded, the most commonly observed activities performed by hens sitting on nests, when they were simply sitting, inactive, appeared to be nest building activities and movements of eggs already present in the nest.

Orientation in the Nest

The numbers of recorded cases of each activity in which the hen was oriented outwards into the servicing aisle, into its own pen, or obliquely across the nest so that it was facing neither into nor out of the pen, are given in Table 5.5. The figures presented are mean values for certain treatments in each of the experiments and are further subdivided according to whether hens were in top or bottom nests when engaged in the activities. Results of Chi-square analyses which proved significant are presented in Table 5.6.

Table 5.6 Significant Chi-square values determined for numbers of hens in different activities (A), orientations (O), nest levels (L), in nests in certain treatments (T), in all four experiments (E) and overall

Experiment	Chi-square Value (and Significance) of Effect:							
1	O_{2df}	A_{4df}	L_{1df}	OA_{6df}	OL_{2df}	OT_{2df}	AL_{4df}	
	639.9 ***	2879.8 ***	827.7 ***	95.3 ***	16.7 ***	36.1 ***	13.2 *	
2	O_{2df}	A_{3df}	L_{1df}	T_{3df}	OA_{6df}	AT_{12df}	LT_{3df}	OLT_{6df}
	584.0 ***	3357.7 ***	431.2 ***	54.9 ***	144.9 ***	35.7 ***	114.7 ***	12.9 *
3	O_{2df}	A_{3df}	L_{1df}	T_{3df}	OA_{6df}	OT_{6df}	LT_{3df}	
	431.3 ***	2106.9 ***	650.8 ***	191.6 ***	69.4 ***	18.6 **	258.8 ***	
4	O_{2df}	A_{3df}	L_{1df}	OA_{6df}	OL_{2df}	OT_{2df}	AT_{4df}	
	624.1 ***	3482.7 ***	1083.9 ***	37.3 ***	10.5 **	88.1 ***	11.3 *	
Overall	O_{2df}		A_{3df}		L_{1df}		E_{3df}	
	2041.5 ***		11842.1 ***		1897.7 ***		251.8 ***	
	OA_{6df}	OL_{2df}	OE_{6df}	AE_{12df}	LE_{3df}	OAE_{18df}	ALE_{12df}	
	287.9 ***	25.2 ***	48.7 ***	26.3 **	152.1 ***	53.1 ***	22.0 *	

Table 5.5 Numbers of hens recorded sleeping, sitting (active), sitting (inactive), in the laying stance or standing while oriented out towards the service aisle, into the pen or obliquely across the nest in certain treatments in all experiments

Row (Experiment)	Treament	Sleeping			Sitting (active)			Sitting (inactive)			Laying Stance			Standing
		Out	In	Obl.	Out	In	Obl.	Out	In	Obl.	Out	In	Obl.	
1	Curtains	4	9	1	3	6	6	19	57	9	1	4	1	11
Top	No Curtains	6	11	2	12	4	7	37	45	21	2	0	0	14
Nests	TOTAL	10	20	3	15	10	13	56	102	30	3	4	1	25
Bottom	Curtains	4	37	0	18	30	24	89	383	57	1	18	8	64
Nests	No Curtains	12	40	6	32	28	30	148	344	60	5	12	2	63
	TOTAL	16	77	6	50	58	54	237	727	117	6	30	10	127
2	Approach I	1	6	2	9	4	5	35	49	6	1	1	1	14
Top	Approach II	0	3	0	2	2	4	14	25	6	0	1	0	1
Nests	Approach III	7	19	0	3	10	15	32	101	23	0	1	2	16
	Approach IV	1	4	1	6	5	6	29	65	19	0	1	3	7
	TOTAL	9	32	3	20	21	30	110	240	54	1	4	6	38
Bottom	Approach I	3	7	1	8	7	8	33	128	19	1	9	1	41
Nests	Approach II	9	31	4	18	16	29	76	211	42	0	6	4	24
	Approach III	6	21	1	11	13	22	70	180	42	1	5	2	36
	Approach IV	1	25	2	14	19	13	65	154	43	2	3	1	28
	TOTAL	19	84	8	51	55	72	244	673	146	4	23	8	129
3	Top/Exist.	0	2	0	6	2	1	18	45	7	1	3	1	7
Top	Top/Adjust.	0	1	1	3	0	0	10	32	5	1	2	1	3
Nests	Bottom/Exist.	0	0	0	1	1	0	0	4	0	0	0	0	1
	Bottom/Adjust.	0	0	0	1	1	2	2	5	1	0	0	2	2
	TOTAL	0	3	1	11	4	3	30	86	13	2	5	4	13
Bottom	Top/Exist.	0	9	0	10	11	6	17	61	17	1	1	1	18
Nests	Top/Adjust.	1	3	0	6	6	3	21	48	12	0	1	1	9
	Bottom/Exist.	2	14	2	5	14	12	55	161	20	5	6	3	34
	Bottom/Adjust.	5	25	3	10	18	26	60	235	61	3	5	6	25
	TOTAL	8	51	5	31	49	47	153	505	110	9	13	11	86
4	Nest-Backs	2	4	3	5	5	6	30	45	35	0	0	0	4
Top	No Backs	4	6	2	3	8	2	31	54	20	0	3	1	14
Nests	TOTAL	6	10	5	8	13	8	61	99	55	0	3	1	18
Bottom	Nest-Backs	17	54	13	20	40	47	112	333	201	3	7	1	60
Nests	No Backs	15	55	4	28	46	23	151	395	75	7	17	2	60
	TOTAL	32	109	17	48	86	70	263	728	276	10	24	3	120

In each experiment and overall, significant differences were found in the numbers of hens recorded in different activities, orientations and nest levels. As previously indicated, sitting, inactive, was the most commonly observed activity. In all experiments also, the most frequently recorded orientation of hens in nests was into the pen and the numbers of hens in the bottom level nests were significantly greater than numbers in top level nests. Significant differences in numbers of hens in nests were also found between treatments in Experiments 2 and 3 and between different experiments overall.

Activity and Orientation on the Nest - Experiment 1

In Experiment 1, significant interactions were found for orientation with activity, nest level and treatment, and for activity with nest level. The activities sleeping, sitting inactive, and laying stance occurred while the hen was facing into the pen more often than when she was facing in any other way. Whilst sitting on the nest actively involved in some other action, hens were no more likely to be facing in one particular direction than in any other. Orientation of hens in the nest tended to differ for top and bottom nest recordings, following the same pattern as the trend shown for the overall results in Figure 5.18. The significant treatment by orientation interaction reflects the tendency for hens in curtained pens to face in towards the pen to a greater extent than hens in uncurtained pens (see Figure 5.11). Hens in top level nests also tended to be observed whilst involved in sleeping proportionally more often than hens in bottom nests (Figure 5.12).

Activity and Orientation on the Nest - Experiment 2

Analysis of results from Experiment 2 indicates interactions between orientation and activity, treatment and activity and treatment and level. As was the case in Experiment 1, all activities except sitting, active, were not frequently observed to occur while the hen was facing into the pen. Sitting whilst actively engaged in some other activity did not occur in any one direction to a greater extent than in any other. Activity x orientation trends are shown for all experiments in Figure 5.19. Treatment by activity trends are shown in Figure 5.13. Standing was proportionally more common in the case of hens nesting in pens equipped with approaches of type I, the original nest approach. Proportionally less hens nested in top nests in pens with type II nest approaches than in other pens. A significant orientation by level by treatment interaction was also found for this experiment. These trends are illustrated in Figure 5.14, which shows that outwards orientations were comparatively more common in top level nestings in pens with approach type I than in other pens and that the numbers of 'inwards' recordings in top level nests were relatively higher in pens with step-up approaches.

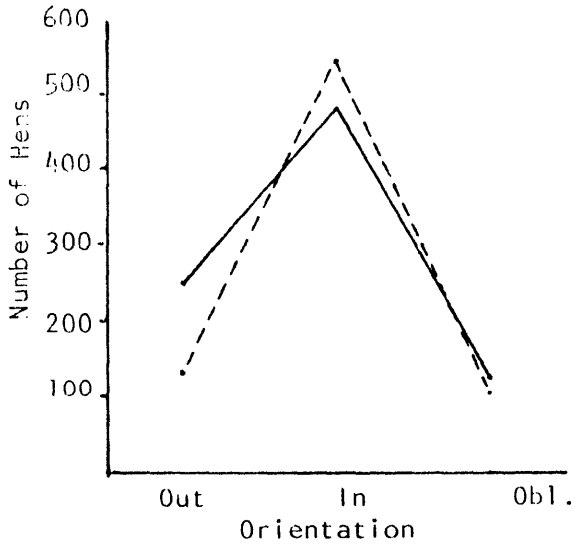


Figure 5.11 Numbers of hens in pens with curtains (---) or without curtains (——) to be oriented in particular ways - Experiment 1

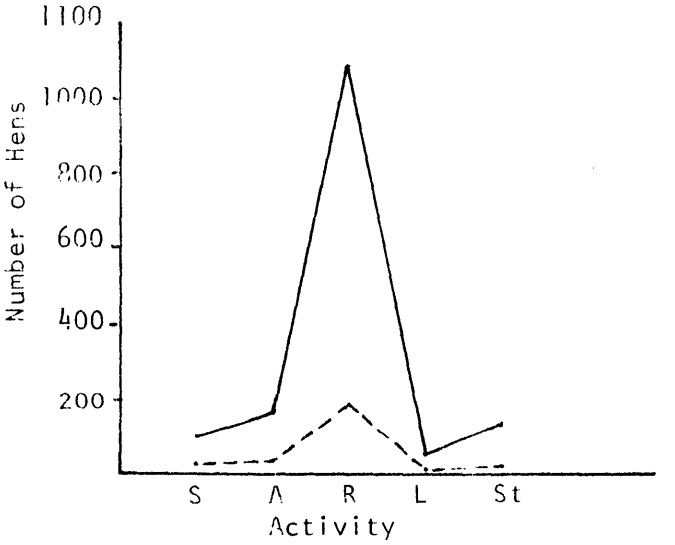


Figure 5.12 Numbers of hens in bottom(——) and top(--) nests observed to be sleeping (S), sitting but active(A), sitting, inactive or resting(R), in laying stance(L) or standing(St) - Experiment 1

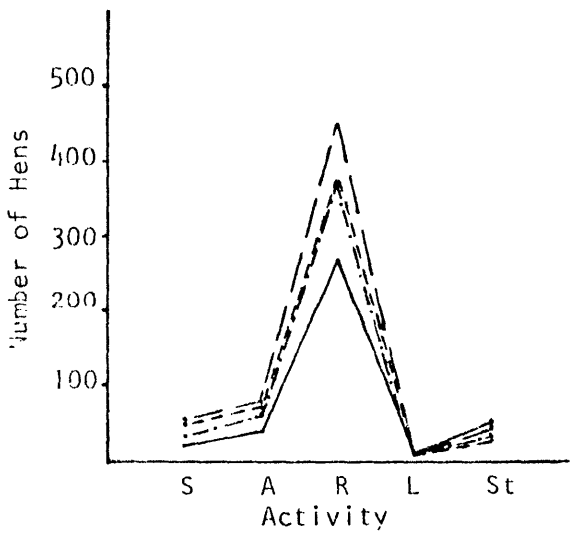


Figure 5.13 Numbers of hens sleeping(S), sitting,active(A), sitting,resting(R), in laying stance(L) or standing(St) in pens with approach type I(—·—),II(--), iii(— —) and IV(—··—) - Experiment 2

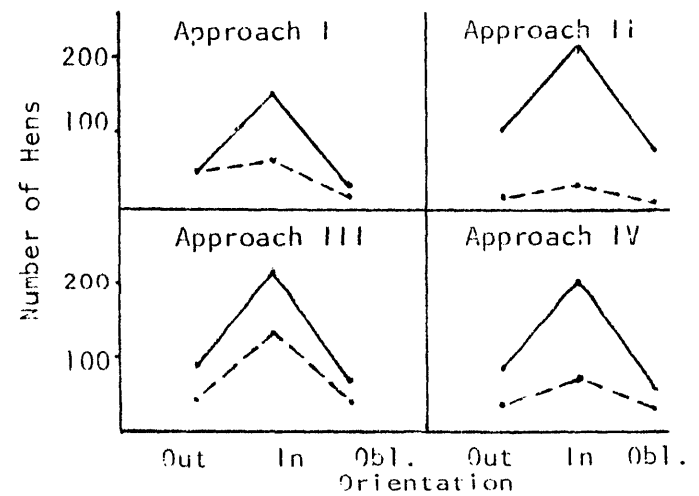


Figure 5.14 Numbers of hens in different orientations in bottom(——) and top(--) level nests in pens fitted with approach types I,II,III and IV - Experiment 2

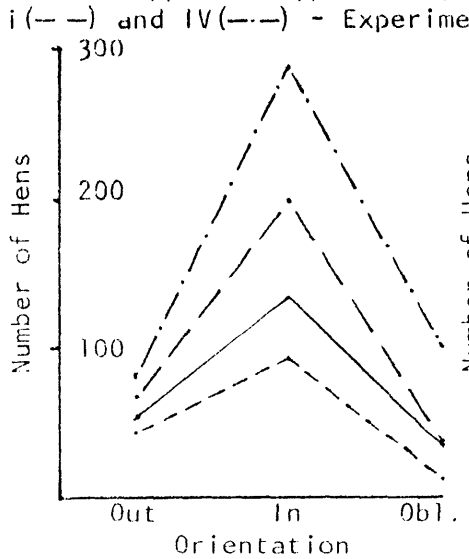


Figure 5.15 Numbers of hens in different orientations for TE (——),TA(--),BE(— —) and BA(—·—) treaments - Experiment 3

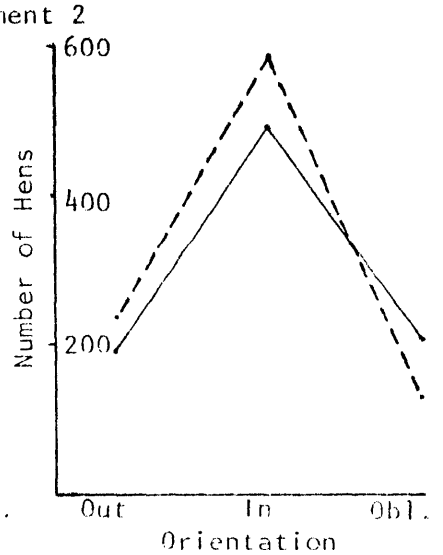


Figure 5.16 Numbers of hens in different orientations for pens with (——) or without (--) nest-backs - Experiment 4

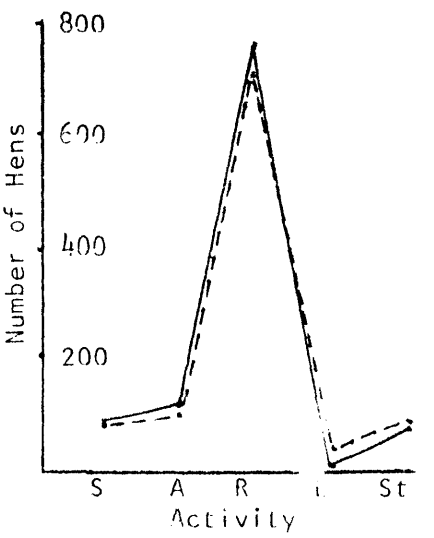


Figure 5.17 Numbers of hens sleeping(S), active(A),resting(R),in laying stance(L) or standing(St) in pens with(——) or without(--) nest-backs - Experiment 4

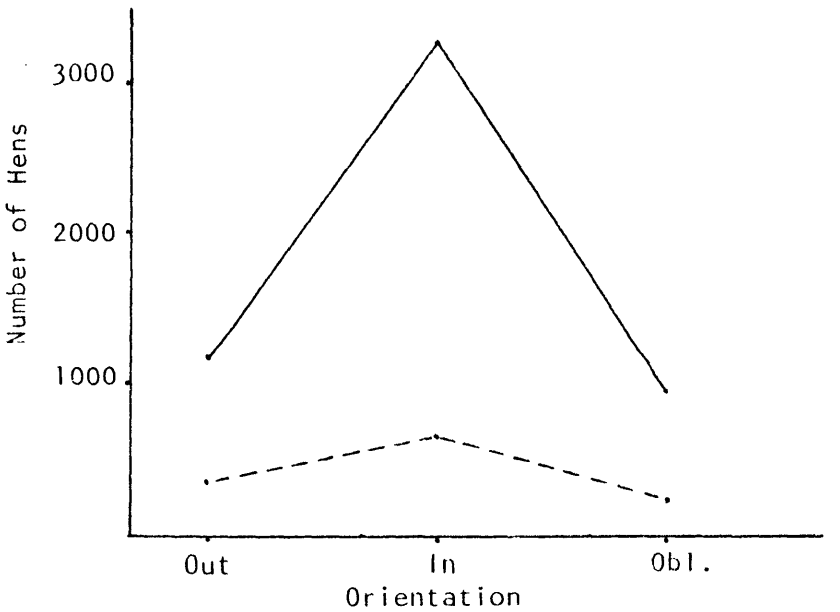


Figure 5.18 Numbers of hens in different orientations in bottom (——) and top (---) level nests - overall

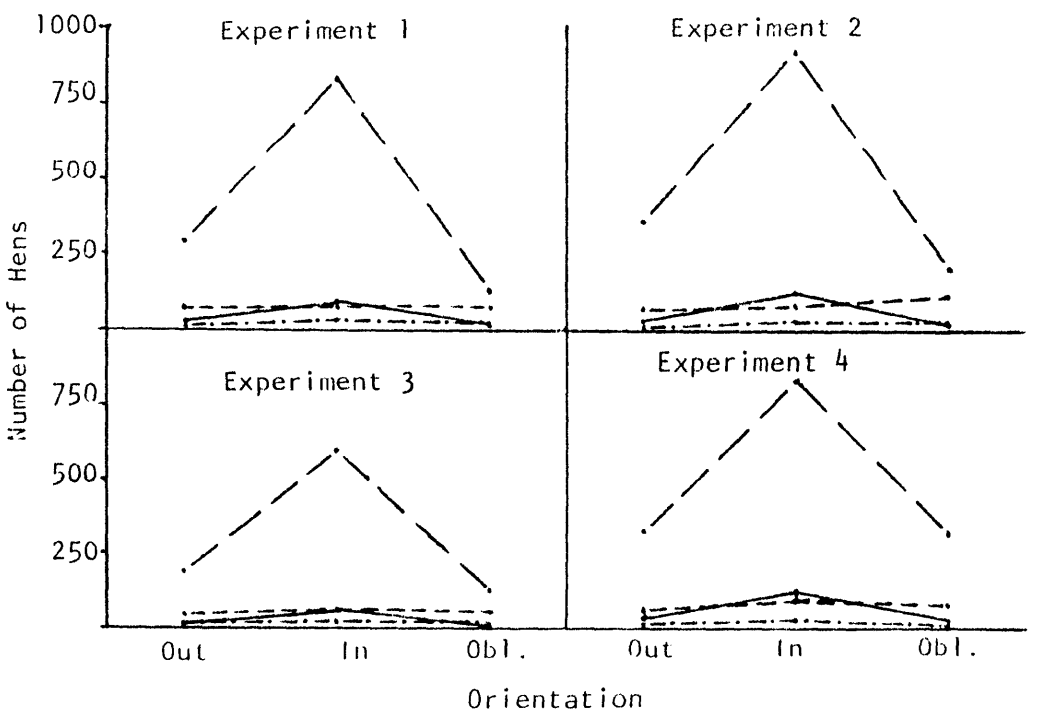


Figure 5.19 Numbers of hens in different orientations whilst engaged in certain activities; sleeping (——), sitting, active (---), sitting inactive or resting (— —), or in laying stance (— · — · —)

Activity and Orientation on the Nest - Experiment 3

Analysis of Experiment 3 results again revealed significant differences in the numbers of hens found oriented in certain directions while performing different activities. The same trends as previously recorded for other experiments were shown (see Figure 5.19). The number of hens found oriented in particular directions was also shown to differ in different treatments. In general, the trend followed was for the proportion of recordings of hens facing into the pen to increase the greater the overall usage of nests. Hence, proportionally more recordings of 'inwards' orientations were found for pens in which hens had originally had access to bottom level nests only, which also tended to be those pens which had shown the highest nest usage levels (see Figure 5.15). Generally, oblique nestings were less frequently recorded than either of the alternative orientations, except in the case of pens in which only bottom nests had been available via an adjusted approach initially. Numbers of recordings of oblique nestings were somewhat elevated in these pens. Top nest usage was highest in pens in which top nests had only been available initially and lowest in pens in which hens had previously only been given access to bottom nests.

Activity and Orientation on the Nest - Experiment 4

Significant differences were found in the numbers of hens recorded in alternative orientations whilst engaged in different activities, or whilst in alternative nest levels or in pens with or without nest-backs in Experiment 4. Trends in the frequencies of occurrence of different orientations for certain activities were similar to those found in the other experiments except that the numbers of hens recorded in the oblique position during quiet periods of sitting on the nest were considerably increased (see Figure 5.19). Proportionally more hens nesting in bottom level nests faced into the pen than was the case for top level nesters, following the overall trend shown in Figure 5.18. More oblique nestings were recorded in pens with nest-backs than in pens without them, as illustrated in Figure 5.16. A less significant trend ($.01 < P < .05$) was also found for the frequencies of occurrence of different activities in pens with or without nest-backs. Figure 5.17 shows that slightly more sleeping and sitting was observed in nests with nest-backs than in those without them. The reverse was true of the activity 'standing'.

Overall analysis revealed that, although there was a general tendency for all activities except sitting, active, to be performed in the preferred 'inwards' orientation, differences in the trends seen were found for different experiments. These trends are shown in Figure 5.19, and the tendency for higher numbers of oblique recordings of sitting, inactive or resting, hens to be associated with results from Experiment 4 has already been noted. Hens in Experiment 4 were found proportionally more often sleeping and less often standing than their counterparts in other rows, while hens in Experiment 3 were found sleeping proportionally less often and in the laying stance more often than was generally found in other experiments.

Activity and Orientation on the Nesr - Overall

Nest levels were used to different extents in different experiments. Top nests were most poorly used in Experiment 3 in general, and used to the greatest extent in Experiment 2. The trends for numbers of activities which occurred in top as opposed to bottom nests differed slightly, but significantly, for different experiments (see Figure 5.20). Perhaps the most obvious difference in this respect was for the numbers of hens sitting, active, in top level nests in Experiment 2 to be proportionally higher than in the other experiments.

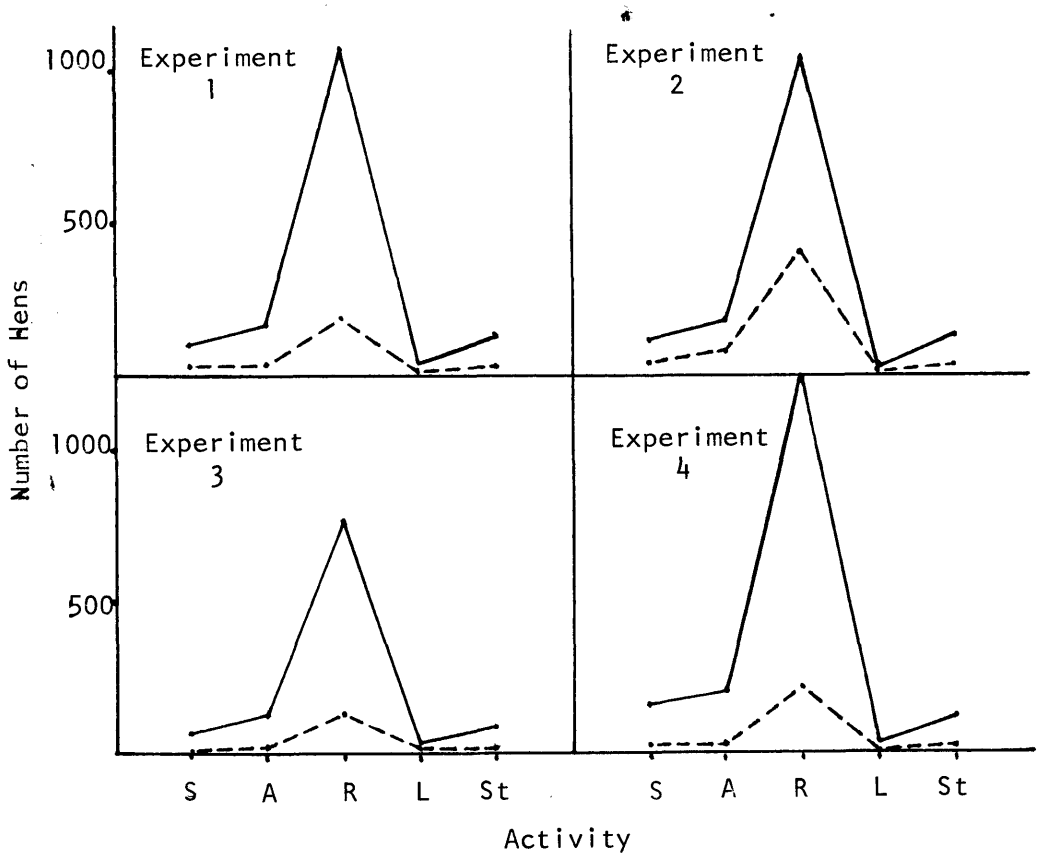


Figure 5.20 Number of hens recorded in the activities sleeping (S), sitting, active (A), sitting, inactive or resting (R), in laying stance (L) or standing (St) in bottom (——) and top (---) level nests - all experiments

During the course of these observations notes were taken of occasions on which hens appeared to be hiding in nests because of injury and the unwanted attentions of other hens, instances of occupation of nests by broody hens and occupation of nests by cockerels. In only three cases did hens appear to be hiding in nests to avoid other hens. In all cases the hens remained in the nest for a considerable length of time through the day without apparently laying. Six hens were found to be broody during the week in which these observations were recorded. Observations on broody hens which were apparently

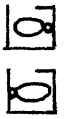
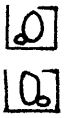
not laying were discarded from the observational results. Cocks were recorded in nests on seven occasions during the week of observation. In most cases, these cockerels seemed to be in the nests in order to avoid others. One case was noted in which a hen was observed to be dust-bathing in the litter in a nest, but it was not known whether the hen had entered the nest specifically to dust-bathe or whether the hen had entered the nest for the purpose of laying an egg and the dust-bathing was incidental. No other instances of dust-bathing were recorded during that observation period.

The number of nests occupied for purposes other than nesting seems therefore to be very low, although it was apparent that hens were using nests for 'roosting' in, but this tended to occur outside the times that nests would otherwise be used for nesting purposes. Hens also appeared to enter nests and stand in them when the time of feeding approached and particularly when the workmen began to fill and load feeding buckets in the work area of the shed immediately prior to distributing the feed.

More detailed observation of the orientation of hens on the point of oviposition produced the results presented in Table 5.7. Analysis of variance of the total daily figures indicates a highly significant ($P < .001$) difference in the numbers of observed ovipositions which took place while hens were oriented in particular ways in the nests. When the sorted data were subjected to Duncan's Multiple Range test (at the 5% level) it was revealed that orientations A and C were more often observed than any other. Orientations in which the hen's body was directed towards the back of the nest, or out towards the servicing aisle, were least often recorded. Highly significant differences were also found between the numbers of hens observed at the point of lay on the four days during which the observations were taken, far fewer ovipositions being noted on the final day than on any other.

In most cases, treatments did not influence the orientation of hens at oviposition. However, when the three most popular orientations were analysed for pens containing nests either with or without nest-backs, one significant difference was revealed. A larger proportion of hens in the pens with nest-backs was found to lay in position type A. This orientation placed the hen with its body facing out towards the centre of the pen while the head was averted into the front corner of the nest in such a way that the hen appeared to be unable to see out into the pen. Orientations B and C which involved the placement of the hens' bodies either facing directly out into the pen, or across the pen, in both cases allowing the birds some vision of the outside pen, were used to a greater extent by hens laying in pens in which the nests were fitted with nest-backs.

Table 5.7 Numbers of ovipositions occurring at different orientations in all experiments and overall

Experiment	Treatment	Orientation A 	B 	C 	D 	E 	Significant Chi-square Analyses
1	Curtains/Closed	1	1	4	0	0	
	Curtains/Open	5	3	3	0	1	
	CURTAINS	6	4	7	0	1	
	No Curtains/Closed	8	2	2	0	0	
	No Curtains/Open	5	1	4	0	0	
	NO CURTAINS	13	3	6	0	0	
2	Approach I	4	0	2	1	0	
	Approach II	1	2	3	2	2	
	Approach III	5	3	7	4	0	
	Approach IV	5	1	5	1	0	
3	Top Nests/Existing	4	3	2	0	1	
	Top Nests/Adjusted	1	0	1	2	1	
	Bottom Nests/Existing	4	1	2	2	0	
	Bottom Nests/Adjusted	8	5	2	4	0	
4	Nest-Backs/No Egg	0	1	2	0	0	Nest-backs vs
	Nest-Backs/Nest-Egg	1	2	7	0	2	No nest-backs,
	NEST-BACKS	1	3	9	0	2	A vs B vs C
	No Nest-Backs/No Egg	5	3	4	0	0	$\chi^2_{2df} = 6.2^*$
	No Nest-Backs/Egg	6	1	4	1	1	
	NO NEST-BACKS	11	4	8	1	1	
	Overall	63	29	54	17	8	$\chi^2_{4df}=63.2^{***}$
	Sorted overall totals:	E 8	D 17	B 29	C 54	A 63	

Times Spent in the Final Nest in Laying

Analysis of variance of times spent on the final nest in laying by marked hens is shown in Table 5.8.

Table 5.8 Analysis of variance of times spent on the final nest in laying by marked hens in either top or bottom level nests in all pens and experiments

Source	D.F.	S.S.	M.S.	F	Significance
Between Experiments	3	0.0599	0.0200	0.51	N.S.
Between Pens Within Experiments	44	1.8502	0.0421	1.08	N.S.
Between Levels	1	0.7090	0.7090	18.13	***
Levels x Experiments	3	0.1451	0.0484	1.24	N.S.
Error	44	1.7211	0.0391		
Total	95	4.4853			

Mean pen values for times spent on the final nest in laying are given in Appendix 5.6 for both top and bottom level nestings. However, analysis indicated that the only significant difference was between times spent in top level nests as compared with bottom level nests. Hens spent on average 1 hour 35 minutes on the final nest in top level nests, and 1 hour 25 minutes on the final nest in bottom nests. It should be noted, however, that these figures include time before and after oviposition, contain some error since each recording was only accurate to within half an hour due to the recording technique, and may not represent continuous times on the nest, since hens were observed to leave the nest for some time and then return to the same nest between observational visits.

Usage of Nests in the Set

In addition to these results, recordings were also taken of the numbers of marker hens which were also observed to lay in the alternative nest level to that in which they usually laid and the numbers of hens which were observed in nests other than those that they eventually laid in. The numbers of occasions on which eggs were laid in the 'wrong' nest level and occasions on which hens were observed in other nests prior to laying in the final nest were also recorded. These data are summarised in Table 5.9.

It would appear from these results that hens which laid in bottom nests were more likely to repeat this tendency on subsequent occasions than were hens found to lay in top nests. However, the majority of marked hens, from both top and bottom nests, did demonstrate a marked preference for one level over the other. Approximately 85% of all marked hens used only nests of one level throughout the period over which they were kept under observation, which amounted to between six and ten ovipositions.

Table 5.9 Numbers of occasions on which hens were recorded to lay in nests in the alternative nest level, or were observed in nests other than the final nest, and the number of hens which were involved in these activities - top and bottom level nesters

	Laid in 'Other' Level		Nested Elsewhere Same Level		Nested Elsewhere 'Other' Level	
	Occasions	Hens	Occasions	Hens	Occasions	Hens
Top Level Marker Hens	99	40	90	51	17	10
Percentage All (190) Hens		21.1		26.8		5.3
Bottom Level Marker Hens	60	29	167	84	12	8
Percentage All (272) Hens		10.7		30.9		2.9

Approximately a third of both top and bottom level marker hens were observed to occupy more than one nest during at least one nesting. Taking into consideration that marker hens were observed to lay on 3,370 occasions, additional nest occupancies were only recorded in about one out of every 12 nestings. However, additional nest entries probably occurred to a much greater extent in reality because a large number of nest entries which occurred between observation visits would not have been recorded.

Cases in which hens returned to the nest-set some time after they had been recorded to lay in a nest and leave it were also recorded (see Table 5.10).

Table 5.10 Numbers of hens observed to return to the nest-set after completion of the day's nesting

Top Level Marker Hens		Bottom Level Marker Hens	
Returned to:		Returned to:	
Top Nests	Bottom Nests	Top Nests	Bottom Nests
5	8	4	12

Although these results are very limited, they do suggest that some hens may return to nests and use them for, presumably, other purposes than nesting. At least in the case of hens which tended to use top nests for laying in, these returns to the nest-set seemed largely to be to the alternative level of nests, which these hens generally did not use for nesting purposes.

The total numbers of hens which did or did not eventually select the same nest for at least half of the observed nestings are shown in Table 5.11. Analysis revealed that the proportion of hens which eventually selected and laid in the same nest for at least half of the observed nestings differed for top and bottom level marker hens. Top level nesters tended to use the same nest for at least half of their nestings in a higher proportion of cases than did bottom level nesters. In all, only 38.4% of top level marker hens and 27.2% of bottom level marker hens laid in the same nest for at least half of their observed nestings.

Table 5.11 Numbers of hens which did or did not lay in the same nest on at least half of the occasions recorded for either top or bottom nest level marker hens

	Number of Hens	
	Top level hens	Bottom level hens
Laid at least half of their eggs in same nest	73	74
Did not lay at least half of their eggs in same nest	117	198
	$\chi^2_{2df} = 6.4$ *	

The total numbers of top level and bottom level marker hens which predominantly laid in each of the six alternative nests in top or bottom level nests respectively are shown in Table 5.12. Portions of 'hens' which appear in the Table arise from situations in which hens did not lay in one single nest on more occasions than in any other. For example, a hen laying three eggs in each of two particular nests but no more than two two eggs in any other nest was classified as having predominantly selected both of the former two nests and each nest was credited with a hen score of 0.5.

Table 5.12 Numbers of top level and bottom level hens which laid predominantly in each nest alternative in either level of the nest-set

Nest Level	Number of Hens Predominantly Selecting Nest: A	B	C	D	E	F	χ^2 Value
Top	63.5	32.8	14.7	7.8	20.9	50.5	20.5**
Bottom	58.6	45.3	38.1	31.8	38.5	62.5	
Both Levels	119.1	78.1	52.8	39.6	59.4	113.0	

In general, marker hens exhibited a tendency towards selecting the outermost nests in a set more frequently than nests in the middle of the set. This tendency was particularly noticeable in the case of hens which laid in the top level of nests.

5.4 Discussion

The trends shown over time in the percentage of floor eggs recovered from pens in each row and overall are similar to those that would be expected by most producers of eggs from hens in deep litter shedding. Initial rates of floor-laying are high but decrease markedly over the first few weeks of production. In the present study, floor egg percentages had generally stabilised considerably by the end of the first eight weeks of recording. It is not known whether the decline in floor-laying which occurred between weeks 8 and 9 was a result of elimination of one of the more preferred sites for floor-laying under the nest-sets, or whether the same change would have occurred if this measure had not been taken. However, there seems no logical reason why floor-laying levels should decline so dramatically at this time if the elimination of these areas was not involved, and indeed a decline at this stage would not be predicted by those experienced with floor-laying patterns of large flocks in the early stages of lay. It seems more likely, therefore, that the drop in floor egg percentages at this stage was a response to the elimination of a preferred floor-laying site which forced hens to break established habits and select new nesting sites, many of which may have been in provided nests.

Although the actual levels of floor-laying during the first weeks of these trials differed for different experiments, the trends related to week of recording remained much the same. To some extent, the application of treatments just as hens were coming into lay and just before recordings were commenced probably contributed to the high floor egg percentages in the first weeks and the magnitude of the decline in that they added to the 'unfamiliarity' of the situation.

None of the experiments provided results which suggest that the rate of decline of floor-laying could be markedly increased in any way, except, perhaps, by the elimination of floor-laying areas as already noted. It therefore appears as if hens must 'learn' to use nests in some way. On the other hand, some treatments, and perhaps experiments, were more or less effective in attracting hens to the nest area or into the nest, or discouraging hens from using floor sites for nesting purposes than were others even from the very onset of lay.

The provision of a nesting area in pens by curtaining off the nest-set and area around it with hessian was ineffective in reducing the number of floor eggs laid in pens. However, it did result in a higher concentration of floor eggs in the floor area behind the curtain than would otherwise be expected, or at least this was the case during one week in which the positioning of floor eggs was followed. Hence, curtaining may have been effective in attracting nest-seeking hens to a particular area to lay but unfortunately it made the floor area behind the curtain more attractive too and so floor-laying levels remained much the same.

One problem experienced with the nest-set curtains was that they tended to trap the wind and so to billow and flap quite a lot. This initially seemed to frighten hens somewhat, and hens may have been deterred by this. Experiences in the first few days or weeks with this may have encouraged hens to develop floor-laying habits. Attempts to reduce the amount of movement of the curtains by securing them down tended to make them more difficult to get under and hens may also have been discouraged in their nest-seeking attempts by this. Even slight billowing of the curtains tended to decrease the amount of space available to hens to get up to or down from elevated nests and this may also have dissuaded potential nest users. However, one would anticipate that this would affect top level usage in particular, and yet no significant differences were found in the proportion of total nest eggs which were laid in the bottom level in curtained as compared with uncurtained nest-sets. Curtaining may also have provided hens or cockerels low in the peck order with a place to hide from dominant flock-mates and this could conceivably result in additional pressure being placed on available nests, and so to reduced nest usage for nesting purposes. However, observations revealed that apparent usage of nests by hens or cockerels for hiding from other birds was extremely unusual in any pen in the shed, and so this factor may not have been important.

Despite all these possible problems, floor-laying levels in curtained pens were no worse than those in uncurtained pens. This is encouraging, particularly since the curtaining treatment involved quite dramatic alteration of the pen

and hens were given no time to become familiar with the new set-up before coming into lay. On the other hand, hens in pens without curtains had months in which to learn how to get up to the nests and to become familiar with the nesting situation that would be available to them when they first came into lay. In the light of this, it is considered that further investigation of means of providing 'nesting areas' as opposed to just providing nests could be worthwhile.

One interesting finding was that hens in curtained nests tended to face in towards the pen more than did hens in uncurtained nests. There could be several explanations for this. Curtains could act as 'wind' breaks and so alter the orientation of hens on the nest. However, it seems more likely that hens would prefer to face into a breeze anyway, to prevent lifting of feathers. A more likely explanation would be that hens attempt to seek visual isolation by turning away from the body of the flock, and if a visual barrier is provided the need to do this may be reduced. Results of preference studies in which feral hens were found to face into the pen while laying in more preferred and enclosed nests support such a suggestion (see Study 4.4.5). It could also be that the movement of curtains in an unpredictable way in the wind may have been a fear inducing stimulus, and hens may have been 'keeping an eye' on the activity in that direction as a result.

The 'blocking off' of areas under nest-sets was initially ineffective in reducing floor-laying. Seemingly inconsistent with this finding was that floor-laying levels were generally reduced in these pens, as in all pens throughout the shed, when all of these areas were filled in with litter after the eighth week. However, in the initial attempts to close off these areas, boards were fixed across the area directly underneath the nest-set which still allowed hens up under the nests and nest approaches to a certain extent, and in fact a number of hens found they could lay with their heads through the boards into the area directly beneath the nests. This was not possible once the areas were filled in with litter, in which case the area excluded involved all the area under the nests and most of the area under the approach to the nests as well. There was some evidence to suggest that initial exclusion of these areas may have forced at least some hens into what may have been the next alternative, since slight increases in levels of bottom nest usage were found in pens in which these areas had initially been blocked off.

Hens nesting in top level nests in this experiment were found to be sleeping more often than hens in bottom nests were. A high proportion of nestings took place in bottom level nests and as a result, hens in bottom nests seemed to be subject to a greater level of disturbance than hens in top nests. Hens which did use top level nests therefore probably had greater

opportunity to rest quietly with eyes closed or sleeping than did hens in the more popular bottom nests.

Floor egg percentages were considerably lower in pens in which alternative nest approaches had been provided than in pens with the original nest approaches in Experiment 2. These differences emerged early in the trial and persisted throughout the period of study. The results were somewhat surprising since on a visit to the shed in the week preceding installation of the new approaches the author was interested to note a large number of hens in all pens standing in the open nests waiting to be fed. This observation was taken to suggest that accessibility to the nests may not have been as much of a problem as it had been in the earlier studies on broiler hens (see Studies 3.1, 3.4).

All three new approaches in Experiment 2 (types II, II and IV) were found to be associated with reduced floor egg numbers. However it is difficult to say whether it was improved accessibility to the nests or some other factor associated with these approaches which contributed to the reduction of floor-laying.

Several problems were associated with the use of the original metal approaches provided in the pens. Firstly, upper level nests could only be entered after the hen had actually flown from the ground to the nest approach, as there was insufficient horizontal distance between the lower approach and the upper approach to allow hens to jump or fly from one to the other. Once either approach was reached, the metal rungs were too wide and slippery for many to get their balance on. Hens were often seen to slip down and sometimes off the metal perches. Despite these problems, a good number of hens still managed to use the top level nests. In fact percentage nest eggs laid in bottom level nests were no higher in these pens than in pens with either of the step-up type approaches. However, the total numbers of eggs laid in top level nests were lower.

Once hens had reached the metal approach in front of the nests, the difficulty was then to get from the metal perch to the nest. This seemed to present difficulties to many hens, particularly when attempting to use bottom level nests because of the large distance between the perch and the entrance of the nests and the relatively narrow entrance. Hens were often seen to fall when attempting to get into bottom level nests.

Similar difficulties were experienced as the hen attempted to leave the nest or approach. The process of getting down from nests at the top level was further complicated by the fact that feeders and waterers were placed at about

landing level for hens flying or jumping down from the metal perch. It was not uncommon to observe hens crashing into these fixtures in their descent from the nests. Once hens had got up to nests or approaches in these pens with the original type of approach, they seemed rather unwilling to get down again. Hens using nests with alternative approaches tended to mount the approach on a number of occasions before finally settling in a particular nest. The tendency to remain in or in front of nests in the case of hens which had mounted type I approaches may explain the observed differences between treatments in the number of hens recorded in different activities. Hens in pens with type I approaches were recorded in standing positions in a greater proportion of cases than were hens in pens with the other types of approaches.

It is apparent from the nest level data that the improved nest usage in pens with approach type II was primarily a result of an increase in the number of hens which nested in bottom level nests. Not only was the percentage of nest eggs laid in the bottom level much higher in pens with this type of nest approach, but activity data indicate higher levels of bottom nest occupancy in pens with these type II approaches than in pens with other types of approaches. Observation of hens using approach type II indicated that the problems encountered in getting from the ground to the approach and from the approach into the nest had largely been eliminated, at least at the bottom level, by the provision of the wooden runged platform approach. Hens could not slip over on these platforms, and they could simply walk along the platform and into the nests. The problem that was not overcome by this type of approach was in getting up to the top level of nests, since hens still had to fly up to the approach, sometimes from the bottom approach but usually from the floor, and they also had to fly down again. Consequently, a large number of hens came to lay in bottom nests but approximately the same numbers of hens used top level nests as in pens with the original approach, hence the high percentage of nest eggs that were laid in bottom level nests. Over time the differences between pens with alternative approaches decreased, as hens in type II pens began to use top nests more, possibly as a result of familiarity with the approach set-up.

In contrast to pens with type II approaches, nest usage at both top and bottom levels was increased when approach types III and IV were in use. Much the same proportion of total nest eggs were laid in bottom nests in these pens with step-up approaches as in pens with the original type of approach, although overall levels of usage were higher with step-up approaches. Hens in these pens were able to step or hop up to the top level nests, and so the difficulties associated with usage of top nests were largely eliminated. Hens using nests in bottom levels with approaches III or IV had to crouch down somewhat to get between the second and third platforms of the approach to get into nests. It

is not known to what extent this may have affected the results. For instance, hens may have achieved a greater sense of isolation by 'crawling' into the nests in this way, or nests may have been darker because of the constricting platforms outside. It may have been these features which attracted hens into the nests to lay rather than the fact that the approaches made the nests more accessible. On the other hand, hens may have been discouraged to some extent by the small opening through which they had to pass to gain access to the nests, and the advantage gained through improved accessiblity to the platform in front of the nests diminished somewhat. Observation of hens using these approaches did not throw any light on which of these suggestions is more probable. It is also possible that some other feature of the step-up approaches influenced the attractiveness of the nests or at least the hens' selection of them in preference to floor sites.

Nest usage tended to be highest in pens fitted with step-up approaches without dividers. There appeared to be some hesitation on the hens' part to approach the sheet metal dividers in type IV approaches initially. Possibly the shiny appearance of these dividers may have made the hens more cautious when selecting nests, or perhaps disturbance or eviction of hens by others patrolling along the front of nests may not influence whether hens remain in nests to lay or return to them on subsequent occasions. Whichever the case, nest usage levels were no better in pens with such dividers across the step-up approach than in pens without them. It may be that the restricted access space between step-up platform levels to bottom nests effectively reduced this type of patrolling anyway, and so rendered dividers superfluous. However, observations seemed to indicate that patrolling was still carried out to some extent in pens with both approach types III and IV and so it is more likely that this behaviour does not discourage nest usage or that the dividers were simply ineffective in reducing it.

The ability of hens to get up to and use nests may be influenced by their general ability to explore their environment or to fly or jump in order to gain elevation. Of interest is the reported decrease in floor-laying associated with automatic nests when nests were situated just beneath waterers and accessible by sloping wire floors (Anon., 1982). This result could have been an effect of increased nest accessibility, or of enhanced ability to use elevated sites or familiarity with the nesting area because of proximity to the waterers which hens would previously have had to become familiar with finding and using. However, the results of the present experiments suggest that the effect of approaches, even if only installed when hens were beginning to come into lay, may have been related to some factor in addition to this, since their effect was immediate and a number of hens in each pen were already known to use nests

for standing or perching in prior to their first oviposition. The effectiveness of the same approaches on other strains of hens can not be assumed, bearing in mind the considerable strain effect on perch usage shown by Faure and Jones(1982a;b).

The significant differences found in the number of hens recorded in particular orientations at different nest levels for different approach treatments may indicate that orientation in these pens may be governed to some extent by the number of hens wanting to use the nests. Hens often actively defended the nest against the entry of other nest-seeking hens, and to do this they had to face out towards potential intruders. In those treatments in which use of top level nests was relatively high, more hens tended to face in towards the pen. Since usage of bottom level nests was in all pens quite high, these trends may not have been apparent.

Certain practical difficulties were experienced in the use of the new nest approaches installed in pens. The greatest problem was the difficulty in getting floor eggs out from underneath the approaches and/or nest-sets. This was a problem with all the new approaches, but particularly the case with step-up approaches. In addition, step-up approaches occupied a considerable proportion of the available floor space in each pen, and it is not known to what extent this may have increased effective bird density in the pens and so affected behavioural and productive parameters. Servicing of pens was also made somewhat more difficult, again because of the area that was taken up by the new approaches. Similar difficulties were also experienced in pens fitted with nest-set curtains in Experiment 1.

Exclusion of top level nests in Experiment 3 resulted in extremely high floor-laying levels. The provision of a step-up approach to these nests did nothing to alleviate the problem. Results for pens with bottom level nests only, accessible by the existing metal rung approach, were not much better. Although floor egg percentages declined through the three week period during which the treatments were in force, it was apparent that rates of floor-laying were likely to remain higher in this than in any of the other experiments. The results suggest that inaccessibility was probably a major cause of high levels of floor-laying in this experiment although 'unattractiveness' of elevation to nest-seeking hens may have also been involved. Since actual production, and therefore potential nest usage, was somewhere below its peak during the first few weeks of recording, it is more likely that inaccessibility resulting from difficulties encountered in actually getting up to, into, out of or down from nests would be more important in this respect than inability to use nests as a result of their prior occupance due to increased pressure on available nesting space.

It should be noted that hens did not have access to perches during

either the rearing or laying phases, although they could use approach rungs for perching from 20 weeks of age. It is conceivable that many pullets were not able to use top level nests because they were unfamiliar with the process of 'gaining elevation'. It may well be that hens require previous training in this respect, or need to learn to use such facilities as elevated approaches to nests. The provision of perches during the rearing phase would seem a possible way of achieving this.

Although strictly not comparable, it is interesting to note the considerable differences between floor-laying levels in this experiment and those recorded in the other experiments. Percentage floor eggs tended to be higher in pens with only the bottom nests available and the original approach than in other pens in the shed in which the nest-set and approach were unaltered, at least during the first three weeks. It was also noted that in many other pens in the shed, top nests were rarely used without deleterious effects on floor egg percentages. Since pressure on available nesting space during these first weeks is unlikely to have been a serious problem, it could be that provision of only the bottom level of nests did not allow hens enough 'choice'. It may be, in fact, that there are hens that have a preference for ground or low level nests, and others which prefer more elevated sites. If the preferred type of nest is not available, then some of the hens may lay on the floor. It has already been suggested that individual variation exists in nest height selection (see Study 4.5.1). It would be interesting to see whether differential rates of floor-laying could be achieved by the provision of all bottom, all top, or some combinations of top and bottom nesting in a situation in which ample nesting space was available, for example one nest for each bird, and easy access to nests provided by improved approaches. In this way, the importance of provision of several nest levels to allow for individual preferences could be better assessed.

There are several possible reasons why provision of a step-up approach was not associated with a reduction in floor-laying in this experiment as it had been in Experiment 2. Firstly, the design of the step-up approaches was different. The approaches provided in Experiment 3 had three platform levels whereas those in Experiment 2 had four levels with less distance between the levels. Hens did seem to experience greater difficulty in using Experiment 3 step-ups, but it is not known if this affected their use of the elevated nests. It is also possible that the maximum of potential top nest layers had learnt to use these nests in the absence of any alternative sites and no matter how good the approach to the nests was, no more hens would lay in these elevated nests. A further possibility is that some hens may need to experience nesting in bottom level nests and get used to gaining access to them before they will venture to higher levels to lay. With the possibility of such experience

eliminated, only hens who had previous experience of getting up into the top nests before coming into production may have used these nests for nesting purposes later, and since all pens had been the same before flocks came into production, during which time bottom level nests were available, the same number of hens came to use nests in both top nest situations with or without step-ups.

Pens with bottom nests only, but a wooden platform approach, were found to produce the lowest floor-laying levels of any in this experiment. Possibly the same factors which operated to increase nest usage in pens with type II approaches in Experiment 2 were involved. Differences between the four treatments decreased after all pens were returned to their original state and decreased even further after areas under all nest-sets had been filled in. However, some residual effect of the treatments was apparent throughout much of the study period indicating the importance of experience and the formation of laying habits on selection of nest sites. In fact, after returning pens to their original state, at which point there was an immediate but slight drop in floor-laying levels, no significant change in floor egg percentages occurred over the weeks until exclusion of areas under nest-sets at the end of week 8. This serves to illustrate the strength of attachment to nests which hens have had previous experience with, and also the effectiveness of elimination of preferred nesting areas which forces hens to break with habit, to reselect alternative sites and form new preferences. It is particularly interesting in this respect to note that by week 16 differences between treatments in percentage floor egg values were minimal.

Relative proportions of top and bottom level nestings changed in a predictable manner after all pens were returned to their original state. Hens which previously had gained access to top nests via a step-up approach more readily accepted bottom level nests than hens in pens with top level nests and original approaches, probably because they had learnt to use these approaches and found readjustment to the original type difficult. Hens which had only had access to nests via the original approach were able to continue using the top nests as per usual. As soon as access was given to top nests in the case of those hens which had only been allowed bottom nests initially, a number became top level nesters immediately, but little change in numbers using top nests occurred after that. This may also indicate the existence of a group of hens which has a preference for more elevated nest types.

Observation of activities of hens in nests indicated differences between treatments in Experiment 3 in the numbers of hens facing in different directions in the nest. The trend again tended to be towards higher numbers of orientations

into the pen in treatments for which highest nest usage was recorded. As previously noted, this may have something to do with levels of disturbance, and consequent facing in towards oncoming hens, and possibly even defence of the nest. Similar trends were also apparent for overall data. Overall, hens faced 'inwards' to a greater extent in bottom nests, which were in most cases most heavily used, than in top nests. Similarly, experiments in which levels of nest usage were highest showed highest levels of 'inwards' orientations.

A further factor that may have been involved in the observed differences between proportions of orientations occurring at different levels, is a possible correlation of both orientation and level usage with social rank. It is conceivable that hens lower in the flock hierarchy may use top level nests for nesting to get away from flock-mates who may nest in the more 'favourable' bottom nests. These same hens may also tend to face away from the pen to avoid contact with flock-mates either visually or physically. Since no attempt was made to determine flock hierarchies or relative status of top nesters, this suggestion awaits further clarification. However, this hypothesis would fail to explain differences between treatments or between experiments in proportions of hens facing in different directions. It would also be somewhat inconsistent with the finding that a considerable number of top nesting hens would return to nests at the bottom level at other times of the day to, apparently, pursue other activities. It is possible, however, that the opportunity of encountering other hens during these return visits is somewhat reduced, since they tended to occur outside periods of maximum nest use.

The observed trends for numbers of hens in different levels to differ for different treatments reflects the trends in egg recordings previously noted for Experiment 3. More hens were recorded in top nests in those pens in which top nests only had been available for the first three weeks of the study. Similarly, counts of hens in nests indicated differences between experiments which are attributable to different levels of nest usage for nesting purposes in each of the experiments. No obvious reason for the higher proportion of oblique nestings in the case of hens in pens which had originally been provided with bottom level nests and adjusted approaches in Experiment 3 could be seen.

Results of Experiment 4 indicate that nest-eggs were ineffective in attracting hens into nests and away from floor sites to lay in the early stages of production. This was particularly interesting in the light of studies conducted on selection of nests with or without nest-eggs which have been reported in Study 4.1.2. However, it has also been noted that a number of hens lay their first eggs indiscriminately, and since these eggs tend to lie around in the shed for some time prior to being collected they may serve as 'nest-eggs'

themselves, and attract hens to the floor sites in which they are laid. Their attractiveness may even be considerably greater than that of the nest-eggs provided intentionally, since they possessed the size characteristics of eggs from that strain, whereas provided nest-eggs were bantam eggs, and therefore smaller (see Study 4.1.2). The eggs that were laid on the floor may have been all the more attractive also, because at least for some period they would have been warm. There is at present no evidence that the warmth of a newly laid egg, or one which has recently been sat upon, is any more attractive to a hen than a cold egg however.

A further consideration is that hens which are just coming into production may not respond to eggs in the same way that they do when mature. An attempt to determine the time at which hens begin to respond to eggs by way of attempted egg rolling behaviours and other egg manipulations, and also the stage at which hens will preferentially select alternative nest sites containing eggs, has been reported (see Study 4.1.4). There was some indication that complete egg rolling behaviour may not be shown until several eggs have been laid. It may well be that hens do not 'recognise' eggs for some time early in lay and do not respond to them as stimuli which elicit nest entry and/or the sitting component of nesting behaviour. If this were the case, nest selection habits could already be established before hens begin to respond to the stimulus provided by the nest-egg, and so floor-laying tendencies be unaffected by their provision.

The numbers of eggs eaten by hens was thought to be highest in those pens provided with nest-eggs. As the nest-eggs aged, breakages tended to become more common, and this may have led to exaggerated egg breakage and eating levels in pens in which they were provided. It was also suggested that the presence of eggs in the nests may encourage hens to remain on the nest for extended periods, particularly after lay. This could lead to broodiness and ultimately to lowered production, and could also lead to problems associated with egg breakage and increased pressure on available nesting space and resulting competition for nests. However, recorded times on the final nest for marked hens were found to be similar for all pens in the shed, which throws considerable doubt on this suggestion.

Although overall analysis indicated that differences in percentage floor egg data of pens with as opposed to without nest-backs only approached significance, there was some evidence that the provision of an additional dimension of confinement to the nest may be useful in influencing levels of nest usage. Studies of the activity of hens on nests indicated that hens used these nests with backs in slightly different ways. Hens using such nests tended to be

more settled in the nesting phase, sitting and sleeping to a greater extent and standing less than hens in nests without nest-backs. An interesting comparison can be drawn here with the findings of Wood-Gush (1972) who was able to show that the amount of time that hens of a Rhode Island Red x Light Sussex strain spent sitting in the pre-laying hour was significantly greater in cages enclosed by solid metal walls on two sides and back than in open cages. These, and the present results, suggest that some aspect(s) of enclosure, whether relative darkness, visual isolation or some other factor, act as releasers for at least some components of nesting behaviour.

The usefulness of providing nest-backs for nesting facilities has been indicated by a study reported by Hearn (1981). This report indicated that floor-laying levels were lowest in a pen in which plastic fertilizer bags were nailed to the backs of banks of otherwise open nests when hens were 26 weeks of age and just coming into lay, as opposed to being provided one week later, as was done in five other pens.

Another behavioural change associated with nesting in nests with backs was towards relatively more oblique and less inwards orientations as compared with nestings in nests without backs. The hen sitting across the nest in this way appeared to be able to look out of the nest through the small ventilation gap at the back of each nest. This tendency became particularly obvious if one passed down the service aisle during peak laying hours. One would be confronted with a row of metal nest-backs with an eye fixed at each ventilation gap, apparently watching every move. It is suggested that such an orientation, in which the hen could view comings and goings both inside and outside the pen, may have resulted from the partial obstruction of, what was in other pens, a clear view of activities going on in the adjacent aisle or pen opposite. This may have been a defensive measure.

Overall, the most common activity was sitting, inactive or resting, which from previous studies on nesting behaviour of hens in pens was known to occupy a good deal of a hen's daily nesting time. Hens in Experiment 4 tended to sleep to a greater extent and stand less, possibly because hens in nests with nest-backs did exhibit the tendency to settle more readily and to be less easily disturbed in their enclosed nesting environment. Standing in nests also seemed to be reduced at certain times of the day, undoubtedly because hens standing in nests waiting for feed could not easily see out into the feeding aisle down which their feed came.

Most activities were noted to occur whilst the hen faced into the pen. In this orientation hens could watch most approaches that were made towards

the nests, except those made by the observer or other technicians. There is some evidence to suggest that wild gallinaceous birds may nest facing towards the flock area or at least in towards an open area. This may present the most probable direction of approach of a potential predator which the hen needs to be aware of, or it may serve as the best or most direct avenue of escape from the nest in case of disturbance.

Only sitting, active, was not performed in any particular direction in these studies. Since this was often associated with nest building activities, particularly rotations and foot scraping, it was not surprising that it was recorded equally often in any orientation, since these movements could place the hen in any direction at any one time. The numbers of hens performing these activities were particularly high for top level nestings in the case of Experiment 2, possibly as a result of greater disturbance due to increased nest usage at the top level in pens with step-up approaches.

More detailed study of orientation of hens at the point of oviposition revealed that, although hens tended not to lay facing out the back of their nests, they also avoided facing directly out into the pen when laying. Instead, they tended to avert their heads into a corner whilst raising themselves into the laying stance from their position facing into the pen, or more side on in the pen. In such positions the observer could not, or could only partly see the eyes of the hens involved from any position inside the pen. These results tend to concur with others already described (see Study 4.4.5) in that they seem to indicate a tendency for hens nesting in rather exposed nest sites or in a barren nesting environment to avoid facing directly out into the flock area.

Of interest was the relatively high proportion of nestings in Experiment 4 which occurred across the nest. Whether this is simply a reflection of the general tendency of hens in these pens to orient themselves obliquely in the nest, whilst engaged in any activity, to a greater extent than hens in nests without nest-backs, or whether hens particularly moved themselves into such positions at point of oviposition, is not known. However, it is worth noting that hens oriented across the nest at oviposition could theoretically see more of the pen than could hens facing out towards the pen but with head averted into the nest corner. Perhaps the rather more secluded environment of these pens with nest-backs diminished the avoidance response of hens about to lay to visual contact with the flock or flock area.

Analysis of data for times spent in the final nest in laying for marker hens indicated that top level nesters spent more time on the nest than did bottom level nesters. It is impossible to say whether hens which elected to

use top nests were also hens who tended to spend more time sitting on the nest anyway, or whether hens which did nest in top nests were subjected to less disturbance and so were more likely to sit for longer as a result of their selection of nest level. Unfortunately, although times on the nest were recorded for all nestings of hens which laid in both top and bottom nests, the data for such individuals were limited and analysis of times spent in laying in either top or bottom nests was not considered worthwhile. It would be interesting to study nest usage by such individuals which use both top and bottom nests further.

Times that marker hens spent on final nests in laying are remarkably similar to those recorded by Turpin (1918) for Rhode Island Red and White Leghorn flocks of approximately the same size as in the present study, which were housed in pens with elevated, open nests. He found that the Reds spent on average 1 hour 45 minutes and the Leghorns 1 hour 35 minutes on the final nest for each egg laid. The present results give average times of 1 hour 25 minutes and 1 hour 35 minutes for bottom and top level nestings respectively. Not only are the two sets of results very similar, despite the fact that they were conducted some 68 years apart in which time considerable selection pressure has been applied to available strains for different purposes, but they could possibly be even more comparable if one considers the fact that Turpin's hens had slightly more nesting space available than did hens in the present study and so may have been less prone to disturbance in the nest by other hens.

Marker hens which laid in bottom nests appeared to be less likely to lay at the alternative level than hens that were marked as top nesters. Several possible explanations exist for this. Bottom level marker hens could be more conservative in their selection of nest site. This seems unlikely since distribution of each hen's ovipositions between nests at each level tended to be more conservative in the case of hens laying in top level nests. More probable is that many bottom level nesters may not have found out how to use top level nests, whereas top level nesters had the option of selecting nests at either level. It is also possible that, as mentioned previously, hens that use top level nests could be lower in the flock hierarchy than those that tend to use the bottom level nests, and their selection of top level nests may be as a result of being forced from bottom nests which some may, in fact, have preferred to use.

It was particularly interesting to note, however, that the vast majority of all marker hens only used one or the other nest level for nesting purposes. On the other hand, returns to the nest-set to use them for other purposes tended more frequently to be to the alternative nest level. It is suggested

that hens may tend to avoid using specific nests or nest areas, which they usually lay in, for purposes other than nesting. This tendency would be expected in wild or feral birds in which it would act as an anti-predator and hygienic measure. Further investigation of such individual tendencies to avoid using the same sites that are laid in for other purposes would also be of interest

Top level nesters also tended to be more conservative in their selection of a nest than bottom level nesters, but the repeatability of both was much lower in these conditions than would have been predicted by Study 3.1.

A tendency for hens to prefer to lay in 'end' nests in the set was established for marker hens. Similar tendencies have previously been noted (see Study 3.1) for other groups of hens in pen situations. The reasons for such an 'end nest' effect is uncertain, but perhaps it relates to a hen's desire to get as far away from the flock, flock area, or other nesting sites as possible. Since the scope for doing this is limited in a pen situation, hens may respond by nesting in the most extreme nests in a set. This tendency was most obvious in the case of top level nesters, probably because competition for these nests was lower than was the case for bottom nests. Hence, hens in top nests were able to express their preferences for alternative nests to a greater extent than were hens nesting in bottom nests.

Although floor-laying declined considerably throughout the study period, a large number of hens continued to lay in floor sites at the conclusion of 16 weeks of production. In considering nest usage several questions arise. Firstly, are birds using nests for purposes other than nesting and if so, are they interfering with use of nests by hens for nesting purposes? Secondly, is pressure on the available nests as created by nesting hens so great that all hens are simply not able to use the nests and consequently hens are forced to lay on the floor? Thirdly, is there adequate nesting space available but some hens just do not elect to use it because they do not know it exists, experience difficulty getting to it, do not respond to the stimuli relevant to nesting at the provided site, or the appropriate stimuli are not present, or because they find preferable sites elsewhere in the pen?

Results of the present study indicate that use of nests for purposes other than nesting was uncommon. Records of numbers of hens engaged in particular activities throughout the day indicate high levels of correlation between numbers of hens in each activity and numbers of eggs laid over the same time period. Peaks in numbers of hens sitting, active or inactive, and in laying stance, in particular, occur around the time at which most eggs are laid. The increase in numbers of hens sitting, inactive or resting, tends to slightly precede that of eggs laid. This suggests that hens spend some time on the nest prior to oviposition sitting quietly, and that relatively less of this sitting is carried on after oviposition. This is also predicted by earlier behavioural studies (see Study 3.3.).

Although less obvious, relationships between eggs laid and numbers of hens sleeping, and eggs laid and numbers of hens standing were also found. An early morning peak in numbers sleeping suggests that either hens use nests specifically for the purposes of roosting in over night and through the early morning, or that this behaviour accompanies the very early phases of nesting, particularly at times when activity in the shed is quite low and disturbances at the nest relatively infrequent. Even if hens are specifically using the nests for sleeping or resting in, it is unlikely to affect availability of nests for nesting purposes because few eggs are laid at this time of day anyway. Similarly, the slight increase in numbers of hens standing in nests just prior to feeding time probably interferes little, if at all, with use of nests by nest-seeking hens by virtue of the fact that most hens had already laid by that time of day.

It would therefore seem that hens were not likely to have been forced to lay in floor sites because of insufficient nesting space created by the occupation of such sites by non-nesting hens or cockerels. It was also apparent that nests were only rarely maximally used by nesting hens. Pressure on bottom level nests was quite high at certain times of day in certain pens, but cases in which all nests, at even this popular level were occupied were unusual. Unfortuantely, although recordings were taken thrice daily, all were pooled to provide daily and then weekly floor-laying records. It may also have been worthwhile to analyse data from each of the three periods. This may have indicated differences attributable to the pressure on nests by nesting hens and therefore of competition for nest sites on the numbers of floor eggs laid.

5.5 Conclusions

The results of the studies reported in this Chapter suggest that the majority of floor-laying which occurred throughout the investigation was not produced by insufficiency of available nesting space, but by inadequacy of the nesting environment provided. Inability of hens to find or use the provided nests, or difficulty in doing so, was probably also involved. This is indicated by the results of Experiments 2 and 3.

Another factor which would seem to be implicated in the occurrence of floor-laying is the apparent lack of responsiveness, or reduced responsiveness, of hens to appropriate stimuli from the nests. This may be indicated by the tendency of what would appear to be a large proportion of all hens in all pens to lay the first eggs on the pen floor. Inability of hens in initial nesting encounters to find or respond to appropriate stimuli from the nest which were previously shown in preference tests to elicit approach to or examination of

potential nesting areas, or which elicit nest entry or sitting and remaining in the nest, is suggested by experiments with nest curtaining and provision of nest-backs and nest-eggs.

Furthermore, floor-laying may have occurred in many cases simply because the floor sites offered some combination of stimuli which was sufficient to elicit site examination, entry and sitting, at least for some hens, and which may have been even more acceptable than provided nesting facilities in this respect. This is suggested by the finding that exclusion of preferred floor-laying areas resulted in an immediate increase in levels of nest usage throughout the shed.

While it is appreciated that the conditions provided by these studies are in many ways different from those that may occur in commercial situations, several useful principles have emerged from these studies. It is apparent that ability of hens to get up to and use provided nests may be an extremely important factor in determining nest usage. Approaches to the nest-set which allowed the hens to step or hop up to nest levels and/or walk directly into nest-boxes were found to enhance nest usage. These were, however, ineffective in situations in which the only available nests were those situated at a height equivalent to the top level of nests provided in the set. This result, and the overall tendency for hens to use lower nest levels to a much greater extent than upper levels, could be taken to indicate that top level nests in a two-tiered nest-set are inefficiently used, and so could be done away with and replaced by less elevated nests, so increasing overall nest usage. However, the present studies suggest that there does exist a certain proportion of hens which seems to prefer higher nests, and failure to provide such alternatives may result in this fraction of the flock rejecting nests altogether and laying in floor sites instead.

While the creation of a nesting area in the pen by means of a hessian curtain around the entire nesting area did not result in a reduction in floor-laying, it did have the effect of altering the distribution of floor eggs, such that they tended to be concentrated in the floor area within the nesting area. This indicates that improved design of the nesting enclosure, possibly so that it does not interfere with access to provided nests or is sufficiently high to provide a sense of isolation to hens using provided nests but not to hens nesting on the floor area within or behind the enclosed area, may result in more effective nest usage.

Hens showed a favourable response in terms of nest usage to the provision of nest-backs to individual nests. This indicates that at least some of the factors previously shown to influence nest selection either through encouraging

hens to approach the nest type, to enter the nest, or to sit or remain in it, may be effectively used to manipulate levels of nest and floor usage in nesting. Evidently, the provision of a confining dimension to the nests by way of nest-backs, or the sense of enclosure or concealment or even the light intensity that it provides, can be used in this way. However, additional evidence indicated that not all stimuli from the nest may be effective in this respect, and the provision of nest-eggs, at least as presented in this study, would seem to be of little use in the establishment of nest usage habits in hens coming in to production. It may well be that hens in the first few days of nest selection, when nest usage tendencies may be established simply do not respond to certain stimuli from the nest. A possible hormonal involvement in such a response has previously been discussed (see Discussion, Section 4.5).

It would be of interest to establish which of the other factors shown to at least influence nest selection habits in earlier preference studies (see Chapter 4), could be effective in altering nest usage tendencies by encouraging approach to the nests, attracting examination and entry of particular nests, and releasing sitting or the tendency to remain in nests by flocks of hens in the early stages of lay. It seems possible that training of hens to use approaches to provided nesting facilities or allowing birds to gain familiarity with nesting areas may be of use in encouraging hens to use provided nests. Reports suggesting a possible beneficial role of familiarisation of birds with the nesting area by confinement in nests (Craig, 1980) and possibly of forcing pullets to explore the area near or approach to the provided nests in search of, for example, water (Hearn, 1981) would seem to support this idea. Further research into ways of getting hens to use nests by means of provision of better types of access to the nest-set, or by encouraging exploration of the pen environment or ability to get up to, into, out of or down from nest-sets prior to onset of lay, and therefore of increasing hen familiarity with the nesting area, would undoubtedly be of value also.

CHAPTER 6

GENERAL CONCLUSIONS AND PRACTICAL IMPLICATIONS

The results of studies conducted on the nesting behaviour of domestic hens indicate that the form of the behaviour pattern exhibited by hens may be affected, quantitatively, by a number of factors. These include the age or experience of the hen with nesting (Study 3.1), the breed of the hen (Study 3.4), its position in the flock hierarchy in a group situation (Study 3.1), its familiarity with the nesting environment (Study 3.2) and the environment in which it is housed (Study 3.5). The time at which certain component activities are first observed and the length of time that hens will perform such activities also seems to be affected by the time of day at which the oviposition occurs or perhaps by the position of the oviposition in the sequence (see Study 3.3). Individual hen differences were apparent throughout the studies, not only in terms of the form of the nesting sequence displayed, but also in the types of nest sites selected and the degree of attachment formed to the nest site (see Study 3.2).

An inverse relationship between activities associated with the nest-seeking phase, for example, pacing and nest calling, and those relevant to nest attentiveness, such as nest building and material gathering, was noted throughout the behavioural studies (e.g. Study 3.1, p.88). Increases in the times spent in, or intensity of performance of, the nest-seeking component of nesting behaviour were invariably associated with a decline in importance of those factors relevant to attention and attachment to the nest, such as time spent sitting in the nest and incidences of nest building (e.g. Study 3.2; Figure 3.2.1). Involvement of a large 'nest-seeking' component in the nesting behaviour of hens tended to be associated with situations such as the onset of production (Study 3.1), a change in nesting environment (Study 3.2), inability of hens to find suitable nesting sites in some environments (Studies 3.1 and 3.2) and inability of certain individuals, particularly those low in the flock social hierarchy, to establish a preferred nest site (Study 3.1). It is also suggested that the increased incidences of pacing and escape movements often occurring in such situations may partly be attributable to frustration, rather than active nest-seeking, resulting from the inability of hens to use established nests or find appropriate nest sites.

Many of the behaviour patterns exhibited by hens, particularly in the laying cage environment, appeared aimless or functionless in the context of the environment in which they were observed (e.g. rotations in laying cages; Study 3.5, p.164). However, the relevance and adaptive value of the behaviour patterns become apparent when they are compared with the same activities performed by their wild relatives nesting in a natural habitat. Most of the behaviours

reported to be performed by wild gallinaceous birds outside of the conditions of domestication were observed in some situations in the studies conducted herein. The domestic hen has apparently retained most, if not all, of the motor patterns that would have been involved in the establishment of a nest by her wild ancestors. The occurrence of these activities was altered somewhat, probably both through genetic selection and as a result of the environmental conditions in which the behaviour patterns are displayed.

Studies conducted on the selection of different nest types by domestic strains of hen indicate that selection of a nest site is likely to be based on a range of stimuli emanating both from the nesting area and from the nest itself (Chapter 4, Conclusion, pp.304-306). Many factors were found to influence the selection of nests. Response to some of these tended to be widespread, extending to all, or almost all, hens tested (e.g. presence of nesting material, Section 4.2, pp.220-232). For other features of the nest or nesting area, individual variability was apparent, although each individual hen usually responded preferentially to only one, or a limited number, of nest types (e.g. nest shape, Section 4.3, pp.232-247).

Hens seem to be capable of responding to a number of criteria in their selection of a nest. In addition, they appear to be capable of responding differentially to these criteria and may also respond in different ways to different levels of the one stimulus. For example (see Studies 4.1.2 and 4.1.3), hens responded more strongly to the presence of nesting material in their selection of a nest than they did to the presence of a nest-egg, but they were more responsive to two nest-eggs than they were to one nest-egg. Similarly, hens did not respond to the size of the angle of a nest recess when nests also differed markedly in the light intensity within the site (Study 4.4.1, p.250), presumably because they responded to the light stimulus more strongly. However, when an attempt was made to keep the light intensity in each nest option the same (Study 4.4.2, p.253), other groups of hens responded strongly to different nest recess angles.

Graded responses to different levels of stimuli and responsiveness to a number of stimuli may be adaptive for hens nesting in a natural habitat for several reasons. These would increase adaptability to the environment. If only one factor and one precise level of the appropriate stimulus could elicit nest selection, hens might need to travel long distances from the flock area in search of that stimulus and go on looking without ever coming across a site having that particular characteristic. Since the egg would eventually have to be laid anyway, considerable egg wastage, as well as energy wastage, would result. Moreover, the hen would also be vulnerable to attack by predators as she searched at length for a nest site at a distance from the flock area.

If hens responded to a number of stimuli, and to different levels of these stimuli, then eggs could be laid in a variety of sites in the hens' habitat. If hens only responded to a limited range of stimuli in nest selection, many eggs of different hens could be laid in the same nest, resulting in unmanageable clutch sizes and increased risk of a large proportion of all the eggs laid by flock members being lost through predation. Adaptability in this respect could be further enhanced by individual variability in responsiveness to different stimuli.

Failure to respond to more than one stimulus would also appear to be maladaptive in that it could result in placement of eggs in positions which may be unfavourable in many situations. For example, factors associated with ideal conditions for incubating eggs may not necessarily be the same as those ideal for concealment of the eggs and sitting hen from predators.

It is apparent from the reports of nest sites used by gallinaceous hens in a natural habitat, that sites selected are extremely varied. It would not be expected that an 'all or none' stimulus response would be operative, particularly since ovipositions are physiologically pre-programmed and the hen herself has only limited control over the timing of each oviposition.

It appears that in nest selection there are several important aspects involved and the stimuli to which nest-seeking hens respond may be different in different stages of the nest selection and nesting phases. Firstly, some factors may be important in getting hens to the nesting area. The position of the nest site in terms of its height above the ground (see Studies 4.5.1-10) or the type of cover in which it occurs, and therefore the site's concealment value (see Study 4.6), may be influential in this process. It is also possible that light, or light intensity gradients, may also be used to orient the hen to potential nest sites (see Studies 4.4.1 and 4.4.2). Other factors may also be involved.

Secondly, once a nesting area has been approached, certain stimuli may act to release nest examination and entry. From the nest preference studies conducted, it seems that stimuli related to the light intensity in the site relative to that in areas outside the nest, the degree of 'confinement' or 'sense of enclosure' provided by the site (see Discussion, pp.269-277), the presence of eggs in the nest (see Discussion, pp.215-219) and probably a number of other factors, may be involved in the nest examination and nest entry responses.

Thirdly, once a hen has entered a potential nest site, she may then respond to certain stimuli by sitting in the nest and by remaining in it until oviposition occurs. Factors which are likely to be involved in producing these responses include the presence of a nesting material (see Discussion, pp.229-232),

light intensity (see Study 4.4.2, pp.251-254), the 'depth' of the nest or concealment afforded in the site (Study 4.4.4, pp.257-261), the sense of confinement or enclosure of the nest (Study 4.4.6, pp.263-266) and, perhaps, light intensity differentials (pp.270-271).

Certain factors appear to be more important in determining nest selection than others. In the nest preference studies conducted in the course of this research, hens were noted to respond very strongly to the presence of a nesting material in potential nest sites and this applied regardless of the previous nesting experience of the hen. Preferential selection of nests containing nesting material, as compared with bare nests, was considerably stronger than responses to either the presence of eggs in the site (Study 4.1.3, pp.209-212) or additional confinement provided to the nests by nest curtains (Study 4.2.1, pp.220-225). The response to nesting material was recorded for both of two very different breeds of hen, suggesting that nesting material may act as a releaser for nest entry or sitting in the nest. However, the nature of the stimuli which the hens actually respond to are not known. It is suggested that the ability of the material to be manipulated may be important (see Discussion pp.220-232).

The responsiveness of hens to nesting material has a number of implications in the provision of nesting facilities under a wide range of commercial housing conditions. It would seem unlikely that hens would readily accept nesting facilities not containing a nesting material unless no substitute is available elsewhere in the pen or cage. It is therefore not surprising that considerable difficulty has been encountered in establishing nest usage habits in hens provided with roll-away nesting systems in deep litter pens (Anon., 1964) or in experimental get-away cages in which sand-boxes have been included (Wegner, 1980). Further research into the exact stimulus/stimuli from nesting material which release the sitting or 'remaining in the nest' components of the nesting phase could be valuable. Such studies could suggest means of providing suitable floor types or materials for nesting purposes that could be used to maximise nest usage in automated egg collections systems.

Other factors for which preferences were established included the presence of eggs and the level of illumination in the nest site. However, the use of nest-eggs proved to be ineffective in increasing the proportion of eggs laid in provided nests in small scale floor-laying trials (see Chapter 5, p.320), probably because young birds with little nesting experience seem not to respond maximally to the egg stimulus (see Study 4.1.4). Although initial selections of nests with differing levels of illumination were found to be influenced by prior experience, hens were found to form attachments, eventually, to unilluminated nests in almost all cases (Study 4.4.2). It is suggested that hens may respond to changes in light intensity as they approach potential nests or/and intensity differentials as they sit within the nest and look out from it. It may well be

that light intensity is used to orient the hen to sites which possess some sort of confinement or concealment value, since responsiveness to decreasing light intensity would also tend to result in the hen selecting more enclosed sites. At what stage hens respond to light intensity and whether they respond to light intensity gradients as they approach the site or to light intensity differentials as they look out from within the nest could only be determined by further research.

The sense of enclosure or confinement of the nest site and the concealment it affords are also apparently important features of the nest although the exact stimuli to which hens respond in selecting nests which possess these characteristics have not clearly been identified. However, hens responded to the presence of a confining vertical or overhead barrier (Study 4.4.6) and also preferred to nest behind certain types of physical and visual barriers (Study 4.6). Hens therefore tend to nest 'next' to something and it was apparent that the greater the number of dimensions of confinement which a site possessed, the more popular it was (e.g. Study 3.1, p.93). Hens also apparently respond to the presence of some form of visual barrier in front of the nest. Probably a broken, irregular barrier which allows the birds to see out beyond the nest as well as providing some concealment to the sitting birds may be more effective in this respect (see Study 4.6).

The provision of added dimensions of confinement to the next may afford a useful means of creating more acceptable nesting facilities in large scale enterprises. The use of nest-backs in otherwise open nests in a small scale floor-laying trial indicated that levels of floor eggs laid may be reduced by such procedures (see Chapter 5, p.320). However, in the design of nesting facilities which incorporate such features, particularly for Australian conditions, the adequacy of nest ventilation must also be taken into consideration.

The finding that hens responded to overhead confinement most strongly when it was provided at a certain height (see Study 4.4.6, p.265) may indicate the importance of providing other facilities in the shed, such as feeders and waterers, at heights which will reduce the possibility of them being used as cover for floor-laying hens. The actual range of heights in which overhead confinement becomes attractive is likely to vary for different breeds, or/and sizes, of hens. Results of studies into the selection of nests of different depth or recess angle indicated that breed may influence responses to these features (see Studies 4.4.3 and 4.4.4), and this may be determined by the size of the hen.

Hens demonstrated responses to nest recess 'angle' which suggested that they preferentially select more confined nests, but only to a certain point at which nest size interferes with the performance of nest building activities (see Discussion, Study 4.4.3). This may have a number of implications in the provision of nests in large scale commercial enterprises. Nests may need to be sufficiently confined but the nest must also be large enough for the hens to

perform complete rotations and foot scraping activities within it without being impeded by its size. This will ultimately be affected by the size, and therefore the breed, of the hen. By implication, the results of the present research also suggest that single nests may be preferable to community nests in such situations since they provide a higher degree of confinement and a greater number of confining barriers to respond to. This could only be verified by larger scale nest usage studies in large flock situations.

Results of studies comparing nests of differing 'depth' (height of the front 'lip' of the nest) indicate that hens tend to select nests which appear to allow the nesting hen to sit low in the nest, below the level of the nest opening, and so be effectively concealed while sitting within it (see Discussion, Study 4.4.4). The nest depth which will afford such an effect will therefore depend on the size, and so the breed, of the hen which is using the facilities. Nest depth may be a factor which could be simply and effectively manipulated to increase the acceptability of nesting facilities in commercial situations.

In the provision of nesting facilities it should be borne in mind that hens may not necessarily seek visual isolation from other nesting hens or other flock-mates in general (Study 4.4.7, p.268). They do seem, however, to seek isolation from the general flock area. It would be useful to understand exactly what the hens seek concealment or isolation from in the flock area in order to provide nests which satisfy these criteria.

The orientation of hens in more preferred, more confined nests was found to be different from that displayed in less acceptable open types of nests (Study 4.4.5, p.262). In deeper nests offering higher levels of confinement or concealment, hens tended to face into the pen area while sitting and laying to a greater extent than they did in more open nest types. The orientation of hens while nesting in certain nest types may provide a useful and simple criterion for the determination of suitability of provided nest types, at least in terms of the degree of confinement or concealment afforded, in both experimental and practical situations.

Other minor factors found to influence nest selection patterns in some situations were nest shape and nest entrance shape (Studies 4.3.1 and 4.3.2, pp.233-243). Many other factors, not necessarily studied by the author, including the colour of the nest, position of a nest in a set or in the shed and its aspect, may also influence the selection of a nest by the individual hen. These sorts of factors may be used by hens to distinguish own, or previously used, nests. Nest usage levels in sheds with nests which differ with respect to these secondary factors may be very similar, provided all nests in each shed are the same with respect to that factor. However, since individual hen variability is apparent in the selection of different nest types, then it

could be used to distribute the usage of nests more evenly between all nests in a shed and so to encourage maximal nest usage.

It may be that a 'smorgasbord' of different nest types, at least in terms of those factors for which considerable individual variability in 'preference' is apparent, may be the best means of providing nesting facilities in a whole flock situation to maximise nest usage. At the same time, factors for which very strong preferences have been determined, such as for nesting material and possibly those factors related to nest concealment, should possibly be constant throughout the shed.

Nests at or near the end of a set were often found to be more heavily used than were other nests. It is therefore suggested that the provision of a higher proportion of such end nests, perhaps by using larger numbers of nest-sets containing fewer nests per set, may be effective in increasing the overall effectiveness of the provided nesting environment. Alternatively, perhaps elimination of 'end' effects in the floor area, such as occur at corners or, perhaps, changes in the floor environment or other barriers which would impede movement of hens about the floor area, may provide a means of reducing the selection of floor sites and so encourage the usage of nests (e.g. Study 4.3.1, p.239).

Comparison of the effectiveness of different factors, applied together, in determining nest selection has not, as yet, been seriously attempted. However, as previously indicated, some stimuli from the nest are apparently more important than others to the nest-seeking hen. Hens, for example, demonstrated very strong preferences for nests containing nesting material as compared with bare nests, and this response was apparently greater than that for nest-eggs (Study 4.1.3, p.210) or nest confinement (Study 4.2.1, p.222). When studied together, light intensity was apparently more influential than nest angle in determining nest selection (see Study 4.4.1, p.250). The relative importance of different stimuli in the determination of nest usage patterns warrants further investigation.

To what extent preferences for different nest features may be effective in establishing nest usage habits in commercial flocks of birds also remains to be determined. Some of the factors known to influence nest site selection may not reduce floor-laying because hens may fail to respond to them early in their laying history when such habits are established. It is interesting in this respect that while there was some indication, from small scale floor-laying trials, that the degree of nest enclosure or confinement could influence nest usage patterns, the provision of nest-eggs was ineffective in this

respect (Chapter 5, p.320). It should be noted, however, that floor-laying studies were conducted in small, crowded and barren pens, very different in many respects from those used for the housing of laying hens under commercial conditions. Conclusions drawn from such studies should therefore only be extrapolated to the commercial situation with some caution.

Also, the tendency to use nests, regardless of how attractive they are to nest-seeking hens, will be governed by the ability of hens to find the nests or to be attracted to the particular area in which the nests are sited. Although essentially a ground nesting species, the domestic hen does quite readily accept elevated nests in confined housing conditions. Results of studies conducted on the selection of nest elevation indicate that this may occur as a result of the hens' inability to find suitable isolation or confinement elsewhere in a rather barren environment which in turn encourages them to seek isolation through elevation (see Section 4.5 Discussion, pp.297-301). The possible effectiveness of visual nesting barriers surrounding the nesting area in encouraging hens to seek nest sites in designated nesting areas is also suggested. These would probably be most effective in situations where nests are sited at ground level and so do not possess the qualities of isolation otherwise provided by elevation (see Study 4.5.5). Results of preference studies (Study 4.6) indicate that the type of barrier provided may also be important, with broken, irregular cover possibly being the most effective in this respect.

The ability of hens to find or get to provided nesting facilities is suggested to be of overriding importance in the determination of nest usage habits in flocks of hens. Studies conducted in small, deep litter floor pens with provided elevated nests showed that the type of approach provided to the nest-set may have a great impact on the proportion of hens which will eventually lay in nests rather than on the floor (see Chapter 5, pp.319-320). Individual preferences for different nest heights were apparent in nest preference studies and, although upper-level nests were apparently less often used by flocks of hens in general, the provision of some such upper level nests may be extremely important to a certain proportion of the nesting flock (see Discussion,Chapter 5).

The ability, or desire, to use elevated nests was found to be influenced by the prior rearing or laying experience of hens (Study 4.5.6). It is suggested that in encouraging hens to use provided elevated nests, prior training either in the use of nests or in exploring the total pen and nesting environment may be of value. The provision of perches, confinement of pullets in nests and elimination of factors which may discourage exploration of the total pen environment, such as electrification of the tops of feed lines, may be effective in this respect. Allowing pullets sufficient time, prior to the onset of lay, to become familiar with the total pen and nesting environment, and particularly with the provided nesting facilities, would also seem to be of major importance.

The selection of nesting environment, and responsiveness to stimuli from the nest, may also be influenced by the environment in which birds have been incubated, brooded and, perhaps, reared. It is worth noting, in this respect, the results of a study conducted by Hess (1972). He found that approximately half of a group of mallard ducklings hatched and reared for the first few days after hatching in simulated nest-boxes, subsequently nested in provided elevated nest-boxes whereas their counterparts hatched and reared for two days in a simulated open ground nest totally avoided elevated nests on reaching sexual maturity. The value of manipulating hatching and rearing environment in the establishment of subsequent nest usage patterns may, therefore, be a worthwhile venue of further research.

If, as suggested earlier, graded responses to a number of different stimuli from the nest do occur, then it may only be necessary to provide better alternatives than those which are available elsewhere in the pen environment, rather than the best alternatives, to obtain satisfactory nest usage levels in commercial situations. Whether this is 'satisfactory' from the bird's point of view, or in terms of bird welfare, is more difficult to say. It may therefore be important that further research be directed towards the determination of means of creating a less suitable nesting environment on the shed floor, as well as creating a more suitable nesting environment in the provided nesting facilities. In the floor-laying studies conducted by this author, one factor which was found to have a particularly makred effect on floor-laying levels was the elimination of a preferred floor-laying site under the nest-set in all pens (see Chapter 5, p.321).

Although nest-usage habits can undoubtedly be manipulated by alterations of the nesting and floor environments, some proportion of floor eggs may be inevitable. It is unlikely that a situation could be achieved at which all eggs from a maturing flock of hens will be laid in provided nesting facilities. Some percentage of hens simply may not be responsive to many stimuli from the nest, particularly for the first day or two of lay. This may be caused by nervousness or may be determined hormonally (see Discussion, pp.299-300). Nevertheless, the provision of nesting facilities, and the management and rearing of flocks of birds, can undoubtedly be manipulated to minimise the number of floor eggs laid thereafter and so substantially reduce the problems associated with floor-laying tendencies in commercial flocks of floor housed hens.