Study 3.3

Additional Studies of the Nesting Sequence Performed by Mature Hens

3.3.1 Introduction

In this study the time, in relation to the time of oviposition, at which several pre- and post-lay behavioural activities would commence was recorded for both nest and floor nestings. Thus, an attempt was made to quantify the actual sequence in which the activities occurred, the times spent in varying activities and how this was affected by the time of day at which the oviposition occurred and the environment in which it occurred.

3.3.2 Materials and Methods

(a) *Observations and Recordings*

The same 37 hens were observed as in the previous Studies 3.1 and 3.2. Hens were housed in the original pen used and described in those studies. This pen was equipped with the set of six nests described in Study 3.2 and in use for the final 28 days of that study. Husbandry procedures were the same as those described in Study 3.1.

Observations involved in this study commenced 11 days after the conclusion of Study 3.2, at which point the hens had been laying for about 16 weeks. Observations were conducted over a period of three weeks. Only a limited number of activities was recorded for each hen as detailed records of the times that such activities commenced were required, and it would otherwise have been impossible for one observer to keep an accurate record of such behaviours of each hen if all activities were recorded. The time at which pacing commenced was recorded. Calling was not recorded because it had been found in previous studies that calling tended to be heard in association with pacing. The times at which hens mounted the approach in front of the nest-set were recorded as was the time at which hens first entered a nest or nest site and times of subsequent visits.

The number of nest entries per oviposition was also recorded. Although this was easily determined for nest layers, a nest entry being recorded if a hen moved its whole body into a nest-box, it was not so easily distinguished in hens seeking out floor sites. However, a 'nest' entry into a floor site was defined as having occurred if the hen approached the site in the nest examining stance, with eyes directed into the site and body and neck stretched horizontally out toward it, and then moved into the site, usually a corner.

The hen 'entering' a floor site paused for at least five seconds in the site. She usually sat within the site, sometimes only momentarily, and performed the early settling in movements, or pecked about at the litter as if about to settle in the site following a floor site 'entry'. Where hens approached the site, sat and settled into the litter without the characteristic nest examination approach, this was also recorded as an entry. The nests or sites which were entered were also recorded.

The times at which ovipositions occurred were noted and the orientation of the bird at the time of oviposition recorded. Orientations were only recorded for analysis where hens were allowed to lay by themselves without being disturbed by other hens. Only nestings in nest-boxes or corners were analysed. Also noted were the situations in which post-lay cackles were given. Where post-lay cackles were recorded, the position of the hen at the commencement of the call, during and at the end of the call were taken down. Finally, the time at which the hen left the site of her oviposition was recorded.

The observer did not attempt to observe every laying hen each day. Consequently, pre-lay behavioural patterns of individual hens were not necessarily followed for successive eggs in a laying sequence. However, the observer did endeavour to follow and record as accurately as possible, the complete sequence of events leading up to and following oviposition for any one nesting.

From these records for individual hens, the following parameters were determined:

1. Time from commencement of pacing to oviposition
2. Time from first mounting of approach to oviposition
3. Number of times the approach was mounted per oviposition
4. Time from first nest entry to oviposition
5. Number of nest entries per oviposition
6. Proportion of nestings in which the first nest entered was that eventually laid in
7. Time from final nest entry to oviposition, i.e. time spent in the nest finally selected
8. Orientation in the nest or corner at oviposition
9. Positions before, during and after post-lay cackles
10. Time remained on the nest after oviposition.

Parameters 4, 5, 6, 7, 8 and 10 were all recorded for both nest and floor-layers. Parameter 1 data were not classified as from either nest or floor nestings, as nest-users at this stage only occasionally displayed pacing as such. Instead, the first indication of their intention to lay was usually movement to and mounting of the approach. Parameters 2, 3 and 9 only related to nestings in nest-boxes. Parameter 9 was only recorded for nestings in provided nest-boxes.

(b) *Analysis of the Data*

All timed data were subjected to regression analyses to investigate any trends in the time at which particular activities were first observed to occur or the duration for which the activity occurred that could be related to the hour of day in which the oviposition took place. Although the timec data were precise measurements, the times at which oviposition occurred were classified into the hour in which they occurred, e.g. between 1.00 pm ard 1.59 pm, for ease of handling of the data. For regression analysis, oviposition time was recorded as a theoretical average time mid-way through each hour, e.g. 1.30 pm. In numerical terms this translated to an x value of 13.5.

Where both nest and floor-laying data were recorded, separate regression analyses were performed on the data from both nesting environments, and regression analysis was also performed on the combined data. Regression coefficients for polynomials of best fit up to the third degree were again calculated on the University's DEC20 computer, using the BAR3 programme (Burr, 1975). Analyses of variance were performed on all nest and floor-laying data in order to establish whether the times at which certain activities commenced or the length of time over which they occurred was influenced by the environment in which the nesting took place.

Analyses of variance were performed on data obtained from each hen for each activity to determine if there was any significant hen effect. Where necessary to stabilise variance, appropriate transformations were carried out prior to analysis. Where analysis of variance indicated a significant hen effect, means for each contributing hen were ranked in order of magnitude. Paired comparisons were then made between all means using an approximate Least Significant Difference (LSD) based on the harmonic mean (Snedecor and Cochran, 1967).

Chi-square analysis was performed on the numbers of hens found to lay in certain positions in the nest-box. Where a hen's orientation was recorded on more than one occasion, the most frequently recorded orientation was used as its 'typical' response. Assuming that the probability of all orientations is the same, the analysis tested the null hypothesis of equal probability of hens ovipositing in any orientation in the nest-box. The numbers of hens using each of the different possible orientations within corners on the pen floor were also analysed assuming positions were uniformly distributed.

3.3.3 Results

At the beginning of this study a number of hens had not completely adjusted to the nest-set provided in the pen, which had been installed toward the end of Study 3.2. As a result of this, 19 hens were recorded during nestings which culminated in ovipositions in both floor sites and nest-boxes. Five hens were observed and recorded for nestings in elevated nest-boxes exlusively, while a further ten hens were persistent floor-layers. The remaining three hens had no complete nestings observed and recorded. The reasons for this included tendencies not to display obvious nesting behaviours until the point of oviposition or infrequency of nesting and laying.

1. Timing and Occurrence of Events in the Pre-Lay Nesting Sequence

The times, in minutes before oviposition, at which pacing commenced are given for each hen in Appendix 3.3.1. Times from onset of pacing to oviposition plotted against time of eventual oviposition in Figure 3.3.1. As mentioned earlier, many hens did not really perform pacing prior to mounting the approach to the nest-set. Also, data were only used for pacing when they came from nestings with completed records from the beginning of pacing to oviposition and when the observer was certain that each bird recorded had not paced previously that day. As a result, there tended to be fewer recordings of times from commencement of pacing to oviposition. However, the average time at which pacing commenced was found to be 115.1 minutes before oviposition.

The time from commencement of pacing to oviposition was found to change significantly with the time that the oviposition took place. The length of time from commencement of pacing to oviposition increased the later in the day that the oviposition occurred. The relationship between the time pacing began and the time at which oviposition occurred is described by a quadratic regression equation given in Table 3.3.1. This curve is also plotted in Figure 3.3.1. The trend towards relatively 'earlier' commencement of pacing the later in the day that the oviposition occurred was highly significant ($P < .001$).

The quadratic component of the calculated regression equation reflects the tendency for the increase in time by which pacing preceded oviposition to occur primarily after late morning ovipositions. Ovipositions occurring between 7.00 am and 10.00 am tended to be associated with similar times of initiation of pacing in relation to oviposition.

Table 3.3.1 Significant 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 to describe the change in time (mins) from commencement of each activity to oviposition (y) with the hour of day in which the oviposition occurred (x)

Activity	Nesting Environment	β_0	β_1	β_2	Significance
Pacing	Floor site mainly	447.58**	-90.258**	5.3937	***
Mounting Approach	Nest-box	272.07*	-51.600*	2.9448	*
First Nest Entry	Nest-box	-44.95	10.008		***
"	Floor site	241.35	-50.921⁻	3.1081	*
"	All data	254.03*	-51.588**	3.0516	***
Final Nest Entry	Floor site	-52.98**	8.430		***
"	All data	-23.14⁻	5.567		***

' Blanks in Table indicate that this and higher order terms are not significant
- = (.05<P<.10) ; * = (.01< P < .05); ** = (.001< P < .01); *** = (P < .001)

Since very few instances of pacing were seen to precede mounting of the nest-set approach, no attempt was made to establish any temporal relationship between the two. However, when the nest entry data corresponding to the same ovipositions from which the pacing data came were calculated, it was found that pacing commenced, on average, 57.4 minutes before nest entry first occurred.

The times, in minutes, from first mounting of the nest-set approach for the purpose of nest examination, to oviposition recorded for each hen, are given in Appendix 3.3.2. These times are plotted against the hour of the day in which they occurred in Figure 3.3.2, as is the regression curve calculated for this parameter (see Table 3.3.1). On average, the approach was first mounted in a nesting context 73.3 minutes before oviposition occurred. As for pacing, the first mounting of the nest-set approach took place relatively earlier, or in other words, time from mounting the approach to oviposition became longer. the later in the day that the oviposition occurred. This trend is given by a quadratic regression equation given in Table 3.3.1.

As for pacing, the quadratic component reflected a tendency for time from mounting of the approach to oviposition tc be relatively constant, or even decrease slightly, up to about 10.00 am and to increase again thereafter.

The number of times each hen mounted the approach in a nesting context is given in Table 3.3.2. The numbers of nest entries into either nest-boxes or floor sites recorded for each hen are also given in Table 3.3.2.

For the 59 nestings recorded, a total of 228 approach mountings were observe Of these, 52 occurred during 29 nestings without being followed by a nest entry before the first nest entry ever occurred, i.e., prior the first nest entry, hen mounted the approach, but jumped off again without entering a nest on 52 occasi These approach mountings without accompanying nest entries were seen to precede the first nest entry for approximately half the nestings observed. Following t first nest entry, a further 25 approach mountings which did not result in a nes entry were recorded during the 59 observed nestings. Thus, incidences of approach mountings without subsequent nest entry were more frequent earlier in the nesting sequence, before the first nest entry had occurred. Of the remaining 151 approach mountings which were followed by at least one nest entry before the hen jumped down again, single subsequent nest entries were most commonly observed. However, of the 172 nest entries which occurred during the 59 observed nestings, 21 were second, third or subsequent entries resulting from the one approach mounting.

More simply, about half of the observed nestings were preceded by one or two approach mountings before a nest was ever entered. After the initial nest entry, approach mountings which did not result in nest entry occurred, but were less frequent. The majority of approach mountings resulting in or following the first nest entry resulted in a single nest entry, hens generally getting out of the nest and jumping down from the approach before remounting and enteri another nest. However, in a number of cases other nests would be entered witho the hen necessarily jumping down from the approach and remounting it again later.

Recorded nest entries for nestings in either elevated nests or floor sites (Table 3.3.2) indicated that approximately the same number of nests was entered prior to oviposition in both environments. Although the average number of nests entered per oviposition was calculated to be 2.76 entries per oviposition, hens varied markedly in the number of nests they would enter before eventually laying in one. The greatest number of entries recorded was for the hen, Red, who entered 16 nests before laying on one day. This hen appeared to

Table 3.3.2 The numbers of nest, floor and total (nest + floor) nestings observed for each hen and the total numbers of nest entries, approach/perch mountings and times on which the first nest entered was eventually laid in, associated with these

		Elevated Nests		Floor Sites		Total (Nest + Floor)		
Hen	Total Times Mounted Perch	Total Nests Entered	Total Nestings Observed	Total Nests Entered	Total Nestings Observed	Total Nests Entered	Laid in First Nest Entered	Total Nestings Observed
G34	20	17	7			17	4	7
G35	2	2	2	4	3	6	5	5
Y94	4	4	3	4	4	8	6	7
B99	9	7	1	14	4	21	2	5
B53				6	1	6	0	1
G38	11	4	3	7	5	11	7	8
Y90	22	15	6			15	3	6
Y91	14	13	3	7	2	20	2	5
G39				8	4	8	4	4
B00	7	4	2	8	3	12	3	5
G41	2	2	1			2	0	1
Y95				9	4	9	4	4
Y99	18	6	4	1	1	7	3	5
G42	13	9	2	8	2	17	4	4
B51				9	6	9	6	6
W80	5	5	2	2	2	7	1	4
G40				9	1	9	0	1
B97	3	2	1	1	1	3	2	2
N.N.				4	4	4	4	4

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enter many more nests than this before laying on many other days, although the actual numbers were not recorded.

The number of occasions on which the first nest or floor site entered was that eventually laid in is also given for each hen in Table 3.3.2. Although the birds together eventually laid in the first nest they entered in 96 of 149 recorded nestings, regardless of how many other nests they entered between the first entry and oviposition, individuals again responded very differently in this respect. It was noted, however, that while several hens approached and entered a particular nest directly, this being the nest that they eventually laid in, many hens would spend some time approaching and examining a number of other nests or floor sites before finally approaching, examining and entering a particular nest in which they would eventually lay.

The time at which a nest was first entered before the time of eventual oviposition is given for each observed nesting of each hen in Appendix 3.3.3. These data are plotted for nest-box and floor site nestings in Figures 3.3.3 and 3.3.4. The average time before oviposition that nest entry first took place was 65.9 minutes. The first nest entry preceded oviposition by 66.9 minutes and 65.2 minutes for all nest-box and floor nestings respectively. The difference between the mean times by which the first nest entry preceded oviposition for nest-box as compared with floor nestings was not significant (see Appendix 3.3.4).

The time by which first nest entry preceded oviposition was found to increase as ovipositions became later in the day. The increase in time from first nest entry to oviposition as time of oviposition became later in the day was found to have a significant ($P < .001$) linear trend in the case of nest-box nestings and a quadratic trend in the case of floor nestings. Regression equations describing these trends and also the change in time from first nest entry to oviposition with time at which oviposition occurred for all (nest-box plus floor site) nestings are given in Table 3.3.1. The curves relevant to nest-box and floor nestings are also plotted in Figures 3.3.3 and 3.3.4 respectively. When combined data for nest-box and floor nestings were analysed, a highly significant ($P < .001$) increase in the length of time from nest entry to oviposition with increasing 'lateness' of the oviposition was found.

Time from first nest entry to oviposition, as for pacing and mounting of the approach to oviposition, in the case of floor or all nestings tended to increase only for ovipositions occurring after about 9.00 or 10.00 am. Prior to this,

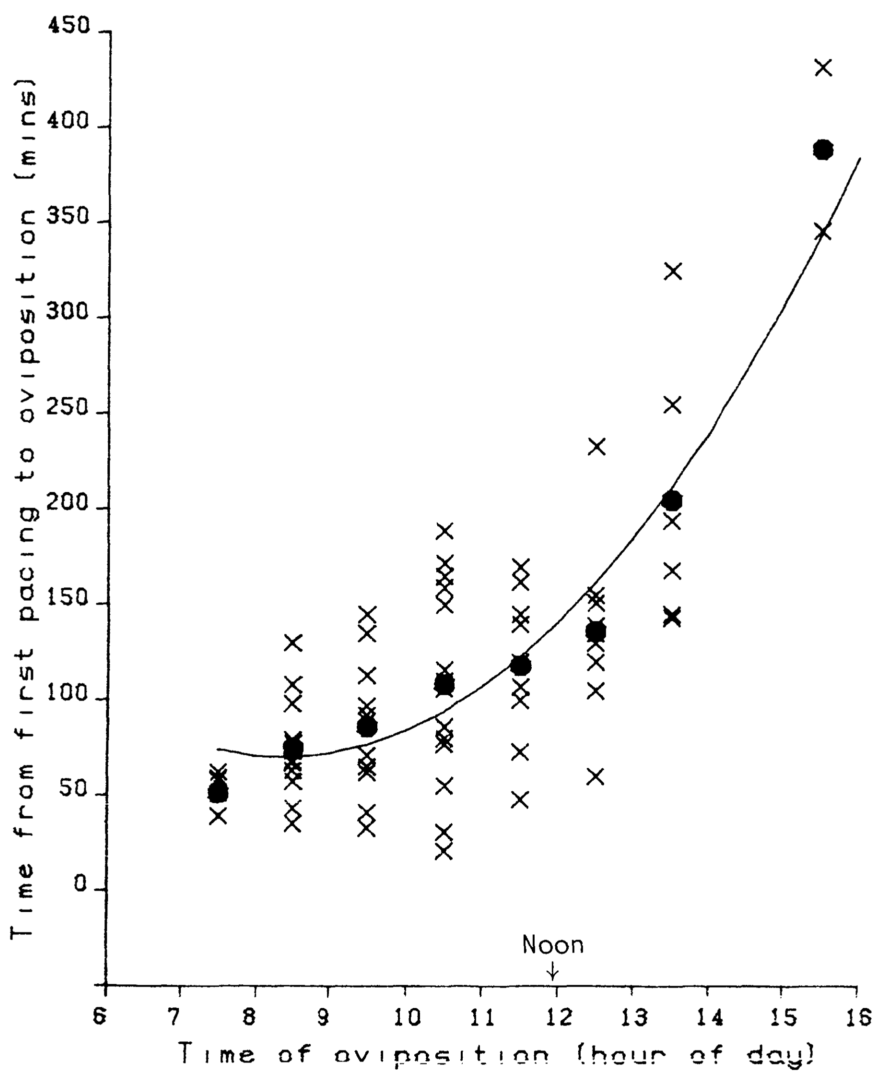


Figure 3.3.1 Time from onset of pacing to oviposition for ovipositions occurring at different hours throughout the day (x=individual recording; ●=mean time for that hour; — =curve describing the trend)

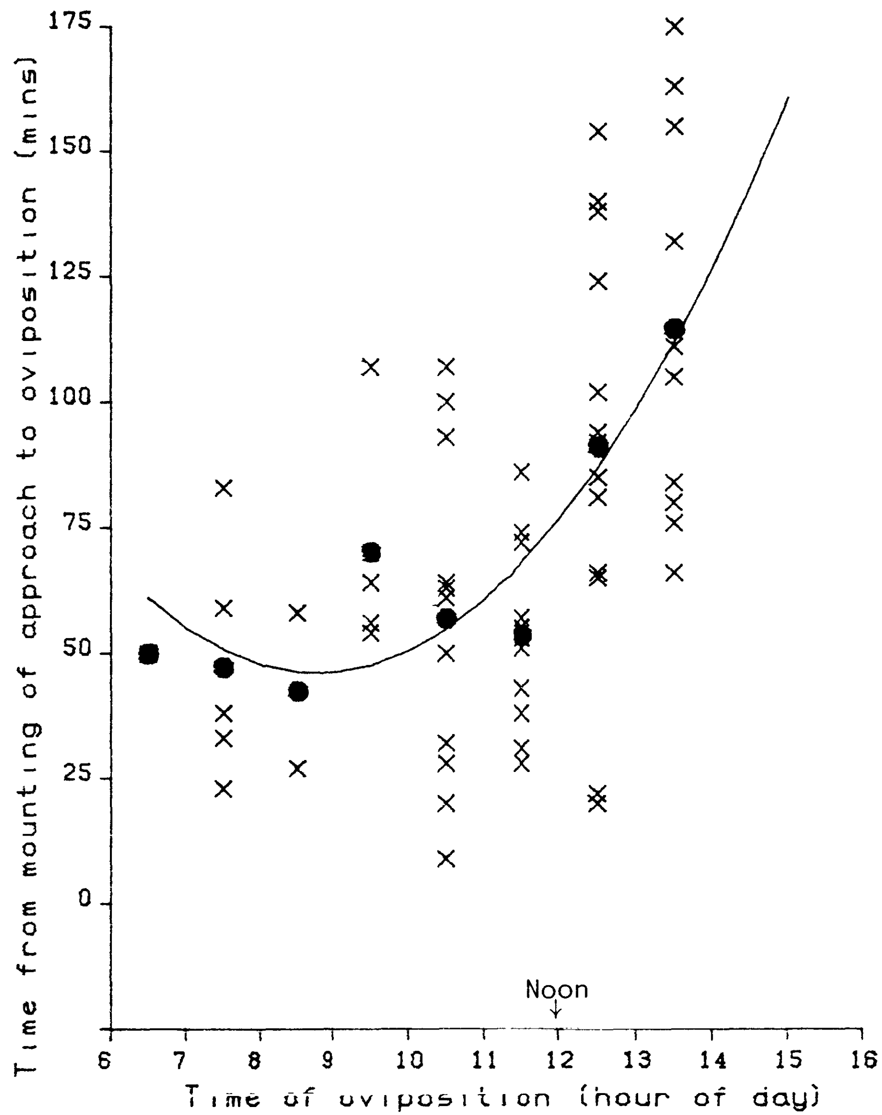


Figure 3.3.2 Time from initial mounting of the nest-set approach to oviposition for ovipositions occurring at different hours throughout the day (x=individual recording; ●=mean time for that hour; — =curve describing the trend)

Table 3.3.2 (cont.)

Hen	Total Times Mounted Perch	Elevated Nests Total Nests Entered	Elevated Nests Total Nestings Observed	Floor Sites Total Nests Entered	Floor Sites Total Nestings Observed	Total (Nest + Floor) Total Nests Entered	Total (Nest + Floor) Laid in First Nest Entered	Total (Nest + Floor) Total Nestings Observed
G43	6	6	1	15	4	21	2	5
W82	17	14	3	15	3	29	2	6
B71				11	7	11	7	7
Y96				17	6	17	4	6
Y98	5	4	1	10	3	14	2	4
W81	5	5	2	2	2	8	2	4
W79	13	12	3	16	3	28	3	6
Y97	1	1	1	1	1	2	2	2
W84				4	3	4	2	3
Red	13	8	2	24	2	32	1	4
G37				12	6	12	5	6
B98	21	16	4			16	1	4
Y92	4	3	1			3	0	1
W83	4	5	1	8	1	13	0	2
Y00	8	7	3	3	2	10	3	5
Total (All hens)	228	172	59	239	90	411	96	149
Average (per nesting)	3.86	2.92		2.66		2.76	0.64	

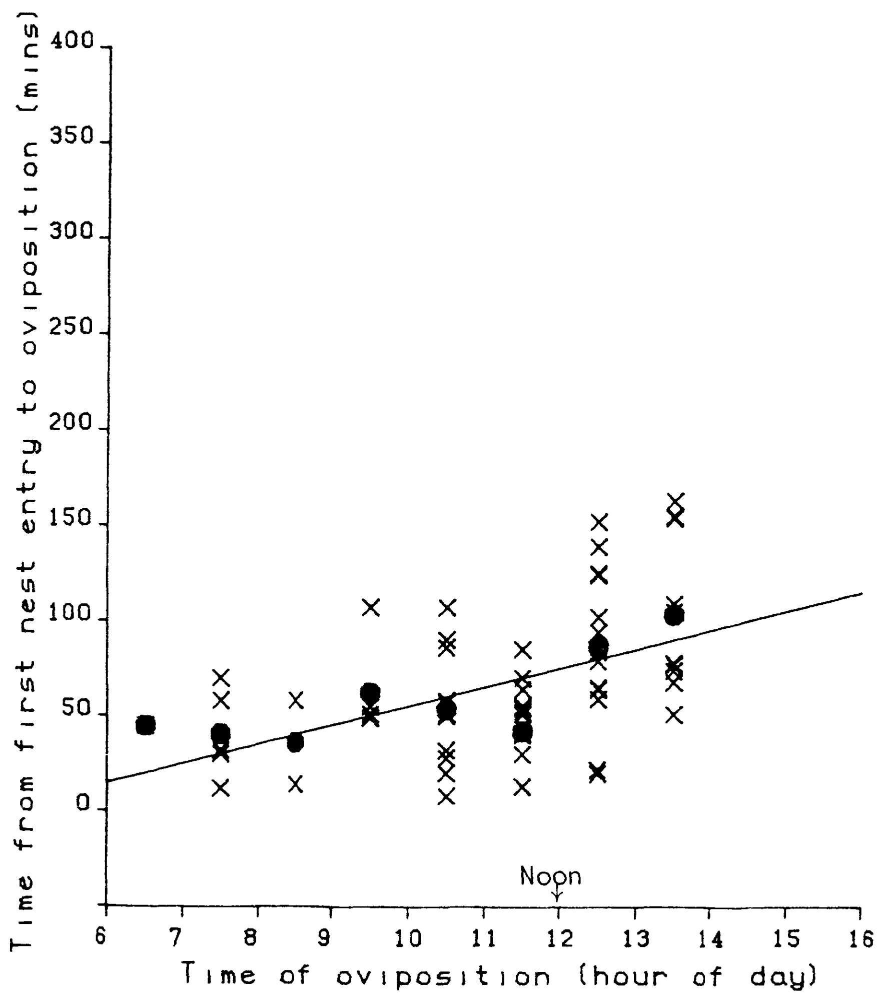


Figure 3.3.3 Time from first nest entry (elevated nests) to oviposition for ovipositions occurring at different hours throughout the day (x= individual recording; ●=mean time for that hour; — =curve describing the trend)

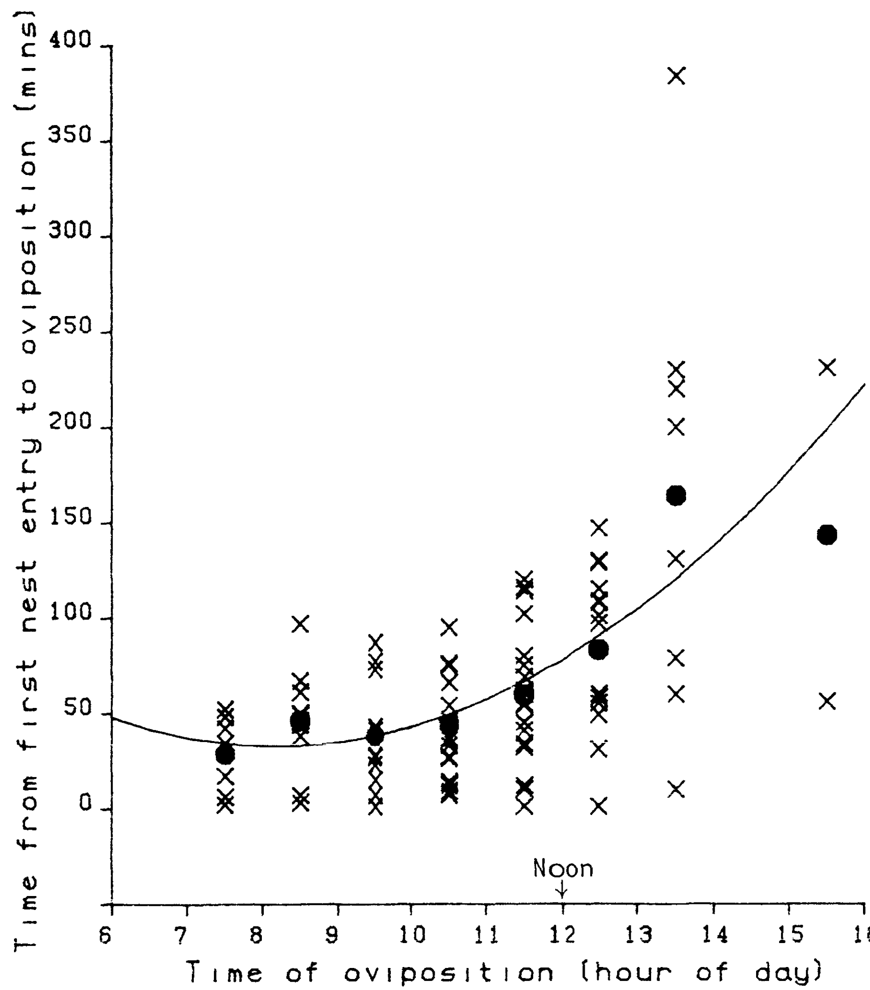


Figure 3.3.4 Time from first nest entry (floor sites) to oviposition for ovipositions occurring at different hours throughout the day (x= individual recording; ●=mean time for that hour; — =curve describing the trend)

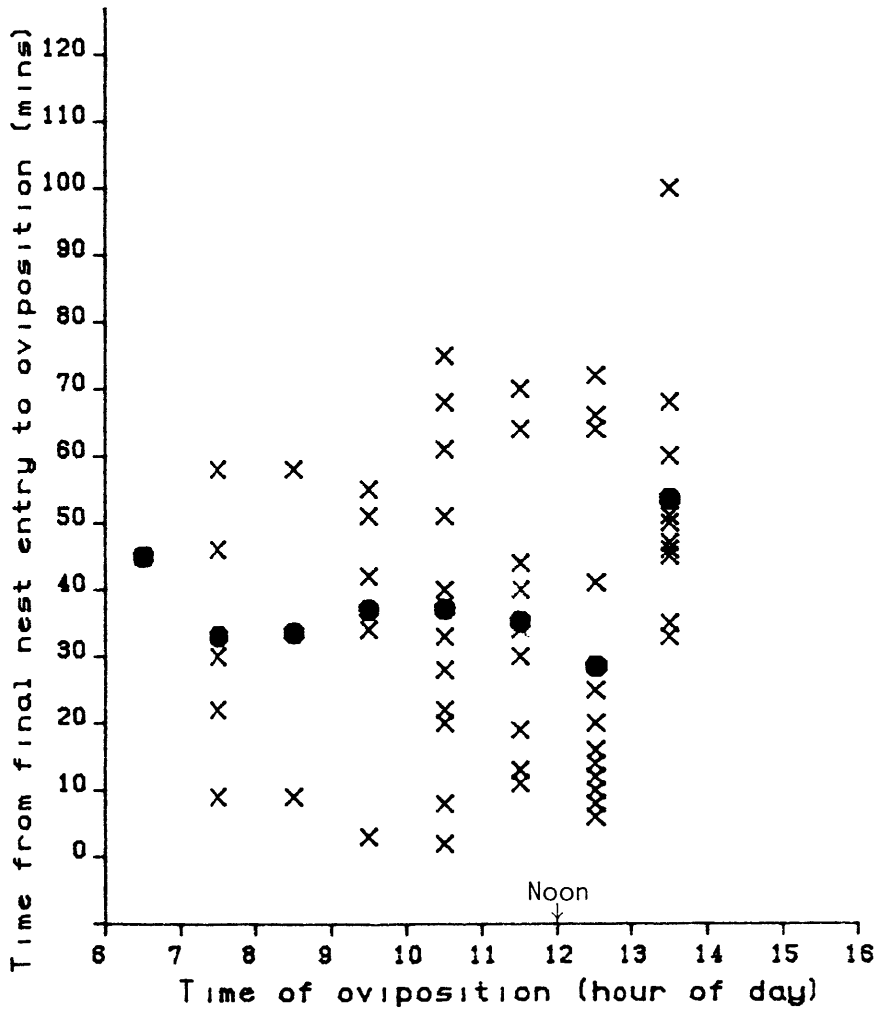


Figure 3.3.5 Time spent on the final nest (elevated nests) before oviposition for ovipositions occurring at different hours throughout the day (x= individual recording; ●=mean time for that hour)

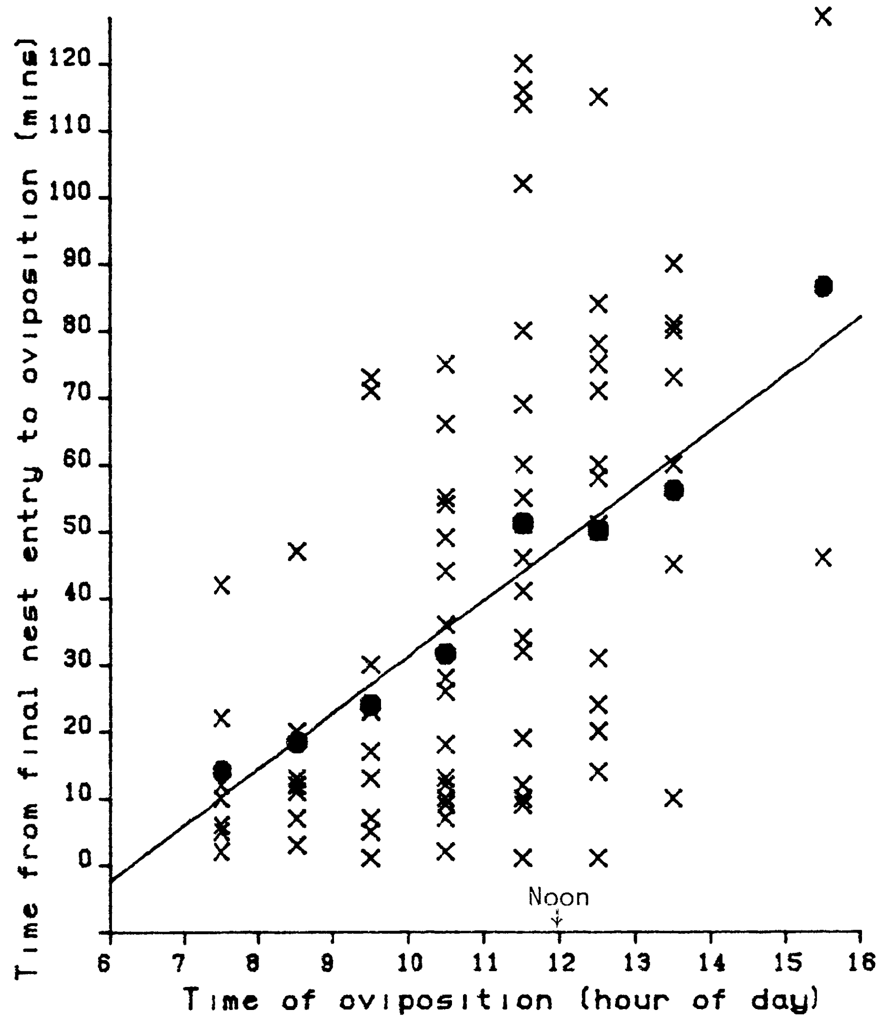


Figure 3.3.6 Time spent on the final nest (floor sites) before oviposition for ovipositions occurring at different hours throughout the day (x= individual recording; ●=mean time for that hour; —— =curve describing the trend)

nest entry times remained fairly steady or even increased slightly in association with the earliest ovipositions, thus the quadratic component of the curve describing these situations.

The times from when each hen entered a nest, in which she was to remain and eventually lay, until oviposition are given in Appendix 3.3.5. These times are plotted against the hour in which the oviposition occurred in Figures 3.3.5 and 3.3.6 for nest-box and floor nesting data respectively. No significant trend was found in the length of time that hens remained within their final nest before laying in the case of ovipositions in elevated nests. However, a significant linear trend ($P < .001$) was found for length of time on the final site over the time of oviposition for floor nestings. The regression equation calculated to describe this trend is given in Table 3.3.1. This line is plotted in Figure 3.3.6 also.

A significant linear trend ($P < .001$) was also found in the combined (floor plus nest) data, indicating that there was an overall tendency for time spent in the final nest to increase the later in the day that the oviposition occurred. This trend was best described by the regression equation given in Table 3.3.1.

The average time spent on the final nest before oviposition was 38.0 minutes. Analysis of variance (see Appendix 3.3.4) indicated that there was no significant difference between times spent on the final nest for nest-box as opposed to floor nestings. Calculated average times spent on the final nest were 37.2 and 38.5 minutes for nest and floor nestings.

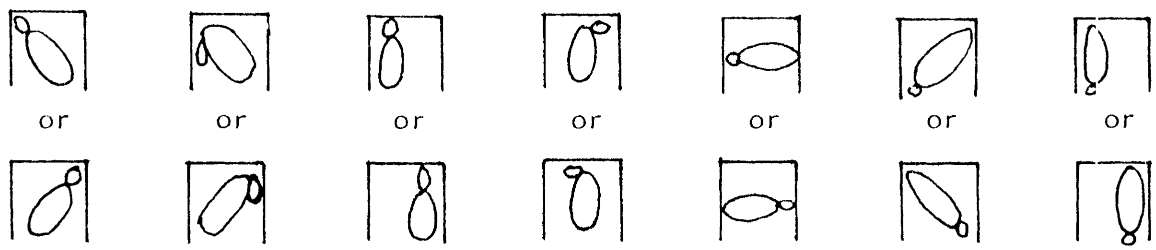
2. <u>Orientation of the Hen at Oviposition</u>

The numbers of ovipositions observed to occur while hens were oriented in particular ways within nests or corners, along with the numbers of hens typically using these orientations, are given in Table 3.3.3. Analysis of the latter results suggested a non-significant trend (.05 P .10) towards non random orientation of hen- in nest-boxes (see Appendix 3.3.6). Hens also exhibited a highly significant (P .001) tendency to lay while oriented in a particular direction in corners of the pen floor. The most preferred orientation in nests was one in which the hen's body faced diagonally across the nest towards a back corner, either with the head facing directly into the corner or averted towards the side wall so that the hen could actually see outside the nest and into the pen, or at least the entrance of the nest.

The most commonly recorded orientation of hens laying in corners was very similar to that preferred by hens laying in nests. Again, the most commonly

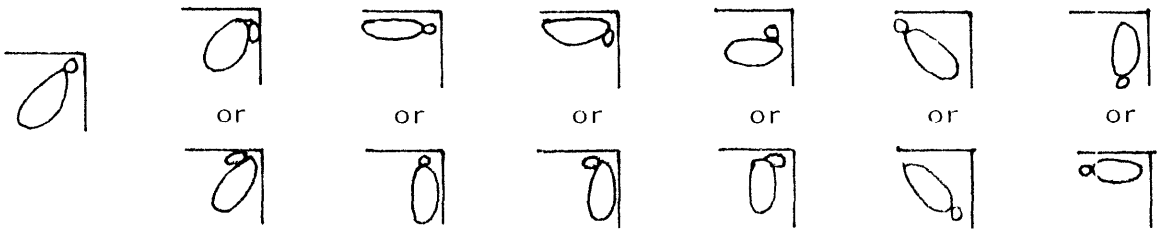
Table 3.3.3 The numbers of ovipositions observed to occur while hens were oriented in particular positions in elevated nests or corners and the numbers of hens typically exhibiting such orientations (in italics)

Elevated Nests



	A	B	C	D	E	F	G
Oviposition	13	10	6	1	3	3	1
Hens	*6*	*4*	*2*	*1*	*1*	*2*	*0*

Corners



	a	b	c	d	e	f	g
Oviposition	14	12	6	3	1	4	1
Hens	*10*	*8*	*4*	*1*	*0*	*2*	*1*

observed orientation was one in which the body was faced into the corner, roughly half-way between both walls forming the corner. The head of the bird either faced directly into the corner or was averted to the left or right in such a way that the hen could see down one or the other of the walls.

No significant difference was found between the numbers of hens which typically laid with the head facing either into the corner or averted to the side while in this position. Also, no significant difference was found when the numbers of hens typically using any of the other reported body orientations were compared. However, when the numbers of hens typically oriented with the body facing into the corner as described, regardless of the position of the head, was compared with that of all of the other reported orientations together, this orientation directly into the corner was found to occur significantly ($P < .001$) more often than all others put together. Similarly for nest ovipositions, the orientation of the body into a back corner regardless of head position was typical of more hens than all others ($.001 < P < .01$).

It should be noted that these analyses were *a posteriori* tests which should be viewed with some caution. Analyses were only performed on types of orientations which were observed during the course of the study. Some possible positions of the hens at oviposition were never seen and so are not included in the analysis. One notable omission was any position in which the hen faced directly out and away from the corner. This particular orientation had very occasionally been seen in passing during the previous studies, but was never observed in the three weeks during which this study was conducted. Although the analyses conducted were *a posteriori* tests, the general high level of significance and the fact that numbers of hens rather than total occurrences were analysed, allows us to have considerable faith in the findings.

Relatively few records of hens' orientations at oviposition were obtained. This situation arose because only ovipositions which were not complicated by the presence of other hens in the nest or floor site were used for analysis, and also because not all hens laid in nests or corners, other floor sites sometimes being selected. Sometimes the observer was unable to catch the exact position of the hen at the point of oviposition.

The orientations of hens when laying in the presence of another nesting hen were noted however. When laying in a site occupied by another hen, the tendency was for hens still to face into the corner, whether by squeezing in next to the other hen, climbing on top of her or lining up next to her as close to the corner as she could. If sharing a nest, laying hens would tend to sit and lay while facing into the same back corner. Hens laying together in the same site generally turned their heads towards each other, but very occasionally a laying hen would avert her head away from a particularly aggressive nestmate.

3. Time on the Nest After Laying

The average time that hens spent on the nest after laying was found to be 13.13 minutes. Hens varied markedly in the length of time they would typically spend sitting in the nest before leaving the site. One hen, G35, on two occasions remained in an elevated nest for about four hours after laying, more than twice the maximum time for which any other hen sat. Only these two recordings of sitting by this hen on an elevated nest after lay existed. Since these two records would add considerable bias to the mean times on the nest calculated for the two time periods in which the ovipositions occurred, and since such lengthy sitting periods were not only atypical of the flock but atypical of that particular hen, regression analyses and floor against nest laying analyses were conducted both including and excluding data obtained from G35.

The average times which hens spent on the nest after laying in either a nest or a floor site were 17 minutes and 10.9 minutes respectively. When all data from all nest layings and from all floor layings were analysed, no significant difference was found to exist between the two laying environments with regards to the length of time spent on the nest after oviposition. Regression analyses also failed to reveal any significant trends in times spent on the nest after elevated, floor or all nestings combined, except in the case of elevated nests using all G35 data, for which a significant (.001 P .0 linear trend of the form: y = 123.33 - 8.76x was found (where y = minutes after oviposition; x = hour of day in which oviposition occurred). The times spent on the nest after laying by each hen are given in Appendix 3.3.7. These times are plotted against the hour of day that the oviposition giving rise to them took place in Figures 3.3.7 and 3.3.8 for nest-box and floor nestings respectively. Although G35 data are not included, the regression line determined when such data were used is also shown in Figure 3.3.7.
spent on the nest after elevated, floor or elevated and floor nestings combined with respect to the hour of day in which the oviposition occurred. The times spent on the nest after laying by each hen are given in Appendix 3.3.7. These times are plotted against the hour of day that the oviposition giving rise to them took place in Figures 3.3.7 and 3.3.8 for nest-box and floor nestings respectively.

It should be noted that not all the recorded data for times spent on the nest after laying correspond to the same ovipositions from which the 'before lay' data came. This situation occurs because there were occasions on which a complete nest entry to oviposition nesting record could not be obtained and yet the oviposition to leaving the nest sequence was still accurately recorded, or vice versa. In some cases, birds did not actually even select a nest until they dropped their egg and so no 'before lay' data was obtained, and yet they then remained with the egg after laying which was recorded as a 'time spent on the nest after laying'.

4. Hen Effects

Analyses of variance revealed that hens did not differ significantly with respect to the time that they would commence to pace or mount the nest-set approach prior to oviposition. However, significant hen effects were found for times from first nest entry to oviposition, times on the final nest before laying, and times on the nest after laying (see Appendix 3.3.8). Results of comparisons made between all hens for these parameters are shown in Table 3.3.4. These results indicate that individual variability was apparent in the times that hens would first enter nests, or remain in the nest before or after laying. However, the flock could not be divided into particular groups which spent more or less time in these activities. Instead, there was a gradational range of responses of individuals in the flock with respect to these activities.

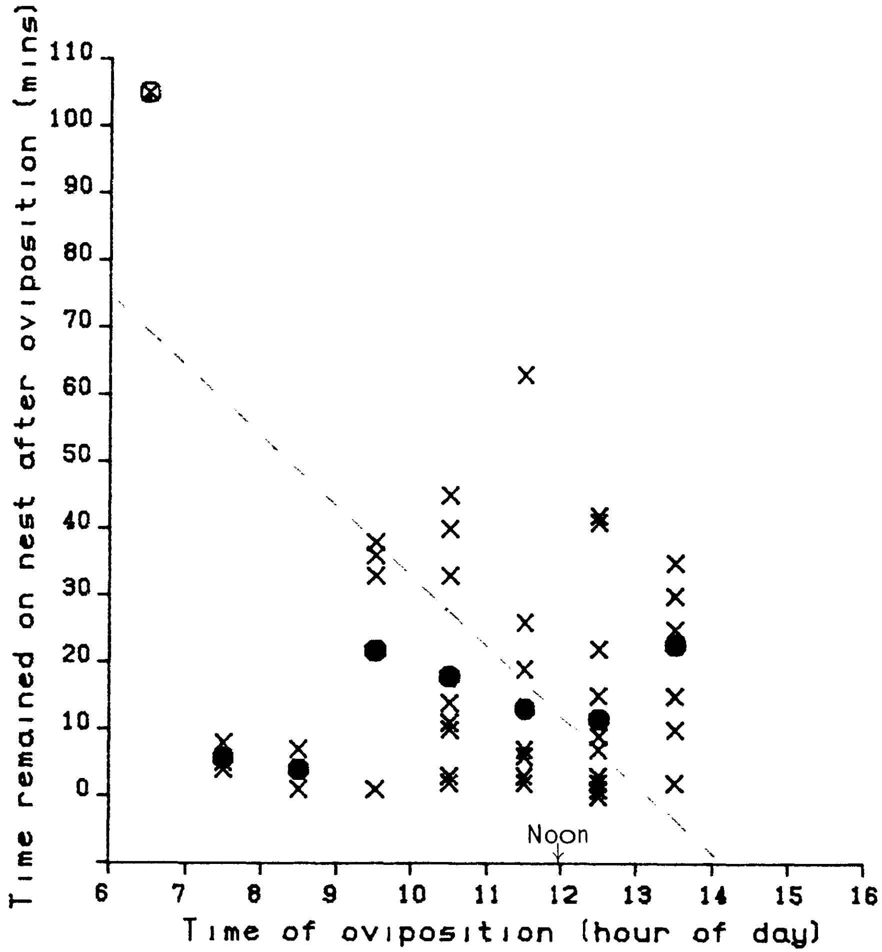


Figure 3.3.7 Time on the nest (elevated nests) after oviposition for ovipositions occurring at different hours throughout the day (x= individual recording; ●=mean time for that hour);- - - = curve describing trend(G35 data in)

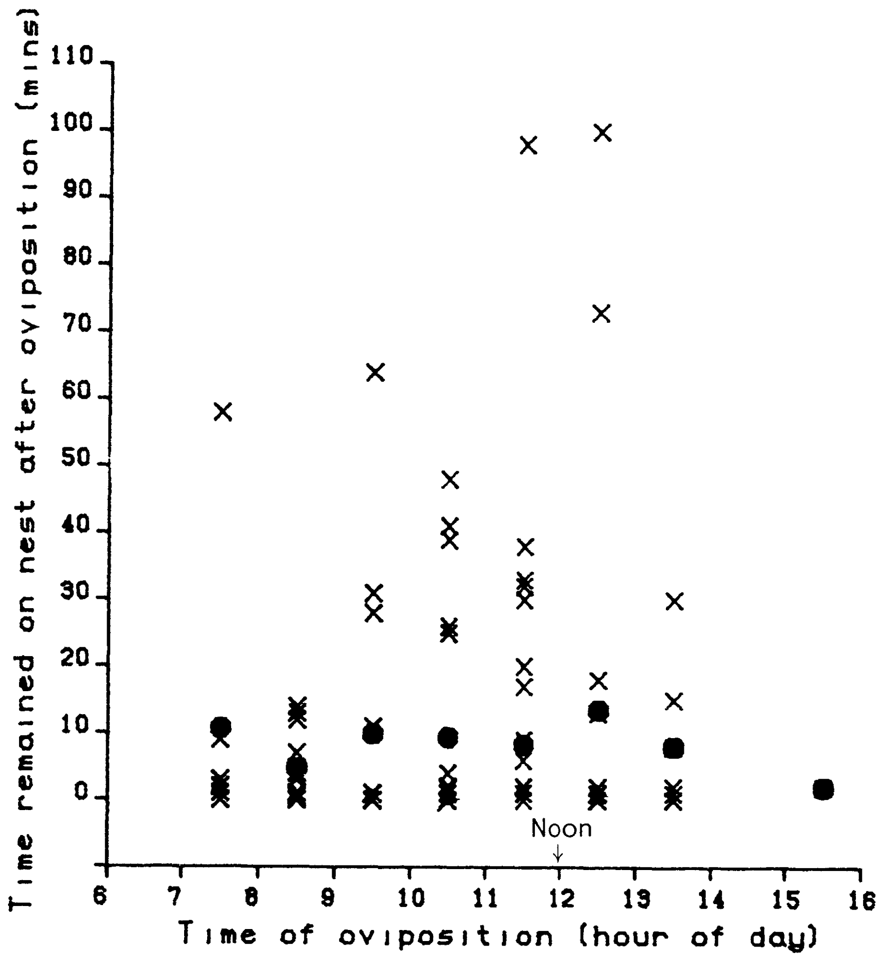


Figure 3.3.8 Time on the nest (floor sites) after oviposition for ovipositions occurring at different hours throughout the day (x-individual recording; ●= mean for that day)

Table 3.3.4 Paired comparisons made between all hens for times spent from first entry to oviposition, on the final nest before oviposition and on the nest after lay

Time of first nest entry:

231.0 ← Mean time (minutes) from entry to oviposition → 14.5

Hen B53 G40 Red B98 G38 Y92 W79 G35 Y90 G42 Y96 Y98 N.N B00 G43 G37 B97 Y91 W82 Y00 Y44 G34 W83 B99 Y95 G41 W80 B71 G39 Y99 B51 W84 W81 Y97

Time spent on final nest:

127.0 ← Mean time (minutes) from entry to oviposition → 5.7

Hen B53 G38 N.N Y92 G35 G42 B97 G37 Y94 B98 B00 Y96 W79 Y00 G34 G41 Y98 Y90 G43 Y95 W82 Y91 B71 W80 G40 Y99 G39 B99 B51 Red W81 Y97 W83 W84

Time on nest after lay:

125.2 ← Mean time (minutes) remained on nest after oviposition → 0.0

Hen G35 Y90 G34 G38 Y94 Y95 Y98 Y00 G42 B00 W79 Y96 Y91 B51 Y99 W81 B71 B98 B99 G43 W82 G37 N.N B53 Red W83 G39 W84 W80 Y93 G40

Hens for which times (based on harmonic means) were not significantly different are grouped by common underlining

Also, hens like, for example, B53 and B97, tended to be either high or low in the ranges of times of both first and final nest entries to oviposition. Others, such as Red, were found to enter the first nest comparatively early but enter the final nest comparatively late.

5. Position of the Hen During Post-Lay Cackling

The hens which performed post-lay cackles after laying in the provided nest-set are listed in Table 3.3.5, along with their position when the cackle began and when it ended. The majority of cackles (29 out of 32) began as the hen was sitting within the nest or as she left the nest and stood on the approach (perch) outside it. If a cackle was initiated in the nest, the hen usually got up and left the nest while still cackling and continued to cackle on the approach in front of it and even after alighting onto the floor. Many cackles were initiated after the hen had left the nest and was standing on the approach outside it (16 out of 32 cases of cackling).

Table 3.3.5 The number of post-lay cackles associated with elevated nestings by particular hens which were commenced/ended in either the nest, on the nest perch/approach or on the shed floor

	Number of Post-Lay Cackles Commenced:					
	In Nest			On Perch		On Floor
	Continued and Ended:					
Hen	In Nest	On Perch	On Floor	On Perch	On Floor	On Floor
G34		1		2		
G35		2	2	2	5	
Y94	1*					
B53		1	2			
Y90			1		7	2
Y91		1*	1			
Y98	1*					
Y00						1**
Total	2	5	6	4	12	3

* initiated by post-lay cackle of another bird
** initated after being evicted from the nest by another bird

The hen generally would continue cackling on the approach for a short time and then dismount, continuing to cackle for several minutes on the floor afterwards. Very few post-lay cackles (three out of 32) began after the hen had alighted to the floor. Very little notice was taken of the cackling hens by most of her flock-mates, regardless of her position when cackling. Cackling by one hen, however, would occasionally prompt another hen who had recently laid, but no others, to cackle also. After a bout of cackling had terminated, the hen would usually cease to perform any nest-related activities. A common occurrence was for a bout of cackling to terminate and within a minute or so, feeding or drinking to recommence.

6. Summary of the Nesting Sequence (refer to Figure 3.3.9)

To summarise the results, the observable nesting sequence would usually commence either with pacing and calling, or mounting of the nest approach by the now mature broiler hens. Obvious pacing was mostly performed before floor site nestings, and commenced, on average, 1 hour 55 minutes before the time of oviposition. The first obvious sign of a hen's intention to lay, in the case of nest layers, was usually the first approach to or mounting of the nest-set approach. On average, intending nest layers first mounted the nest-set approach about 1 hour 13 minutes before the resulting oviposition.

The first entry into a nest occurred, on average, 1 hour 6 minutes before oviposition, and entry into the final nest occurred about 38 minutes before laying took place. Several nests were usually entered before oviposition. There was a tendency for the times from when pre-lay activities were first observed to occur until oviposition, to increase the later in the day that the oviposition occurred. After laying, hens spent an average of 13 minutes on the rest.

3.3.4 Discussion

The results of these studies indicate that the time of day that oviposition occurs may influence the times at which various component activities of the pre-laying sequence commence, and therefore possibly the amount of time spent in such activities. Since pacing or mounting of the nest-set approach were usually the first activities of the nesting sequence to occur, it would seem reasonable to suggest that the later in the day that the oviposition occurs, the longer the period of time over which nesting behaviour will be exhibited.

Since consecutive eggs in a sequence tend to be laid later in the day (Heywang, 1938) it is possible that the observed tendencies in times that activities were first observed may have been a response to the stage reached in the egg laying sequence rather than a direct effect of time of day that oviposition occurred. The results produced by Wood-Gush (1963) indicate that a relationship exists between the 'lag' between consecutive eggs in a sequence and both the time taken over the examination of nests and the time spent in the nest until oviposition. This effect may be related to the responses detected in the present study, since eggs laid later in the day and therefore later in the sequence, tend to be associated with increasingly lengthened 'lags'. It is therefore possible that the Wood-Gush (1963) studies and these studies may have been measuring the same response in reality, and that this response may be

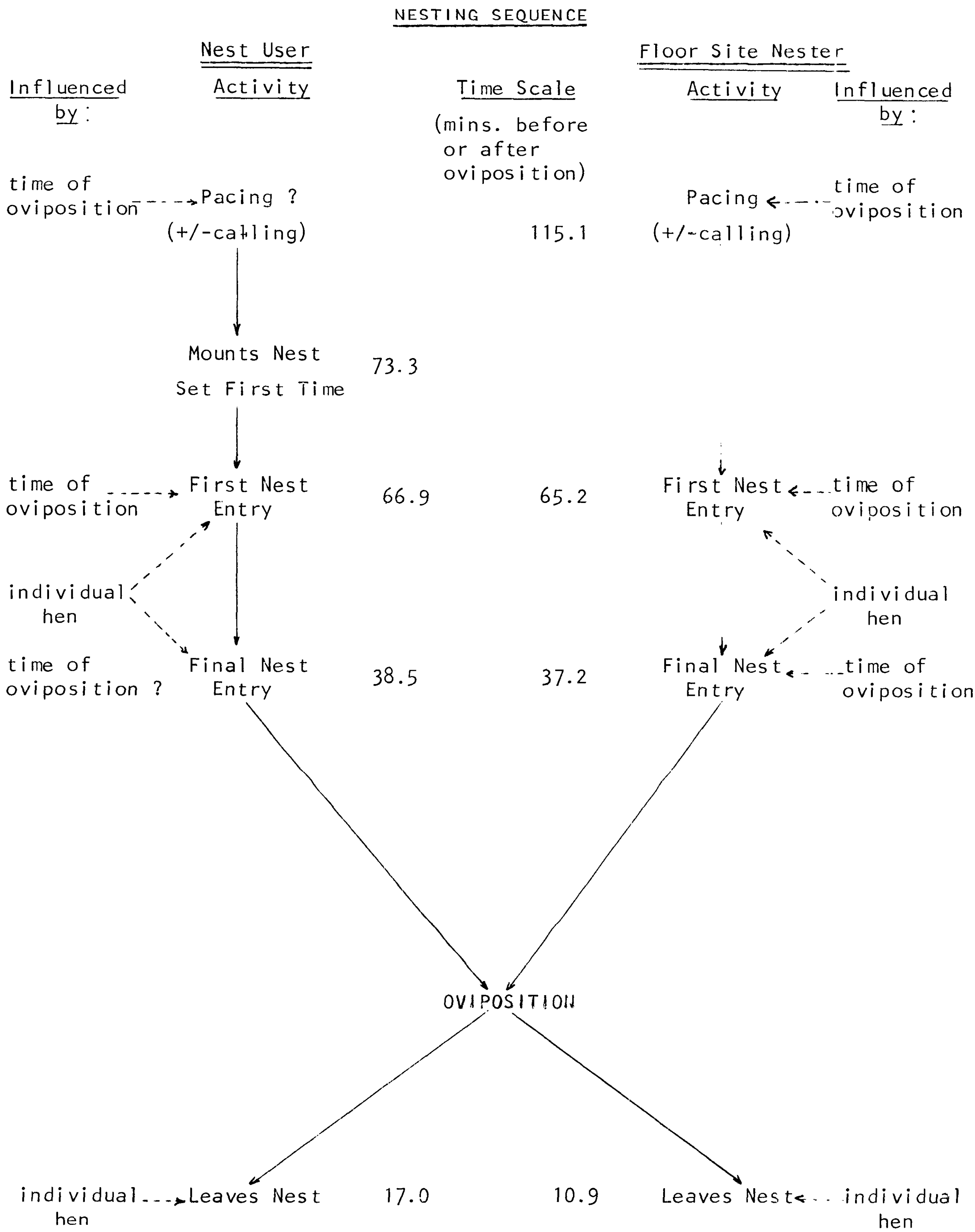


Figure 3.3.9 Summarised results of Study 3.3

to the stage in the sequence, or position in the clutch, to which the egg being laid is attributable. Wood-Gush (1963) does note a relationship between position of the egg in a clutch and times spent in examining nests or spent on the nest although he does not go into further detail.

Wild gallinaceous birds tend to spend successively more time on the nest as the number of eggs in the clutch increases. This has been reported by Kuck *et al.* (1970) for Ring-necked Pheasants, by Maxson (1977) for Ruffed Grouse and by Giesen and Braun (1979a) for White-tailed Ptarmigan. This is probably related to an increased attachment and attentiveness to the nest with the approach of incubation. The tendency for domestic hens to begin to nest earlier, to enter a nest earlier, and to settle in a particular nest earlier in relation to the time at which the oviposition occurs, as indicated by the results presented for this study, may be a vestige of the same behaviour. Although domestication and genetic selection may have suppressed the incubation tendency itself, the laying behaviour associated with the approach to incubation may still be operative.

The apparent trend exhibited during very early nestings (before 9.00 am or 10.00 am) in which hens tended to begin to pace or mount approaches slightly earlier in relation to eventual oviposition than they did at about 9.00 am is of interest. This may be related to an increase in nest-seeking activity associated with the first egg of a clutch or sequence. Certainly, feral fowl display a tendency to avoid previously used nest sites when establishing a new clutch (Duncan *et al.*, 1978) and this may be associated with an increase in nest-seeking activity, to which the pacing and early nest examination and entry observed in penned domestic hens might be a sequel. The significant quadratic trends found in the regression equations describing the change in times of initiation of pacing, mounting the approach and entering floor sites with time of oviposition were not found for the data related to time of final nest entry. This further indicates the possibility that an increase in nest-seeking activity but not necessarily of time spent sitting in the final nest selected, may be associated with the initial eggs laid in a sequence. It would be interesting to repeat these studies attributing times spent in particular activities to the stage in the sequence to which the egg laid belongs, rather than to time of day, to see if this is in fact the case.

Times spent on the nest after laying did not appear to be closely related to time of oviposition. Variation with respect to this parameter appeared, largely, to be a function of the individual hen. Why hens should vary in this respect, as in fact they did for times of initial nest entry and final nest entry, is unknown. However, it may relate to social factors and relative nest attachment by different hens which were found to influence nesting patterns, and which are described in Study 3.1.

The results of recordings of mountings of the approach and nest entry indicate that hens often mount the approach without entry, and that such instanc become less common later in the nesting sequence. It would seem, then, that mot vation to enter nests may build up as hens approach oviposition, more attention being paid to nests as it develops. This increase in motivation to nest has als been suggested by Wood-Gush (1954). Partial responsiveness to specific nest sit early in the nest-seeking phase of hens which have not previously established a particular nest preference may ensure that a number of nests will be examined, a so, possibly, more suitable nests eventually used.

Pacing usually preceded oviposition by considerably longer than did mounting of the nest approach. Since these two activities are primarily associated with nestings in floor sites and elevated nests respectively, it would therefore seem that initiation of nesting may occur earlier in the case of floor nesting individuals. This may relate to relative attachment to particular sites in the case of nest and floor-laying hens. Similarly, hen differences in numbers of nest entries made may also reflect individual differences in attachment to particular nest sites, or attention to them. It is worth noting, in this respect, that the hen observed to enter the most nests prior to oviposition, Red, had been found to be a persistent 'sociable' nester, and a very low ranking individual in the flock (see Study 3.1).

Hens, in the majority of cases, eventually laid in what was the first nest or nest site to be entered. Although some hens did examine and enter a number of nest sites before approaching the one finally selected, most made quite direct approaches to particular sites. As previously discussed (see Study 3.1) dalliance during the early nesting and examination phase would appear maladaptive in a natural habitat, particularly in the case of mature hens which have previously established a nest.

Mean times, from first nest entry to oviposition, on the final nest before oviposition, or after oviposition, were unaffected by where the nesting took place. Unlike those of Perry *et al.* (1971) the results did not indicate that hens spent any more or less time in the nest site depending on whether it was a provided nest-box or some floor site. Perry *et al.* (1971) found that the latency of laying, that being the time from final sitting to laying, was 43.5 minutes and 94 minutes for floor and nest-tube layers respectively ($P < .001$). In the present study, hens averaged 37.2 and 38.5 minutes in the final nest befor laying for nest and floor-layers respectively. However, hens nesting in the provided nests in this study were fairly exposed, since the nests were quite low to the ground, rather open and apparently not particularly attractive to the hens, as indicated by the relatively poor acceptance of them, despite the fact that they were quite accessible. Mounting of the nest-set and nest entry were commonly observed without resulting in sitting in the nest and it is suggested that disturbance of hens in the nest may have been a factor contributing to a rather low mean time spent in the nest.

Results pertaining to the orientation of hens during oviposition suggest that hens may attempt to avoid visual contact with the flock area during oviposition.

Orientations of other ground nesting species during the nesting phase indicat that both social (Burger, 1974) and environmental (Gochfield, 1978) parameters ma be operative. However, environmental conditions were similar throughout the sheltered pen in the present studies, and aversion of the head rather than the whole body, in many cases, seems to indicate a visual cue. It also seems unlikely that hens were actively avoiding contact with other nesting hens, since results of Study 3.1 indicated that many hens were tolerant of other birds in the same nest, and others even actively sought proximity to other nesting hens during the nesting phase. Results of studies reported later (see Studies 4.4.7 and 4.5.2) also indicate that hens nesting in a rather barren environment do not necessarily avoid visual contact with other nesting or non-nesting hens. Another study (see Studies 4.4.5 and 4.5.5) suggests that this orientational response may result fro a certain lack of confinement from the general flock area provided by the nesting facilities.

The results obtained for post-lay cackling shed further light on the purpose of this vocalisation. It was suggested in Study 3.1 that cackling could be either adaptive or maladaptive to a bird nesting in a natural habitat. The hens observed to cackle in the present investigation usually commenced to cackle from within the nest or on the perch outside the nest on most occasions, and generally terminated the cackle after reaching the floor. Cackling would therefore seem to occur mostly in situations in which the hen is moving away from the nest, although this is not always the case. While it is possible that this strategy could be employed to draw attention away from the nest, the general attitude of the hen while cackling, in which the hen walks slowly, even casually away from the site, seems to refute such a suggestion. It seems more likely that hens in a highly motivated state may perform this vocalisation out of context in the rather limited, provided environment. The cackle could possibly be a response to some internal change associated with the desire to leave the nest, or loss of attentiveness to the nest.

Study 3.4

Nesting Behaviour of Different Breeds in the Floor Pen Environment

3.4.1 Introduction

While something is known of the nesting response of different strains of laying hens in cages (Wood-Gush, 1969; Wood-Gush and Gilbert, 1969a; Wood-Gush, 1972) and in floor pens (Turpin, 1918), a great deal still remains to be recorded and understood about the way in which different strains and breeds go about the selection of a nest site. In order to investigate such effects, it was decided to study the nesting behaviour of three very different breeds of hen under similar housing conditions. Ideally, these studies would have been conducted under a range of environment types, in order that the full spectrum of behaviours appropriate to nesting in the case of each breed could be expressed. However, it was decided that possible breed differences would be investigated in the environment provided by deep litter floor pens, since this environment permits expression of many behaviours which could not be executed in the very confined and limited conditions of a laying cage, yet permits closer and more detailed observation than would be possible in a free range situation.

3.4.2 Materials and Methods

(a) *Birds and Their Housing*

The three breeds of hen used in this study were broilers, of a commercial strain, White Leghorns and wheaten Old English Game bantams. These breeds were selected for the following reasons. The White Leghorn has been subject to a high degree of selective breeding for high egg production over many decades. It is generally thought to be a 'non-broody' strain. In contrast, the broiler bird is also a product of many years of selective breeding but for traits associated with its ability to gain weight quickly. The game bantam has essentially been bred for its morphological characteristics, with less emphasis being placed on its productive potential. It is therefore likely that its behaviours related to nesting may be more like those displayed by the wild ancestors of domestic fowl. Certainly, the game bantam is well known for its highly developed maternal instincts, a trait which has tended to be reduced in strains intensively selected for their productivity in terms of egg production. The game bantam should therefore provide a useful comparison to the other breeds whose behaviours, in relation to the selection of nest sites, may have been affected to a greater extent by genetic selection for factors directly related to the process of egg laying, or through selection for other factors which may indirectly influence its expression.

The broiler hens were those used in the previous studies and described in Study 3.1. The White Leghorns had been reared in deep litter floor pens on another University farm and had commenced production at the same time as the broiler hens. They were moved into a deep litter floor pen in the isolation shed, in which the broilers were housed, between three or four weeks after they had commenced to lay. The floor pen into which they were moved was identical to that they had been reared in and had laid their first few weeks' eggs in, except for the presence of the flock of broilers in the adjacent pen. The nest-set provided in the pen was also the same as that to which they had previously had access. Twenty five of these White Leghorns were released into the new pen and were initially accompanied by three cockerels of the same breed.

Several weeks after the introduction of the White Leghorn flock into the shed, the flock of 18 Old English Game bantam hens plus three roosters was moved into the third pen in the same isolation shed. These birds were supplied by a local breeder and had been reared on deep litter. When initially moved to the shed these hens had not reached sexual maturity, but the first eggs were laid within a week or two of introduction. During the first week or two these hens did not have access to the nest-set provided in the pen, since the nest perch had been swung up, occluding the entrance to the nests. For each hen's first few nestings eggs were therefore laid on sites on the shed floor. When allowed access to the provided elevated nests later, however, most hens immediately began to lay in nests rather than in such sites.

All hens of all three breeds had been laying for approximately five months before the observations commenced. The hens were approximately 47 weeks of age at this stage.

Each hen of the broiler and bantam flocks was identified by means of coloured and numbered leg bands. Leghorn hens were recognised and identified by individual morphological characteristics, such as the form of the comb and the side to which it fell. Where these features did not sufficiently distinguish individuals, hens were marked with coloured felt pens on areas of the back, tail and wings.

The pens in which the flocks were housed were identical in most respects, being basically the same as the broiler pen described in Study 3.1. The elevated nests provided in each of these pens are as described for that study also. However, in the broiler pen, these nests were closed off and the set of nests which had been provided for the last observation period of Study 3.2 and available throughout Study 3.3 was used for nesting in this pen only. This nest-set was not as high off the floor as the original elevated nest-set provided in each pen and was known to be more readily used by the broilers.

Acceptance of the original nest-set by both bantams and Leghorns was very good and so no other nest-set was provided. For the duration of this study all flocks were supplied with a commercial layer ration *ad libitum* and were maintained on a constant 16 hour light:8 hour dark lighting regime.

(b) *Behavioural Observations*

From the time of initial introduction into the pens, both Leghorns and bantams were frequently exposed to the presence of the observer who spent considerable time in their pens observing and tending to the birds. As in the case of the broiler hens who had been exposed to the observer for some time during earlier studies, both groups of birds became quite accustomed to the presence of the observer in their pen or elsewhere in the shed, and appeared undisturbed by her presence. By the time that observations commenced, it was the observer's opinion that all the hens had settled into the pen and were quite familiar with her presence during the nesting phase.

The observer recorded, in detail,theseactivities of individual hens which were apparently associated with nesting, on several occasions. All observations were taken from within the pen of each flock under study from a position along the pen wall opposite, and furthest away from, the pen wall on which the nest-set hung. From this position the observer could see most of the act'vities which were carried on inside the nests, but could also be seen by the hens using the nests.

Initially the broiler flock was observed. At this point these hens had been laying for approximately 21 weeks. The flock was kept under observation for one week. The White Leghorn hens were observed during the following week, at which stage they had been laying for approximately the same length of time as the broilers. The bantam hens, having commenced laying some time later than the other two groups of hens, were observed for ten days, five weeks after the White Leghorn observations were taken. Thus, all hens were approximately the same age and had been in lay for approximately the same length of time when the recordings were taken.

Preliminary observations had been made on both the White Leghorn and bantam flocks to establish whether the presence of cockerels was influencing the way that these hens were going about the selection of a nest site. Three hens of both these two breeds were observed during the nesting phase on three occasions in which the cockerels were present in the pen. One hen of each of these two groups was a known floor-layer, while the other two were nest layers. Detailed records of initial nest related behaviours, times of nest entry, the number of nest entries made, the time spent on the nest before lay, the occurrence of nest building behaviours and the time spent on the nest after laying were taken for each nesting. Cockerels were then removed from the pen and the same birds observed during nesting on three occasions a week later. Although these preliminary studies indicated that the presence of the cockerels had no effect on the form of the nesting behaviour pattern performed, the cockerels were removed from the pens for a week preceding and during the period over which the observations on either the White Leghorn or bantam flocks took place. The cockerels were placed in wire crates or in individual cages in the shed out of sight of the hens in the pens when they were removed.

Parameters observed and recorded during this study included instances of pacing, nest calling, material gathering and nest building activities, times at which nesting behaviours commenced, times of first and final nest entries, number of nest entries and times spent on the nest after laying. Pacing intensity was also scored according to the criteria described in Section 1 of this Chapter. However, since pacing of the highest intensity (****) was rarely seen, instances of such pacing were classified with intensity *** recordings. Nestings which were followed by post-lay cackles were also noted.

Three nestings were observed and recorded for each hen. Data recorded for hens which were not observed for three nestings during the observation period were discarded.

Only 32 broiler hens, 24 White Leghorn hens and 16 bantam hens contributed data to the breed comparison results. Several hens in each flock were laying too poorly for three nestings to be recorded during the observation periods allotted to each flock. As a result, the total numbers of nestings observed were 96, 72 and 48 for broiler, Leghorn and bantam flocks respectively.

(c) *Analysis of the Data*

For each flock, the number of nestings which were accompanied by pacing, nest calling, rotations, litter raking, material gathering activities either to the chest, to the back while on the nest, in the shed (off the nest), or after lay (off the nest) and post-lay cackles were tabulated. The number of hens which typically performed each of these activities (performed the activity on at least two of the three occasions recorded) were determined and the breeds compared by Chi-square analysis of these data.

The times, in relation to the time of oviposition, at which nesting behaviour first was noticed, at which first and final nest entry occurred and at which the hen left the nest after laying, as well as the number of nest entries, for each of three occasions on which each hen was observed to nest and lay, were also determined. These data were then analysed using analysis of variance to test for any differences attributable to breed or individual hen effects.

3.4.3 Results

Data related to nesting for three hens of either White Leghorn or bantam breed on the three occasions before and three occasions after removal of cockerels from their respective flocks are given in Appendix 3.4. The nesting behaviour displayed by these hens was apparently much the same after as it had been before removal of the cockerels. This supported the general observation that nesting behaviours of the two flocks seemed little affected by the presence or absence of the cockerels.

During the initial settling in period, the observer had spent considerable time observing and noting down the activities of the bantam cockerels, particularly around the time that hens in the flock were nesting. Cockerels did not appear to be attracted, or in any way affected by the calling of hens approaching lay. Hens called and went about the pen or nest-set 'examining' walls, corners and nest-boxes alone. They were never seen to do this in the company of a cockerel. Several instances were, however, recorded in which a hen, having thoroughly examined a particular site for some time, would be joined by a cockerel who would stand near her and sometimes scratch about next to the site. Occasionally, a cockerel appeared to stand near the site as the hen sat within it, for quite extended periods of time, but it was not clear whether the cockerel in such instances was actually 'guarding' over the nest, or whether his presence there was merely coincidental. Only two of the cockerels were ever observed to approach the nesting hen in this manner and the cockerel second most dominant was more frequently observed in these situations than the dominant cockerel. These activities were recorded during the period of time that the bantam hens only had access to floor sites for nesting in and only about six out of 32 nestings were observed to occur with a cockerel in the immediate vicinity. In those cases in which a hen nested without a cockerel nearby, the nesting took its usual course for that particular hen, the same sites being examined and the same nest selected for the eventual oviposition as were typical of that hen.

After the hens began to nest in the provided elevated nests, the 'participation' of the cockerels, or at least their proximity to nesting hens, was no longer observed. Cockerels rarely went near the nests and were only ever observed to mount the nest-set perch in a roosting context. One White Leghorn cockerel was, however, occasionally seen in a nest-box in which he performed an interesting routine. This involved sessions of quite vigorous scratching about in the nest while in a squatting position, accompanied by a repeated 'clucking' call, very like a food call. Although it was difficult to actually see what the cockerel was doing with his feet because the activity was in the confines of the nest which he fully occupied, he must have been performing quite active scratching or pounding movements, because the level of noise that was generated by these activities was considerable. Hens from other nests in the set and even hens from the main body of the flock on the floor, would move out or up to the perch immediately outside the nest in which the performance was being conducted and peer into the nest. Usually they would return to their previous nest or to the floor soon after.

Total numbers of hens typically performing nest calling, pacing of differing intensities, rotations on the nest, litter raking, material gathering activities and post-lay cackles for each flock are given in Table 3.4.1. The Chi-square values calculated for each of these activities are also given in this Table, as ar the numbers of nestings accompanied by each activity (percentage of all nestings)

Table 3.4.1 The numbers of hens typically performing nest calling, pacing, pacing at four intensity levels, rotations on the nest, litter raking on the nest, post-lay cackles and material gathering to the chest, to the back on the nest, in the shed before lay and after lay, or to the back in any situation for flocks of broilers, White Leghorns and game bantams ;total numbers of nestings accompanied by each activity as % of all nestings given in italics

Activity	Numbers of Hens Typically Performing Activity/*% Total Nestings* Broilers (32 Hens)		White Leghorns (24 Hens)		Bantams (16 Hens)		χ^2 value	Significance
Nest Calling	20	*59.4%*	19	*72.2%*	9	*56.3%*	2.72	N.S.
Pacing	25	*71.8%*	18	*75.0%*	10	*66.7%*	1.29	N.S.
Pacing Intensity								
*	20	*55.2%*	7	*37.5%*	6	*37.5%*		
**	5	*14.6%*	8	*27.8%*	3	*22.9%*	8.37	-
***	0	*2.1%*	3	*9.7%*	1	*6.3%*		
Rotations	30	*89.3%*	23	*91.7%*	15	*9.2%*	0.12	N.S.
Litter Raking	30	*81.3%*	18	*66.7%*	15	*87.5%*	9.04	*
M.G. to Chest	21	*68.8%*	13	*45.8%*	15	*81.3%*	6.90	*
M.G. to Back								
on Nest	8	*27.1%*	4	*20.8%*	4	*33.3%*	0.63	N.S.
in Shed	0	*12.5%*	0	*5.6%*	2	*14.6%*	7.30	**
After Lay	2	*14.6%*	2	*8.3%*	2	*16.7%*	0.56	N.S.
Any Situation	10	*36.5%*	5	*23.6%*	6	*39.6%*	1.52	N.S.
Post-Lay Cackle	4	*17.7%*	2	*12.5%*	1	*10.4%*	0.56	N.S.

N.S. = not significant; - = $.05 < P < .10$; * = $.01 < P < .05$; ** = $.001 < P < .01$

Although it had appeared to the observer that the White Leghorn hens called more than did either of the other two breeds, analysis failed to reveal any significant differences between the breeds, at least in respect to the numbers of hens which typically called, regardless of intensity or extent, was recorded. Similarly, pacing was typically performrd by approximately the same proportion of the hens in each of the three flocks.

There was a trend ($.05<P<.10$) in the data relevant to differing pacing intensities. Leghorn hens tended to pace more vigorously than either of the bantam or broiler strains. It was also noted that pacing seemed to be associated with short duration of pacing and this was particularly obvious in the case of these bantam hens. These birds usually paced minimally before moving towards the nest-set and into the nest examiration and nest entry phase. Pacing in the case of the broiler hens tended to be concentrated along the pen wall which was shared with the Leghorn flock and through which they could see the hens in the adjacent pen. Prior to the introduction of the Leghorns into that pen, pacing had been concentrated along the wall opposite the shed aisle. The Leghorns, also, tended to pace most along the wall dividing them from the broilers.

No significant differences were found between the breeds in the number of nestings which were accompanied by rotations in the nest and foot scraping. This was not surprising since almost all nestings were accompanied by this activity regardless of where they took place, or what birds performed them. Significant trends were, however, found in the occurrence of litter raking activities on the nest. On partitioning the data, the numbers of hens which typically performed litter raking in the broiler and bantam flocks were not significantly different but litter raking was performed by more hens in both these twp flocks than it was in the Leghorn flock (χ^2_{1df} = 9.04**). The activity 'material gathering to the chest' followed a similar pattern. However, these material gathering movements were less often seen in nestings performed by broilers or Leghorns than by bantams (χ^2_{1df} = 6.28*). Although the observer had felt that broilers more consistently performed this activity than did the Leghorns, no statistically significant difference was detected.

Records of material gathering activities to the back while the hen was on the nest, after lay or in any situation, failed to indicate differences between the breeds with respect to tendencies to perform these activities in the nesting sequence. When the number of hens typically performing material gathering to the back in the shed were compared, a significant tendency emerged, bantams more frequently performing the activity than either broilers or Leghorns ($.001<P<.01$).

the observer's opinion that, whilst records of the numbers of hens typically performing these nest-related activities occurred revealed some differences between the three breeds, far more dramatic differences would have been indicated had some attempt been made to record the number of instances of these activities which occurred during each nesting, or the length of time hens were engaged in such activities during the nesting. It appeared that the bantams in particular, but the broilers also, spent more of their time on the nest engaged in nest building and material gathering activities and pursued these activities more vigorously than did the White Leghorns.

The numbers of hens which typically cackled after laying were not significantly different for the three breeds. However, post-lay cackles were only infrequently observed and more meaningful results may have been obtained had the flocks been studied over a longer period. Other hens were completely unaffected and undisturbed by the call, except in several cases in which another hen was very near to oviposition or had just laid and was ready to leave the nest. The effect of post-lay cackles on the cockerels was even less clear. Occasionally, a cockerel appeared to stand alert and attentive during the cackle. In some cases in which the cackle was particularly raucous and was continued as the hen left the nest and jumped to the floor, a cockerel might run to the hen and attempt to mate with her. Usually, however, the cockerels did not appear to be attracted by the cackle and at any rate, cackling hens usually rejoined the main body of the flock shortly after the cackle commenced which limited the opportunities for cockerels to demonstrate any response or attraction to the cackling hen.

Mean values for timed data and numbers of nest entries for each flock are given in Table 3.4.2.

Results of the analyses of variance performed on timed data and numbers of nest entries are given in Table 3.4.3. It is apparent from the highly significant hen within breed component of the variance of each parameter that the time at which an activity was commenced or the amount of time that a hen would spend engaged in an activity was very much an individual characteristic. Despite this considerable hen effect, significant differences were found between the three breeds in the time that hens would remain on the final nest before laying (time from final nest entry to oviposition) and the time that they would remain on the nest after they had laid. For both these parameters the trend was for bantams to spend most, and Leghorns least time sitting on the nest. The times at which hens were observed to begin to nest, regardless of the form that the initial behaviour took, and the time at which a nest would first be entered, were found to be unaffected by breed despite the fact that the broilers had access to slightly different, less elevated nests. However, since these hens tended to be less agile than their lighter counterparts, their nesting behaviour would probably have been more influenced (as compared with that of the other breeds) had they been provided an identical nest-set which was quite inaccessible to them, than it was with the lower, larger nest-set which was provided for their use only.

Table 3.4.2 Mean flock times from onset of nesting to oviposition, times from first and final nest entries to oviposition, times remained on the nest after oviposition and numbers of nest entries per oviposition for broiler, White Leghorn and bantam flocks

Activity Recorded	Flock Broiler	White Leghorn	Bantam
Mean Time (minutes) from Onset of Nesting to Oviposition	93.3	98.2	90.6
Mean Time (minutes) from First Nest Entry to Oviposition	68.5	71.2	70.6
Mean Time (minutes) from Final Nest Entry to Oviposition	39.6	32.9	43.8
Mean Time (minutes) Remained on Nest After Oviposition	15.1	10.5	18.8
Mean Number of Nest Entries per Oviposition	3.4	4.8	4.5

The number of nest entries which would be made for each oviposition was foun to be affected by breed. Broiler hens generally made fewer visits to the nests than did either the Leghorns or bantams. The Leghorns and bantams seemed to move about the nest-set with more ease and much more quickly than the broilers. The Leghorns not only entered more nests during the pre-laying phase but also appeared to spend more time involved in nest examination and nest entry than did the other two breeds. They tended to settle less readily and this is reflected in the recorded times spent sitting on the final nest (time from final nest entr to oviposition).

3.4.4 Discussion

The presence of cockerels in either bantam or Leghorn flocks appeared to affect the nesting behaviour of hens very little. Amongst the Phasianidae, the male is believed to take part to differing extents in nest building (Kendeigh, 1952). Beebe (1936), reported that male pheasants do not share in nesting duties in the wild, except to stand guard over the female and young. However, Kruijt (1964), reported the apparent participation of Red Junglefowl cocks in the nesting sequence under captivity, and McBride *et al.* (1969) also indicated an apparently important involvement of the cock in escorting the nest-seeking fe hen in her search for a nest and back to the flock after laying. The presence of only vestigial aspects of such behaviour patterns in the flocks studied in the present research may indicate that the behaviour patterns, or the birds responsiveness to appropriate stimuli, have been altered in the domestication of the breeds studied and/or that the envronment or conditions provided in these studies do not provide the stimuli necessary to release such behaviours. As has been noted previously (see Chapter 2, Section 2.1.1.iv), the participation of the cockerel, even in feral birds, is not likely to be critical tc the entire nest selection process. In the conditions provided in this study, participation of the cockerel would seem to be even less functional, as nest sites are available and relatively accessible and the threat of predation on the nest unlikely.

The calling and foot stamping or scratching activity in nests recorded for one White Leghorn cockerel may be equated with cornering as described by Kruijt (1964) for Red Junglefowl cocks. This cornering behaviour was believed by Kruijt to function in the selection of a nest site by hens who were attracted to the site in which cornering took place and it was suggested to have a further role in the formation of a nest-scrape. The purpose of the activity in the present study was unclear, for although it attracted hens to the nest in which it was performed, they never attempted to enter the nest and usually left shortly after having investigated its source. The results of this study fail to clarify the position as to the possibility and function of cockerel participation in the nesting sequence, except, perhaps, to suggest that any cockerel participation is negligable or vestigial in the environment provided by a deep litter floor pen, and if existant, is apparently functionless in that environment. However, further, more detailed studies on this problem, specifically detailing the cockerel/hen interaction at nesting, would be necessary to confirm or refute such suggestions.

Under the conditions provided in this study, the behaviour of hens of broiler, White Leghorn and bantam breeds when approaching oviposition was essentially very similar. Hens tended to perform basically the same sequence of behaviours appropriate to nesting. In fact, greater variability tended to be evident between individual hens within the same breed than between breeds. However, where significant breed differences were found, they tended to indicate a greater 'appetitive' component in the behaviour of the Leghorn hens when approaching lay than was evident in the case of hens of broiler and particularly bantam breeds. The Leghorn hens seemed to pace and examine nests more than hens of the other breeds. The bantam hens, and to a lesser extent the broilers, tended to attend to the nest more than did the Leghorns; they performed pre-lay pacing activities less vigorously and spent more time on the nest settling in, both before and after laying, than did the Leghorn hens. Several nest building activities were also found to occur more regularly in the nesting sequences of these birds.

As indicated in the earlier studies (Studies 3.1, 3.2 and 3.3) activities associated with the nest attention phase tend to occur at a higher intensity or to a greater extent in hens which have developed some attachment to a particular nest site. The reverse tends to be true of activities related to the nest-seeking phase. Failure to respond to stimuli from the nest, at least in initial stages of the nesting phase, may have resulted in the Leghorns spending less time in nest attentive behaviours such as litter raking and material gathering to the chest and more time in searching for appropriate stimuli. If this is the case, bantams could be considered the most responsive to stimuli from the nest of the three breeds. They spent more time on the nest both before and after laying than did the other two breeds, despite the fact that they did not enter the nesting phase any earlier and they performed litter raking and material gathering to the chest more often and paced less intensely than did the Leghorns. However, it should be noted that the reduced time spent on the nest before laying by Leghorn hens may simply be explained by the fact that such birds spend more time deliberating over the selection of a suitable site, so allowing less time to be spent on the nest once selected, rather than being less 'nest attentive'. However, this would not account for the fact that the same hens spend less time on the nest after laying. This fact does support the suggestion of reduced nest attentiveness and responsiveness to stimuli from the nest.

Differences in apparent nest attentiveness of the three breeds may have resulted, even if indirectly, from genetic selection of the breeds for different purposes. Nest attentiveness is associated with the incubation phase in fowl and it is not surprising that White Leghorns, effectively 'non-broody' in nature, spent less time in such behaviours than the bantam hens, well known for their highly developed maternal instincts. The broiler hens tended to be intermediate in most respects.

Differences were noted with respect to numbers of entries made into nests. This was possibly a reflection of the relative agility of the birds in part, as the larger broiler hens tended to be more 'clumsy' in their attempts to move from nest to nest and may have recorded less entries as a result of this.

The tendency for broiler and Leghorn hens to pace along the wall separating them from the adjacent flock of birds was interesting. It has previously been noted that individual broiler hens tended, in some cases, to prefer to nest with other hens or to be tolerant of other nesting hens in the same site (see Study 3.1). The present observations seem to reaffirm an attraction towards other hens in nesting, at least in conditions of restricted space when hens are not able to get away from the flock area, or in which nesting sites lack a certain degree of confinement.

It is not known to what extent the differing bird densities in each flock may have been affecting the behaviours displayed. In particular, pressure on the available nests may have been considerably less in the case of the bantam flock which produced about eight to ten eggs a day as compared to about 18 to 20 eggs a day for the broiler and Leghorn flocks. However, in no case in any of the pens were all the nests occupied at the one time, suggesting that nest availability played little part in the behaviours displayed by hens in the different flocks. It is also conceivable, though unlikely, that the presence of the observer in the pen, facing the nesting hens, may have disturbed and perhaps altered the nesting behaviours of the three flocks to a different extent, despite the precautions taken to familiarise the nesting birds with her presence.

It was unfortunate that limited availability of birds and facilities resulted in the introduction of so many confounding variables into this study. However, when considering breed differences, particularly in the behaviour field, such problems are inevitable, even given unlimited access to stock and facilities. For example, the size and agility of the broilers used in this study necessitated the use of larger, lower nests than was provided for the other hens, which possibly would have rejected similar nests on the basis of them being overly 'spacious'. However, these problems should be recognised as possible influences on the results, which should therefore be regarded as trends only.

Table 3.4.3 Analyses of variance for times from onset of nesting behaviour to oviposition, times from first and final nest entries to oviposition, times remained on the nest after oviposition and numbers of nest entries per nesting for broiler, Leghorn and bantam hens

Time from onset of nesting to oviposition

Source	D.F.	S.S.	M.S.	F	Significance
Between Breeds	2	1850.73	925.37	0.67	N.S.
Between Hens Within Breeds	69	196394.30	2846.29	2.05	***
Between Reps w Hens w Breeds	144	200298.00	1390.96		
Total	215	398543.03			

Time from first nest entry to oviposition

Source	D.F.	S.S.	M.S.	F	Significance
Between Breeds	2	337.70	168.86	0.22	N.S.
Between Hens Within Breeds	69	131025.30	1898.92	2.52	***
Between Reps w Hens w Breeds	144	108503.33	753.50		
Total	215	239866.00			

Time from final nest entry to oviposition

Source	D.F.	S.S.	M.S.	F	Significance
Between Breeds	2	4089.67	2044.84	10.54	**
Between Hens Within Breeds	69	64997.81	942.00	4.86	***
Between Reps w Hens w Breeds	144	27926.67	193.94		
Total	215	97014.15			

Time remained on nest after oviposition

Source	D.F.	S.S.	M.S.	F	Significance
Between Breeds	2	2050.87	1025.43	7.00	**
Between Hens Within Breeds	69	66025.63	956.89	6.53	***
Between Reps w Hens w Breeds	144	21092.00	146.47		
Total	215	89168.50			

Number of nest entries

Source	D.F.	S.S.	M.S.	F	Significance
Between Breeds	2	124.72	62.36	9.75	**
Between Hens Within Breeds	69	1032.61	14.97	2.34	***
Between Reps w Hens w Breeds	144	920.67	6.39		
Total	215	2078.00			

N.S. = not significant; ** = .001 < P < .01; *** = P < .001

The extent to which the particular environment in which the studies were conducted influenced the differences in behaviour noted could only be indicated by studies in alternative environments, such as those provided in laying cages or at free range.

Study 3.5
Nesting Behaviour of Hens in Different Environments

3.5.1 Introduction

It is often suggested (e.g. Gilbert and Wood-Gush, 1963; Wood-Gush and Gilbert, 1970) that the nesting behaviour which will be displayed by a hen will be dependent upon the environment in which the bird lives, but that the behaviour pattern will be stable within any one environment. In the early behavioural studies conducted by this author, it had become obvious that in a stable environment the nesting behavioural sequence which is exhibited by a mature hen is fairly constant over successive ovipositions. Individual hen differences are apparent and breed would also appear to have some influence on the form of the behavioural pattern which is expressed. Also of interest, therefore, was the extent to which environment could modify the form of this behaviour pattern. Few attempts have been made in the past to compare the behaviour of the same hens in very dissimilar housing conditions directly. This is understandable considering the design and interpretation difficulties inherent in any such comparison. For instance, some activities which occur in one environment may simply not be physically possible in another or may be expressed in a slightly different way because of limitations of space or appropriate stimuli. In spite of these sorts of problems, a study of the ways in which the nesting environment might influence the form of nesting behaviour displayed by individual hens or the way in which different strains of hen react in a nesting context, was considered worthwhile.

The aim was to record the behavioural patterns associated with the laying of individual hens on a number of occasions in the environment provided by a laying cage and to compare these with the equivalent behaviours displayed when the same birds were established in the floor pen environment later. Similar observations were to be made on another group of hens, except that they would first be studied in the floor pen environment in which their nesting tendencies had developed, and they would then be studied under the laying cage conditions to which they would later be transferred. In this way, not only could the individual hen's response to the nesting environment be observed, but some indication of the influence of the hen's previous nesting experience on this could also be obtained.

3.5.2 Materials and Methods

(a) *Birds and Their Housing*

Hens of the three cross-bred strains were used in this study. These were commercial, hybrid layer strain hens of White Leghorn x Black Australorp, White Leghorn x New Hampshire, and Black Australorp x New Hampshire breeding. Henceforth, these strains will be referred to as black/white (B x W), red/white (R x W), and black/red (B x R) crosses respectively. B x R birds were black feathered and weighed 2.35 kg on average, while both the B x W and B x R birds were white feathered and averaged 2.10 kg and 2.00 kg in weight respectively.

All hens had been reared on feed restriction in deep litter floor pens at the UNE poultry unit, 'Laureldale', to point of lay, which was approximately 24 weeks of age. At this point they were transferred to an isolation shed on the UNE campus.

Thirty six hens, 12 of each strain, were used in this study. Half of the hens (six of each strain) were placed in 21 cm x 43 cm x 46 cm individual laying cages. Two sets of nine cages were used to house these birds. Food and water were supplied to the birds by means of continuous troughs running the length of the cage-sets at the front and back of the sets respectively. Three hens of each strain were placed in adjacent cages in each of the two cage-sets. These hens initially housed in individual cages will henceforth be referred to as Group A hens.

The remaining 18 hens, henceforth called Group B hens, were placed in small 1.75 m x 1.75 m deep litter floor pens. The arrangement of these pens is illustrated in Figure 3.5.1. The nests provided in these pens were constructed of sheet metal, were elevated 32 cm above the pen floor and were accessible via a nest perch (approach) consisting of two wooden rungs. Throughout the study, all nests were lined with wood shavings to a depth of 5 cm which were topped up regularly. Two such pens were used to house the hens. Half the hens, three of each strain, were placed in each of the pens which were positioned next to each other in the shed with just a one metre aisle between them. Food (a commercial pelletted layer ration) and water were supplied to all hens *ad libitum*.

All hens were individually identified by means of numbered, coloured leg bands.

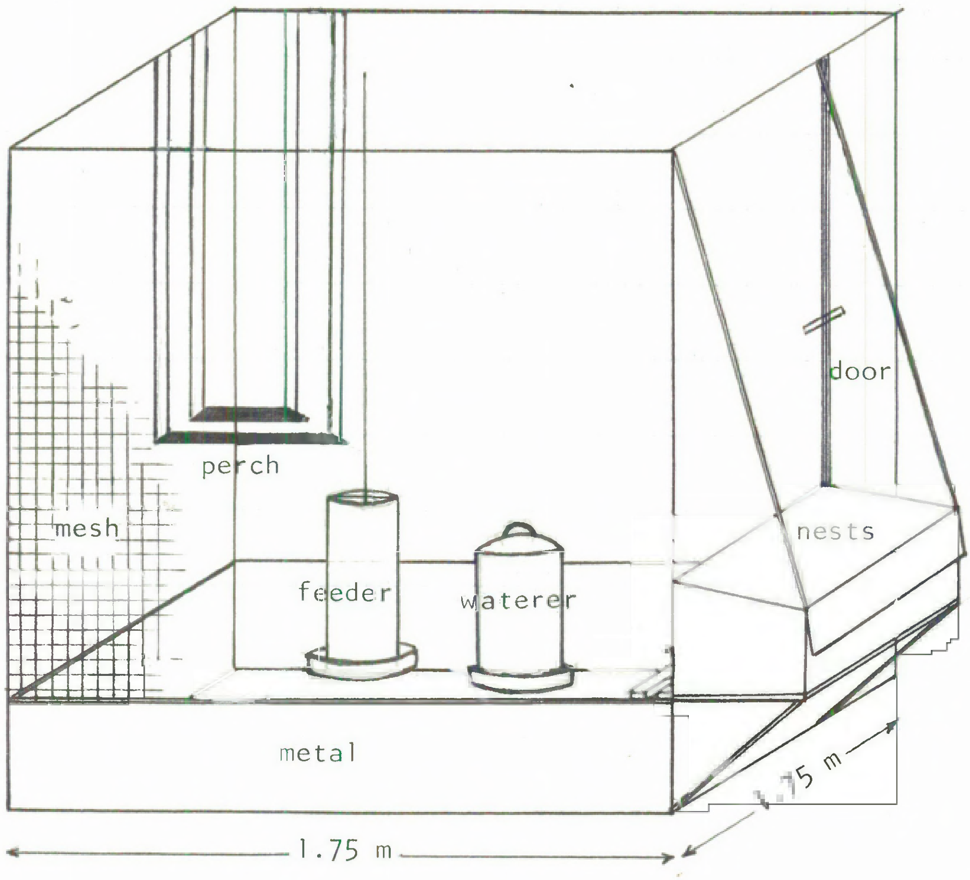


Figure 3.5.1 Dimensions and arrangement of floor pens used to hold hens in 'pen' environment

The hens were introduced into the isolation shed in July, 1980, and were housed in the described conditions until these detailed studies were commenced on 11th September, 1980. Throughout this period of time the hens had been laying in their home cage or pen environment on all but a few occasions. These involved five days on which half of the Group A and half of the Group B hens had been placed in a test-pen environment, described in Study 4.4.1, in order to express nesting preferences for light or dark, and for different nest 'sizes'. These tests took place during the first month that the hens were in the shed, when each hen was placed in the test-pen for four ovipositions.

Of the Group B hens, two hens, one a B x W and the other a R x W strain hen, died before the commencement of observations, one as a result of cannibalism and the other of unknown causes. Shortly after the commencement of observations a further two hens, one of each of the same two strains, were vent pecked by their flock-mates and although one survived, she did not contribute further to the results. Therefore, results from Group B flocks came from the remaining four hens of B x W and R x W origin each, and four B x R hens selected on the basis of egg production from the original six hens of this strain to standardise the numbers.

(b) *Behavioural Observations*

Observations on the two groups of hens commenced on 11th September, 1980. Initially, Group A hens, these being the caged birds, were intensively studied.

The observational procedure and records taken of the behaviours displayed by Groups A and B hens in cages and pens were essentially the same. Commencing at approximately 7.00 am, all hens in the study were manually palpated for the presence of a hard-shelled egg in the uterus. Of the Group A hens, the cage-set which contained the highest proportion of layers or early layers (as predicted from previous records) on that particular day was usually selected for study on that day. Therefore, a maximum of nine caged hens would be studied on any one day.

Using a digital timer, records were taken of the times at which hens started to perform certain pre-laying behaviours, and the length of time (to the nearest minute) that bouts of these activities would continue. Activities which occurred for less than one minute were recorded as occurring for one minute. Bouts of activities which were interrupted by other activities for intervals of under one minute, were recorded as continuous over such periods. The recognition of these 'pre-laying' behaviours was on the basis of changes from the hen's normal (non-laying day) behaviours which the observer had learnt were associated with the approach to oviposition. Behaviours commonly associated with nesting in cages were restlessness and pacing, calling, sitting and escape movements. However, particular hens had demonstrated certain idiosyncrasies in the pre-laying phase which were also noted as indicative of the nesting drive. These included increased agonistic encounters with hens in adjacent cages or standing alert for several minutes as if lookingat or fixating on something. Records were also taken of where hens laid in their cage and of their activities over the 30 minutes immediately following oviposition.

Pacing, calling and escape were classified according to the maximum intensity that was achieved during each nesting. Pacing intensity was classified in the following way:

Intensity + - less than 10 paces or steps and/or changes in direction made in a 10 second interval,

Intensity ++ - between 10 and 20 paces or steps and/or changes in direction made in a 10 second interval,

Intensity +++ - more than 20 paces or steps and/or changes in direction made in a 10 second interval.

Steps taken as a hen merely moved from one pen fixture to another, for example towards a feeder or nest-box, or while scratching about the pen, were not considered to be pacing steps. Pacing hens appeared to be attending to something beyond their pen or cage, or towards pen walls, when performing this activity and gave the impression of 'looking' for something. This characteristic, although subjective, assisted in the recognition of pacing. Restlessness, which is often used to describe the state of hens at the onset of nesting behaviour in studies of nesting behaviour, was classified as intensity + pacing for the purposes of this study, since it generally involved increased locomotion.

Calling intensity was classified in the following way:

Intensity + - pre-lay calling of the low intensity Qwa-qwa-qwa... type, subjectively judged as 'soft' and occurring in bouts of five seconds duration or less,

Intensity ++ - pre-lay calling of the type Qwa-qwa-qwa... given at a higher intensity, subjectively judged as 'loud' and generally occurring in bouts of longer than five seconds or the higher intensity Qwa-a-a... type call usually lasting longer than five seconds per bout. For both types of call the bill is at least partially open and some abdominal movement while calling is apparent,

Intensity +++ - pre-lay calling of the Qwa-a-a... type, judged as 'loud' and bouts lasting at least five seconds, a number of bouts occurring in quick succession. During these calls the bill is well open and the abdomen moves obviously.

These classifications were applied to pacing and calling in both pen and cage environments. Slightly different definitions had to be applied to the intensity of escape behaviours in the two environments, thus:

Intensity + - in pens: jumping up pen walls which may or may not be repeated several times; bouts of pacing between these attempts,
in cages: attempts at 'climbing' cage walls in which only one foot is placed on wall bars as the hen changes direction or is stationary with the other foot on the cage floor.

Intensity ++ - in pens: repeated attempts to jump or fly up pen walls, usually interspersed with pacing; more vigorous and occurring in more rapid sequence than Intensity +,
in cages: more vigorous attempts to climb cage walls, sometimes with both feet off the cage floor; also, attempts to push 'through' cage walls or under feeder,

Intensity +++ - in pens: repeated attempts to fly up pen walls, landing at least 40 cm up walls quite forcefully; attempts usually repeated with only very short intervening bouts of high intensity pacing,
in cages: very vigorous attempts to climb up cage bars, sometimes leaving the hen crouched up at the top of the cage, trying to push as much of the body as possible through the cage bars or under the feeder.

These classifications of escape behaviour in the two different environments are not strictly comparable, but they do give some indication of the relative 'drive' to get out of the home environment in each case.

The orientation of the hen in the cage at the time of oviposition was also noted, as was the activity performed immediately after laying, classified into feeding, drinking, sitting, manipulating the egg, or 'other' behaviours. Types of orientations of hens in the cage are illustrated and classified in Plate V.

In addition, a note was made of the activity which each caged hen was engaged in every two minutes throughout the study period. This was accomplished by means of a number coded checklist of possible activities, which included feeding, drinking, grooming, stretching, changing directions, interacting with neighbours, standing, shaking and pecking at cage fixtures, as well as activities generally associated with nesting. Of the possible nine hens which were under study on any particular day, only those which were going to lay that day were actually observed in this way. These recordings were also terminated for individual hens approximately 30 minutes after they had laid. These records served as a double check on the other observations related purely to apparent nesting activities. They proved particularly useful as a check on times at which certain nesting activities ended, as it was easier to miss noticing that an activity had stopped than it was to notice one had commenced. Further, it was considered that some behaviours in the laying cage may actually be associate with the nesting drive without being apparently specific to nesting and so go unrecorded if the simple checklist of all activities was not used. Such activities included the interactions, pecking and standing attentively, which were important components of the nesting pattern displayed by severa individuals

The predominant activity in the 30 minutes after lay was determ ned from checklist records only, feeding, drinking, sitting and 'other' behaviours being tabulated.

Usually, observations were terminated at 1.30 pm and recordings for hens which had not laid by this time were discarded. Occasionally, the observation period was extended if the observer considered that a particular hen was going to lay within the next half hour. All observations on caged hens were taken with the observer seated in front of the cage-set (feeder side), two metres from the cages but in full view of the birds.

On some observation days, all the Group A hens under study completed nesting activities early in the day. This was not uncommon, as most eggs were laid between 8.30 am and 11.30 am. When this occurred, the observer movec to a position mid-way between the two floor pens to observe the Group B hens. Hens which performed any activity likely to be related to nesting, such as sitting, pacing, calling or restlessness, in the first 45 minutes of observation, were observed no further. Only hens which did not perform any such activities during this period of time and were known to be laying that day were observed further. It was assumed that these hens had not performed any nest related activities on that day before they came under observation and so a complete record of their behaviour related to that oviposition would therefore be taken. This was considered a reasonable assumption since experience gained in previous studies had indicated that nesting activities tended to occur in a fairly well defined time sequence and that even early in this sequence, intervals during which hens performed other activities not related specifically to nesting rarely lasted longer than 30 minutes.

Records were taken of when individual hens commenced particular activities, the time they spent in these activities, the number of nests that were entered, where they eventually laid, their orientation in the nest at oviposition and their activities during the half hour following oviposition. No attempt was made to record each hen's activities which were not obviously nest related, as had been done in the case of caged hens, since it was more difficult and time consuming to identify individually the birds in the floor pen situation than it had been in the laying cages. This was also considered unnecessary as activities, particularly nest related ones, were more obvious in floor pens than they could be in cages in which they were limited by space. However, once a hen had performed activities indicative of nesting, incidences of feeding, drinking and interactions with other hens were recorded as well as the characteristic nesting behaviours. Also, every two minutes after oviposition the activities of individuals were recorded according to a simple number coded checklist of possible activities. This was continued up to 30 minutes after the hen had laid.

Each Group A hen was observed during 15 nestings in its laying cage environment. Individuals seemed to follow a quite distinctive sequence which was repeated before each oviposition. It was considered that 15 nestings would be more than sufficient to establish individual hen trends in the type of nesting pattern displayed. It was therefore decided that observations on the Group B hens would only be repeated for five nestings.

In order to obtain the required 15 recordings for the Group A hens, 40 days were spent observing these hens. At the completion of observations on these caged Group A hens, several days were spent completing observations on the floor penned Group B hens, so that five nestings had been observed for each of these hens. Usually only nestings completed in the first few hours of each day were recorded, to correct any bias created by the fact that the earlier observations on these hens had mostly been conducted on late morning nestings. Only one of the pens was under observation each day.

At the completion of these observations, Group A hens were moved into the floor pens and Group B hens were moved into the individual laying cages that the Group A birds had previously occupied. For a fortnight after the groups were swapped between environments in this way, hens of both groups were observed on a casual basis. Towards the end of this fortnight all the birds appeared to have settled into their new environment and regular individual nesting patterns seemed to have been established. Detailed observations were then recommenced.

Group A birds, now in the floor pen environment, were initially studied in detail. As before, all hens in the shed were palpated early in the morning of each observation day. One pen of hens, again selected on the basis of which pen held the most layers or early layers, was observed on each day. Observations were as for Group B hens in floor pens.

On observation days on which all hens expected to lay that day had completed nesting early in the day, the observer would move into position to record the nesting behaviours of the caged Group B hens. The same procedure as detailed for accessory observations on these birds in floor pens was followed. Again, hens which exhibited behaviours associated with nesting in the first 45 minutes of observation were studied no further. Observations were taken as for Group A hens in laying cages. At the completion of all

Group A observations, several days were again spent completing the observations on Group B hens. Again, mostly only early nestings were recorded on these occasions.

After the completion of these observations, each Group A hen had been observed and recorded on 15 occasions when laying in laying cages, and on 15 occasions when laying in the floor pen environment. Group B hens had each been recorded for five nestings in each of the two environments.

(c) Analysis of the Data

Behaviours which indicated the onset of nesting behaviour, the intensities of calling, pacing and escape activities and the types of activities performed immediately, or for several minutes after oviposition, were tabulated for each hen in each environment. The influences of each of the factors, housing environment, breed and hen, and their interactions, on these parameters were investigated using the BMDP 4F programme for Chi-square analysis available on the DEC20 computer at the University of New England. The predominant activity performed during the 30 minutes after oviposition, determined as the activity which was recorded more often than any other at the two minute intervals that the hen was observed post-lay, was tabulated for each nesting and each hen and the results also analysed. Although these data are not strictly independent, due to possible serial correlation, this approach was taken because the number of hens available for the study was insufficient to allow for analysis on the basis of 'typical' responses. However, the possible lack of independence of the results and, therefore, inadequacy of the analyses applied are recognised and as a result it was decided to accept only low probability values($P<.001$) as evidence of significant differences. Probability levels higher than this but lower than the .05 level(ie. $.001<P<.05$) are considered non significant or, at most, indicative of trends only.

The time at which nesting behaviour was observed to commence and the lenght of time (minutes) that each hen would spend in each of the activities, calling, sitting, pacing and escape, during each of the nestings observed, was also tabulated. Because of likely serial correlation due to successive observations on the same hen, these data were analysed using the BMDP P2V programme for analysis of variance with repeated measures.

The orientation of hens at oviposition in cages were tabulated for each hen for all observed nestings. These data were then analysed by Chi-square analysis, only probability values $<.001$ again being considered as significant due to lack of independence of the data from each hen.

The length of time that hens in floor pens spent in examining nests, either from the pen floor or from the nest-set perch in front of the nests, was also tabulated. The times (minutes) spent in examining nests were analysed using BMDP P2V programme for analysis of variance with repeated measures, to reveal any effects of strain or individual hens within strain. The numbers of nest entries made during each nesting by each hen were also analysed in this way. The distribution of each hen's final selsction of nest site, in which she eventually laid, was analysed by Chi-square analysis also.

All Group B data were analysed independently of Group A data.

3.5.3 Results

The summarised nesting data of several Group A hens, in both cage and floor pen environments, are given in Appendix 3.5.1. These hens showed most of the behavioural patterns typical of their respective groups, although each also displayed certain idiosyncrasies in either the pre- or post-laying phase in either cage or floor environments. One hen of each strain is represented in these summary tables. Activity charts depicting the times at which pacing, calling, sitting and escape activities occurred in the nesting sequerce of several hens on all observed occasions in the cage environment are given in Appendix 3.5.2. The corresponding activity charts of several hens when in floor pens are also given, but in these nest examination time is represented rather than escape, since escape behaviour was infrequently seen in the pre-laying behaviour of penned hens.

Results pertaining to Group A hens will now be detailed. The most commonly observed activities found to be associated with nesting in laying cages were pacing, calling, sitting and standing alert. The average time (in minutes) that each hen spent in pacing, sitting, calling and escape activities thrcughout the 15 occasions on which it was observed to nest are given in Table 3.5.1, as are the times spent in equivalent activities and nest examination by the same birds in the floor pen environment. Also given in Table 3.5.1 are the average times from onset of nesting to lay for each hen in both environments. Parameters for which significant trends were found were the timing on onset of nesting, time spent sitting and time spent in escape behaviour in these Group A birds. Analyses of variance for these parameters are given in Appendix 3.5.3. No significant differences were found for the nest calling, pacing, nest examination time data for this group of hens, nor in the number of nest entries recorded by the three strains.

Analysis of times spent in sitting during the nesting phase revealed that the three strains differed, regardless of the nesting environment. The B x R cross hens spent more time in sitting during nesting than hens of either of the other two crosses involving a White Leghorn parent. Environment, on the other hand, did influence the timing of onset of nesting behaviour and the amount of time spent in escape behaviours. The onset of nesting occurred significantly earlier in relation to oviposition in the cage environment (mean of 76.9 mins) than it did in the floor pen environment (mean of 63.6 mins). The length of time spent in escape behaviour was also significantly greater in the cage than in the pen environment, although, as previously mentioned, the escape behaviours display

Table 3.5.1 Mean times from onset of nesting behaviour to lay and times spent in nest calling, pacing, sitting and escape behaviour between onset of nesting and oviposition in cage and pen environments and mean times spent in nest examination and numbers of nest entries in pens for Group A hens

Strain	Hen	Onset of Nesting (mins before lay) Cage	Onset of Nesting (mins before lay) Pen	Time in Calling (mins) Cage	Time in Calling (mins) Pen	Time in Pacing (mins) Cage	Time in Pacing (mins) Pen
B x W	1	102.1	40.2	8.0	2.3	4.1	4.8
	2	66.7	44.0	3.6	0.1	7.5	19.2
	3	54.4	71.0	28.9	2.2	4.5	18.2
	4	116.1	73.7	18.5	3.1	9.4	3.2
	5	96.1	61.3	3.5	5.5	8.0	0.4
	6	95.8	73.4	3.1	30.3	7.3	34.5
MEAN (B x W)		88.5	60.6	10.9	7.3	6.8	13.4
R x W	1	94.1	96.9	1.2	5.6	6.8	12.5
	2	70.7	74.8	20.8	9.4	14.2	6.1
	3	47.4	39.4	3.9	4.4	8.0	2.9
	4	51.1	34.5	17.3	1.7	6.9	1.5
	5	78.3	67.1	5.0	4.5	6.3	17.3
	6	90.0	50.9	20.3	11.8	16.1	12.3
MEAN (R x W)		71.9	60.6	11.4	6.2	9.7	8.8
B x R	1	82.2	50.3	0.0	1.1	0.6	5.5
	2	73.7	60.9	2.1	0.0	5.2	0.0
	3	77.3	80.9	1.2	26.3	3.6	12.8
	4	54.0	106.8	1.3	1.4	4.1	26.1
	5	63.1	64.2	0.7	5.9	5.5	9.3
	6	72.1	54.3	1.6	1.3	6.0	16.1
MEAN (B x R)		70.4	69.6	1.1	6.0	4.2	11.6
All Strains	MEAN	76.9	63.6	7.8	6.5	6.9	11.3

Strain	Hen	Time in Sitting (mins) Cage	Time in Sitting (mins) Pen	Time in Escape (mins) Cage	Time in Escape (mins) Pen	Time in Examining Nests (min) Pen Only	Number of Nest Entries Pen Only
B x W	1	0.0	4.5	3.1	0.0	17.2	2.7
	2	7.0	8.3	0.4	0.6	4.0	2.6
	3	0.0	13.6	11.7	0.0	27.5	2.9
	4	51.3	33.3	2.3	0.0	25.6	2.9
	5	40.7	35.8	3.1	0.0	19.9	6.3
	6	39.1	23.8	1.1	0.0	4.9	6.4
MEAN (B x W)		23.0	19.9	3.6	0.1	16.5	4.0
R x W	1	27.1	9.3	5.6	0.6	42.3	3.9
	2	11.6	26.8	5.3	0.0	30.6	4.8
	3	24.2	24.7	0.0	0.0	9.3	3.4
	4	8.7	24.1	0.9	0.0	7.1	3.6
	5	33.7	29.2	3.9	0.0	11.8	4.6
	6	7.3	20.3	5.7	0.7	10.6	6.3
MEAN (R x W)		18.8	22.4	3.6	0.2	18.6	4.4
B x R	1	58.0	32.2	0.1	0.3	11.1	4.7
	2	22.7	46.7	6.5	0.0	15.5	4.8
	3	68.8	39.7	0.2	0.0	18.7	2.9
	4	24.5	46.3	2.3	0.0	5.1	5.0
	5	42.3	35.8	0.9	0.0	11.5	4.5
	6	39.8	24.4	9.7	0.0	2.5	1.4
MEAN (B x R)		42.7	37.5	3.3	0.0	10.7	3.9
All Strains	MEAN	28.2	26.6	3.5	0.1	15.3	4.1

in the two environments may not be strictly comparable.

Numbers of nestings which were accompanied by calling, pacing and escape of differing intensities are given in Table 3.5.2. While no significant differences were detected between the strains when time spent in calling was considered, highly significant differences were found between strains in the intensity of calling performed. B x R hens tended to nest without calling more often than did either of the other two strains. Nestings performed by these B x W or R x W hens were most commonly accompanied by the low intensity (+) calling. High intensity calling (+++) was rarely observed, but intensity ++ calling was quite commonly observed in B x W and particularly R x W hen nestings but not in B x R nestings. Overall, high intensity calling (++ and +++) was more commonly observed during nestings in cages than in floor pens, although calling of some type accompanied at least as many pen as cage nestings. This effect of environment was, however, only a non-significant trend on analysis.

Individual hens behaved quite differently with respect to the intensity of calling which they performed in the two different environments, although in each environment the behaviour tended to be stable. Similarly, considerable differences were found for different hens of the same strain. In addition, the types of calling intensity patterns displayed by different strains were different in pens and cages. B x R hens tended to call, to some extent, more often when approaching oviposition in floor pens than in cages. B x W hens, on the other hand, tended to call less, and less frequently at high intensities, in the pen environment.

Similar trends were also found for the frequencies of pacing which accompanied nestings. While no significant differences were found for the amount of time spent in pacing, strains differed in the intensity of pacing. As for calling, B x R hens nested without pacing more frequently than did hens of either of the other strains. Low intensity pacing was most commonly associated with nestings of B x R hens, whereas high intensity pacing tended to be associated with the nestings of B x W and R x W hens. Whether the hens were observed in laying cages or in floor pens had some effect on the pacing intensity performed by the different strains, B x R hens being less affected by environment than the others. The occurrence of different pacing intensities, or in fact pacing at all, was not much affected by environment overall, although individual B x R he were affected in different ways, some pacing less and some more, when moved to the pen environment. B x W and R x W hens, on the other hand, all tended to be affected by environment in much the same way, with a trend towards no or less intense pacing once moved into the floor pen environment.

Table 3.5.2 Numbers, totalled over all hens of each strain, of nestings accompanied by calling, pacing and escape behaviour of different intensities for BxW, RxW and BxR strains in cages or pens and Chi-square values appropriate to these data - Group A

Strain (S)	Cage/Pen (E)	Calling Intensity (I)			
		No Calling	+	++	+++
B x W	Cage	5	48	34	3
	Pen	16	46	28	0
R x W	Cage	23	22	40	5
	Pen	15	53	22	0
B x R	Cage	59	31	0	0
	Pen	42	35	13	0

$\chi^2_{I,3df}$ = 220.2***, $\chi^2_{IxE,3df}$ = 8.7 (P<.05), $\chi^2_{IxS,6df}$ = 100.4***,

$\chi^2_{IxExHen,15df}$ = 54.3***, $\chi^2_{IxExS,6df}$ = 30.9***, $\chi^2_{IxSxHen,30df}$ = 97.2***

Strain (S)	Cage/Pen (E)	Pacing Intensity (I)			
		No Pacing	+	++	+++
B x W	Cage	0	42	37	11
	Pen	16	28	42	4
R x W	Cage	0	35	46	9
	Pen	11	48	29	2
B x R	Cage	22	53	15	0
	Pen	23	48	14	5

$\chi^2_{I,3df}$ = 215.6***, $\chi^2_{IxE,3df}$ = 11.5 (P<.01), $\chi^2_{IxHen,15df}$ = 52.0***,

$\chi^2_{IxS,6df}$ = 55.5***, $\chi^2_{IxExHen,15df}$ = 83.7***, $\chi^2_{IxExS,6df}$ = 24.9***

$\chi^2_{IxSxHen,30df}$ = 100.0***, $\chi^2_{IxExSxHen,30df}$ = 104.6***

Strain (S)	Cage/Pen (E)	Escape Intensity (I)			
		No Escape	+	++	+++
B x W	Cage	32	27	14	17
	Pen	86	2	2	0
R x W	Cage	39	14	34	3
	Pen	79	11	0	0
B x R	Cage	47	28	15	0
	Pen	87	3	0	0

$\chi^2_{I,3df}$ = 436.0***, $\chi^2_{IxE,3df}$ = 136.2***, $\chi^2_{IxHen,15df}$ = 67.7***

$\chi^2_{IxS,6df}$ = 22.8***, $\chi^2_{IxExHen,15df}$ = 28.0 (P<.05), $\chi^2_{IxExS,6df}$ = 17.8 (P<.01)

$\chi^2_{IxSxHen,30df}$ = 105.3***, $\chi^2_{IxExSxHen,30df}$ = 66.4***

Escape intensity followed similar trends to those established for calling and pacing. Escape tended to be missing from the pre-laying behaviour of B x R hens, or if it occurred, was of low intensity. Escape behaviour, particularly of the more intense kind, was more often displayed by B x W and R x W hens. Escape behaviour was rarely observed in the floor pens and was least affected by the change of environment in the case of the R x W strain.

Data related to frequencies of initiating activities and activities occurring after oviposition for Group A hens and relevant Chi-square values for these are given in Table 3.5.3. The activities most commonly noted to signal the onset of nesting for hens in cages were calling or sitting in the case of B x W and R x W hens and sitting in the case of B x R hens. A considerable proportion of R x W nestings were, however, commenced with the hen standing in alert posture and looking out beyond the cage in a particular manner. Nesting in pens was most commonly observed to commence with restlessness/increased locomotion/pacing (all classified as pacing for the purposes of this study) or nest examination. Comparisons between the two environments are not really valid since one alternative available in the pen environment, that being nest examination, has no obvious parallel in a laying cage.

Different hens reacted quite differently when commencing nesting in either cage or pen environments. Some hens continued to commence their nesting with the same behaviour when moved to the new environment. Others developed completely different initiating behaviours which were repeated day after day in the new environment.

The most common activity to be performed immediately after oviposition was feeding. However, this tendency was subject to environmental effects. Feeding immediately after lay was more usual in pens than in cages. Sitting immediately after oviposition was commonly observed in pens but not in cages. Drinking was similarly more frequently observed immediately after oviposition in pens than in cages. Surprisingly, manipulation of the egg just laid, or looking for the egg between the legs if it had rolled away, was more often observed immediately post-lay in cages than in pens. This was not the case for B x R hens, however, which often performed egg manipulations before any other activity after laying in pens also, hence the significant environment by strain interaction effect on activity performed immediately post-lay. As for other parameters, hens varied considerably in the type of activity they would first become engaged in after laying, but within any one environment the pattern would usually be constant.

Table 3.5.3 Frequencies of different initiating nesting activities, first activities after lay and predominant activities during the 30 minutes after lay totalled over all hens in each of the BxW, RxW and BxR strains in cages or pens and appropriate Chi-square values for these data - Group A

Strain (S)	Cage/Pen (E)	First Nesting Activity (A) Displayed Calling (c)	Pacing (p)	c+p	Sitting	Stand. Alert	Nest Exam. (e)	c+e	Other
B x W	Cage	43	6	0	39	1	-	-	1
	Pen	5	37	4	0	0	36	8	0
R x W	Cage	28	3	3	20	36	-	-	0
	Pen	17	25	18	0	0	27	3	0
B x R	Cage	2	13	0	59	0	-	-	2
	Pen	0	35	15	0	0	40	0	0

$\chi^2_{A,7df}$ = 206.2***, $\chi^2_{AxE,7df}$ = 361.4***, $\chi^2_{AxHen,35df}$ = 163.2***,

$\chi^2_{AxS,14df}$ = 109.8***, $\chi^2_{AxExHen,35df}$ = 53.7 ($P<.05$), $\chi^2_{AxSxHen,70df}$ = 353.8***,

Strain (S)	Cage/Pen (E)	First Activity (A) After Oviposition Feeding	Drinking	Sitting	Manipulating Egg	Other
B x W	Cage	49	16	0	22	3
	Pen	48	21	15	4	2
R x W	Cage	67	9	0	14	0
	Pen	18	21	42	0	9
B x R	Cage	55	18	2	15	0
	Pen	4	35	20	15	16

$\chi^2_{A,4df}$ = 191.8***, $_{AxE,4df}$ = 139.3***, $_{AxHen,20df}$ = 88.2***,

$\chi^2_{AxS,8df}$ = 35.5***, $\chi^2_{AxExHen,20df}$ = 70.8***, $\chi^2_{AxExS,8df}$ = 49.4***,

$\chi^2_{AxSxHen,40df}$ = 274.7***, $\chi^2_{AxExSxHen,40df}$ = 95.7***

Strain (S)	Cage/Pen (E)	Predominant Activity (A) 30 Minutes Post-Lay Feeding	Sitting	Other
B x W	Cage	77	0	13
	Pen	46	12	32
R x W	Cage	83	0	7
	Pen	37	19	34
B x R	Cage	74	12	4
	Pen	55	0	35

$\chi^2_{A,2df}$ = 292.00***, $\chi^2_{AxE,2df}$ = 73.6***, $\chi^2_{AxHen,10df}$ = 28.8 ($P<.01$),

$\chi^2_{AxExHen,10df}$ = 69.5***, $\chi^2_{AxExS,4df}$ = 34.7***, $\chi^2_{AxSxHen,20df}$ = 121.7***

Feeding was by far the most commonly observed activity throughout the 30 minutes following oviposition. This was particularly the case for nestings which took place in the cage environment. Overall, sitting was more likely to have predominated in this post-lay period in the pen than in the cage environment. However, a highly significant strain by environment effect was detected when frequencies of post-lay activities were compared. One noticeable tendency was for B x R strain hens to sit more often during this period when in cages than in pens, quite the opposite response to that determined for the other two strains.

Timed data for observed Group B nestings are presented in Table 3.5.4. Analyses of variance which indicated significant differences are shown in Appendix 3.5.4.

Unlike the Group A results, which showed lengthened nesting periods in cages as compared with pens, no significant effect of environment on the time at which nestings were observed to commence was found. A significant strain by environment effect was, however, found. This reflected the tendency for B x W hens to spend considerably longer in pre-lay activities in pens than in cages, while the complete opposite was the case for R x W and B x R strains.

Times spent in calling differed considerably for the different strains. Generally, B x R hens spent much less time calling than did B x Ws or R x Ws. Calling was also of shorter duration in the case of pen nestings. However, a significant effect of strain was exerted on this relationship, the differences between calling times in the two environments being considerable in the cases of B x W and R x W strains, but negligible for the B x R strain. Significant differences were also found between individual hens for amount of time that was spent in calling each day.

As for Group A, no differences attributable to strain or hen were found in the times spent in pacing. However, a significant effect of day, or occasion on which the observed nesting took place, was found.

Group B hens spent significantly more time sitting during the pre-laying phase in pens than they did in cages, a trend also found in Group A hens. This tendency was influenced by strain, time of sitting in the two environments being more nearly equal in the case of the B x R strain. Again, a significant effect of different observation days was detected.

Group B hens exhibited a significant tendency to spend considerably less time in escape behaviour in pens than in cages. This was also noted for Group A.

One trend detected for Group B hens, but not Group A, was for the strains to differ with respect to the number of nest entries performed for each nesting. B x W hens performed considerably more nest entries each day than hens of either of the other strains. In comparison with the Group A nest entry data (Table 3.5.1) nest entry frequencies of all four Group B, B x W hens are quite high (mean number of nest entries 4.0 for Group A and 22.1 for Group B, B x W hens).

Frequencies of the different calling, pacing and escape intensities and the appropriate Chi-square values which were found to suggest trends for Group B hens are given in Table 3.5.5.

A non-significant trend was found for the three strains to use different intensities of calling. Although only a trend, this supports a similar trend noted for Group A hens, B x R hens tending to call at a low intensity, or not at all, whereas B x W and R x W hens tended to call at higher intensities.

Pacings of intensities ++ or +++ were most commonly recorded by Group B hens. However, B x R hens seemed to have a greater propensity to nest without pacing in the pen environment than did the other strains. As previously mentioned, escape behaviour rarely accompanied nesting in floor pens, hence the significant effect of environment on escape intensity.

Frequencies of activities, commencing nesting, immediately following oviposition and predominating in the 30 minute post-lay period, are shown in Table 3.5.6, along with appropriate Chi-square values for these data Like the Group A hens, these hens demonstrated a tendency to announce the onset of the nesting phase mainly by calling, although B x R hens again seemed to be somewhat different in that they often showed no other signs of nesting until they began to 'sit tight'. Hens in pens also tended to commence a considerable number of nestings with nest examination, as observed in the case of Group A hens.

As noted for Group A hens, feeding was usually the first activity performed immediately after oviposition, although sitting was an activity which often followed oviposition in pens but not in cages. Similarly, predominant post-lay activity patterns parallel those indicated for Group A, with feeding being most common.

A number of other activities, apparently associated with the nesting and oviposition of hens, were also recorded. Some of these were shown only by one particular hen and so could be considered as idiosyncrasies. Others were more

Table 3.5.4 Mean times from onset of nesting behaviour to lay and times in nest calling, pacing, sitting and escape behaviour between onset of nesting and oviposition in cage and pen environments and mean times spent in nest examination and numbers of nest entries in pens for Group B hens

Strain	Hen	Onset of Nesting (mins before lay) Cage	Onset of Nesting (mins before lay) Pen	Time in Calling (mins) Cage	Time in Calling (mins) Pen	Time in Pacing (mins) Cage	Time in Pacing (mins) Pen
B x W	1	119.6	113.2	19.6	2.6	4.0	4.8
	2	106.2	201.0	34.2	13.8	3.0	12.8
	3	91.4	112.8	24.2	10.6	7.0	12.4
	4	104.2	192.2	40.2	16.8	13.4	2.2
MEAN	(B x W)	105.4	154.8	29.6	10.9	6.8	8.1
R x W	1	122.0	76.6	44.7	12.8	0.0	4.6
	2	121.8	71.4	41.6	33.4	19.4	17.2
	3	152.8	139.2	44.8	31.8	7.6	7.0
	4	121.2	58.2	28.8	8.2	20.8	8.0
MEAN	(R x W)	129.5	86.4	40.0	21.6	11.9	9.2
B x R	1	192.6	195.8	8.8	10.8	4.6	5.6
	2	132.6	48.6	4.8	13.4	11.0	0.0
	3	165.2	110.2	1.2	6.0	5.2	2.4
	4	138.4	125.4	11.8	3.4	4.4	3.2
MEAN	(B x R)	157.2	120.0	6.7	8.4	6.3	2.8
All Strains	MEAN	130.7	120.4	25.4	13.6	8.4	6.7

Strain	Hen	Time in Sitting (mins) Cage	Time in Sitting (mins) Pen	Time in Escape (mins) Cage	Time in Escape (mins) Pen	Time in Examining Nests (min) Pen Only	Number of Nest Entries Pen Only
B x W	1	42.8	67.4	4.4	0.8	25.4	24.8
	2	9.4	51.6	12.4	0.0	24.6	17.2
	3	1.4	51.4	18.2	1.0	23.8	13.2
	4	0.0	52.0	9.8	0.0	35.8	33.2
MEAN	(B x W)	13.4	55.6	11.2	0.5	27.4	22.1
R x W	1	14.0	28.0	14.4	1.4	21.0	10.2
	2	31.2	20.6	8.6	0.0	20.0	2.0
	3	3.2	52.6	44.2	0.0	18.4	8.0
	4	22.2	26.0	13.6	0.0	11.6	7.0
MEAN	(R x W)	17.7	31.8	20.2	0.4	17.8	6.8
B x R	1	75.2	64.6	0.6	0.0	71.6	14.0
	2	25.8	18.4	15.6	0.0	15.4	3.4
	3	44.2	48.4	1.0	0.0	17.8	4.2
	4	15.4	38.2	8.0	0.0	28.6	7.0
MEAN	(B x R)	40.2	42.4	6.3	0.0	33.4	7.2
All Strains	MEAN	23.7	43.3	12.6	0.3	26.2	12.0

Table 3.5.5 Numbers, totalled over all hens of each strain, of nestings accompanied by calling, pacing and escape behaviour of different intensities for BxW, RxW and BxR strains in cages or pens and Chi-square values appropriate to these date - Group B

Strain (S)	Cage/Pen (E)	Calling Intensity (I)			
		No Calling	+	++	+++
B x W	Cage	0	3	13	4
	Pen	2	4	12	2
R x W	Cage	0	1	17	2
	Pen	0	3	12	5
B x R	Cage	5	7	8	0
	Pen	2	11	7	0

$\chi^2_{I,3df} = 49.4^{***}$, $\chi^2_{IxS,6df} = 19.1 (P<.01)$

Strain (S)	Cage/Pen (E)	Pacing Intensity (I)			
		No Pacing	+	++	+++
B x W	Cage	0	11	9	0
	Pen	1	7	11	1
R x W	Cage	5	2	11	2
	Pen	1	8	11	0
B x R	Cage	2	7	11	0
	Pen	11	6	3	0

$\chi^2_{I,3df} = 41.9^{***}$, $\chi^2_{IxExS,6df} = 12.2 (P<.05)$

Strain (S)	Cage/Pen (E)	Escape Intensity (I)			
		No Escape	+	++	+++
B x W	Cage	1	9	9	1
	Pen	15	2	3	0
R x W	Cage	0	6	8	6
	Pen	17	1	2	0
B x R	Cage	7	5	6	2
	Pen	20	0	0	0

$\chi^2_{I,3df} = 31.8^{***}$, $\chi^2_{IxE,3df} = 52.5^{***}$

Table 3.5.6 Frequencies of different initiating nesting activities, first activities after lay and predominant activities during the 30 minutes after lay totalled over all hens in each of the BxW, RxW and BxR strains in cages or pens and appropriate Chi-square values for these data - Group B

Strain (S)	Cage/Pen (E)	First Nesting Activity (A) Displayed: Calling (c)	Pacing (p)	c+p	Sitting	Stand. Alert	Nest Exam. (e)	c+e	Other
B x W	Cage	20	0	0	0	0	0	0	0
	Pen	2	0	0	0	0	0	0	0
R x W	Cage	13	0	0	5	0	0	0	2
	Pen	10	0	3	0	0	4	3	0
B x R	Cage	3	0	0	14	0	0	0	3
	Pen	7	0	0	0	0	12	1	0

$\chi^2_{A,7df} = 90.3^{***}$, $\chi^2_{AxE,7df} = 28.1^{***}$, $\chi^2_{AxS,14df} = 24.7\ (P<.05)$

Strain (S)	Cage/Pen (E)	First Activity (A) After Oviposition: Feeding	Drinking	Sitting	Manipulating Egg	Other
B x W	Cage	19	1	0	0	0
	Pen	10	3	6	1	0
R x W	Cage	14	6	0	0	0
	Pen	8	3	5	1	3
B x R	Cage	9	8	0	3	0
	Pen	13	0	7	0	0

$\chi^2_{A,4df} = 85.3^{***}$, $\chi^2_{AxE,4df} = 13.8\ (P<.01)$, $\chi^2_{AxSxHen,24df} = 46.4\ (P<.05)$

Strain (S)	Cage/Pen (E)	Predominant Activity (A) 30 Minutes Post-Lay: Feeding	Sitting	Other
B x W	Cage	20	0	0
	Pen	19	0	1
R x W	Cage	17	0	3
	Pen	12	0	8
B x R	Cage	20	0	0
	Pen	11	4	5

$\chi^2_{A,2df} = 96.7^{***}$, $\chi^2_{AxE,2df} = 7.3\ (P<.05)$

widespread throughout the group of hens. During the pre-laying phase a call, quite dissimilar from the nesting call, was often uttered by a number of hens. This call was a quite high frequency, repeated call which was termed 'glicking'. Amongst Group A hens the call was recorded on several occasions for three caged hens and during all but one observed nesting of a fourth caged hen. In this case, the intensity of 'glicking' would gradually build up during the pre-laying phase and would be continued up to a minute or two before oviposition. None of these hens continued to perform this call when moved to the floor pen, although a fifth hen, which had not previously been heard to utter the call, began to perform it on introduction to the pen and subsequently performed it during the majority of it's nestings in this environment. Four of the five hens observed to utter the call were B x W strain birds while the fifth was a R x W hen.

Rotations and foot scraping activity were often observed in cages. Three of the Group A, B x R hens performed these vacuum nest building activities during all 15 observed nestings. One of these performed vacuum litter raking activities on a number of occasions also. Rotations and foot scraping were also performed on a number of occasions in cages by three R x W hens.

One Group A hen exhibited a rather odd tendency when approaching oviposition in the floor pen. This particular hen would begin to stretch some time prior to laying. The frequency of stretching movements would increase markedly as the hen approached oviposition until the hen finally entered and sat in a nest. Stretching was noted to be associated with 14 of the 15 nestings observed for this hen in the pen environment. Stretching had not been particularly obvious in the pre-laying phase of this same hen in a cage, but could have been present and not noticed by the observer. No other hen was noted to stretch repeatedly during the pre-lay phase as this hen did.

Two other activities which became more obvious during the pre-laying phase of several other Group A hens in cages were interactions with neighbouring hens, and repetitive pecking at non-food objects. Two hens displayed an increased tendency to interact, agonistically, with hens in adjacent cages. One hen in particular, B x R hen 1, would begin to direct threats and pecks towards one hen adjacent to her during pacing periods in the final 40 or 30 minutes before oviposition as she moved backwards and forwards along the dividing cage side. Records of numbers of attempted or successful aggressive pecks issued by this particular hen before oviposition on two days, and at approximately the same times on two non-laying days, revealed that the average number of aggressive pecks delivered by that hen during the 30 minutes immediately prior to oviposition was 23, whereas during the corresponding period of time on non-laying days it was two.

One Group A, R x W hen showed a similar tendency towards increased aggressiveness when approaching oviposition in a floor pen. This hen would pace about the pen and in front of the nests, partially examining nests, and as she did so would attack other hens which were in her path. These attacks were often quite vicious and increased in intensity and frequency as the time advanced towards the impending oviposition. Occasionally, peck order violations would occur as the hen, in a highly excited state, would attack a hen dominant to her. After that hen had fought or pecked back, generally reasserting her dominance, the nesting hen would continue on her way and continue to attack other hens. It was, however, more usual for this hen to attack hens subordinate to her and she was often observed to go out of her way to chase after particular subordinate hens during this phase.

One caged Group A, R x W hen was observed to develop an interest in a small piece of wire which hung down outside and to the back of her cage as she approached oviposition. The hen would begin to peck at the wire about 30 minutes prior to oviposition and bouts of this repetitive pecking would increase in intensity and duration as oviposition approached. On non-laying days this hen was observed to totally ignore this wire and no pecks directed at it were noted.

A number of hens were noted to drink avidly during the 10 to 20 minutes immediately prior to oviposition in cages. In some cases, drinking would only commence a minute or two before oviposition or even as the hen was raising herself into the laying stance in preparation for the expulsion of the egg. Several hens of each of the strains in Group A demonstrated this tendency during the majority of their nestings. This observation was considered interesting in the light of previous reports on the drinking habits of laying hens and an experiment was designed and conducted in an effort to investigate water usage patterns and drinking habits associated with oviposition in these hens. The design of this experiment and the results obtained are described in Study 3.

The orientations of hens at oviposition in cages are tabulated for both Group A and Group B hens in Table 3.5.7. These data, and the Chi-square values relevant to them and given in the same table, indicate that hens preferred to lay facing towards the 'back' of the cage, i.e. towards the water trough or away from the observer. When oriented in this way the hens would be facing up the slope of the cage floor. Hens at the point of oviposition in the various orientation alternatives are shown in Plate IV. A stance in which the hen's body was directly up the cage, with the line of the body perpendicular to the back wall of the cage (B), was more commonly recorded than one in which the body was placed diagonally across the cage with the head directed towards either the left or right corners at the back of the cage (F or E). The orientation which

PLATE IV

PLATE IV

Top left: Hen laying whilst oriented towards the back of the cage and to the right hand corner - Orientation E

Top right: Hen laying whilst oriented directly towards the back of the cage - Orientation B

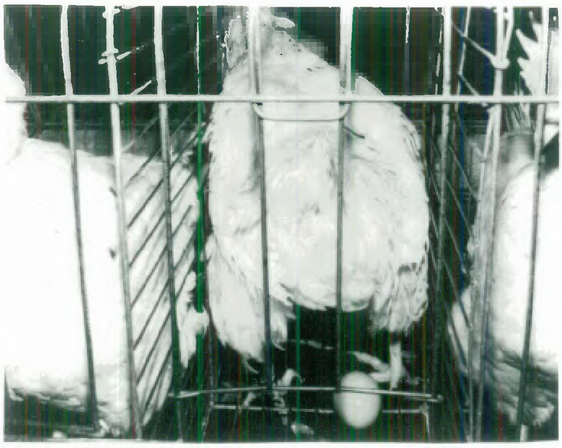
Centre left: Hen laying whilst oriented towards the back of the cage and into the left hand corner - Orientation F

Centre right: Hen laying whilst oriented towards the front of the cage and into the right hand corner - Orientation C

Bottom left: Hen laying whilst oriented directly towards the front of the cage - Orientation A

Bottom right: Hen laying whilst oriented towards the front of the nest and to the left hand corner - side view - Orientation D





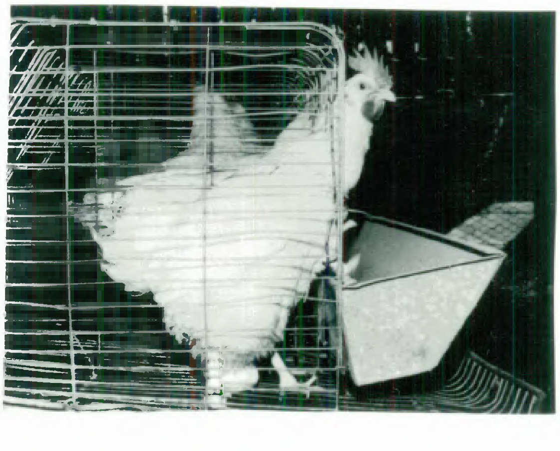
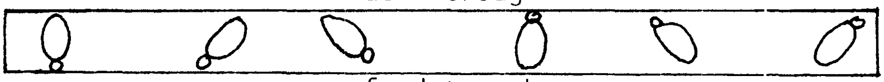



Table 3.5.7 Total numbers of ovipositions which took place while the hen was oriented in particular ways in the cage or when in particular nest sites in the pen and Chi-square values appropriate to these data - Groups A and B

Group	Strain (S)	Orientation (O) in Cage at Oviposition					
		A	B	C	D	F	G
		water trough  feed trough					
A	B x W	2	15	1	36	22	14
	R x W	25	13	7	38	7	0
	B x R	24	17	4	43	2	0
	All	51	45	12	117	31	14

$\chi^2_{O,5df} = 123.2^{***}$, $\chi^2_{OxHen,25df} = 161.3^{***}$

$\chi^2_{OxS,10df} = 56.6^{***}$, $\chi^2_{OxSxHen,50df} = 237.5^{***}$

Group	Strain (S)	A	B	C	D	F	G
B	B x W	10	0	0	10	0	0
	R x W	3	2	6	4	4	1
	B x R	0	0	0	13	4	3
	All	13	2	6	27	8	4

$\chi^2_{O,5df} = 23.2^{***}$, $\chi^2_{OxHen,15df} = 34.9 (P<.01)$, $\chi^2_{OxS,10df} = 23.0 (P<.05)$

Group	Strain (S)	Nest/Nest Site (N) Laid In							
		Nest				Floor Site			
		a	b	c	d	I	II	III	IV
A	B x W	9	18	13	5	25	4	4	12
	R x W	8	20	20	12	2	9	12	7
	B x R	22	25	5	8	0	1	29	0
	All	39	63	38	25	27	14	45	19

$\chi^2_{N,7df} = 45.7^{***}$, $\chi^2_{NxHen,35df} = 160.6^{***}$

$\chi^2_{NxS,14df} = 75.8^{***}$, $\chi^2_{NxSxHen,70df} = 219.6^{***}$

Group	Strain (S)	a	b	c	d
B	B x W	6	6	5	3
	R x W	7	9	1	3
	B x R	5	12	2	1
	All	18	27	8	7

$\chi^2_{N,3df} = 17.7^{***}$, $\chi^2_{NxSxHen,18df} = 41.6^{***}$

placed the hen's body straight down the cage with the hen facing the front of the cage, or the feeder trough (A), was the second most 'popular' alternative. Orientations which placed the hens diagonally down the cage (D or C) were again less frequently recorded than the straight up and down the cage alternative (A).

Individual hens were extremely conservative with respect to orientation at oviposition. Hens usually were only observed to use one orientation, or only use like alternatives, such as orientations of types B and F. It was most unusual to find any one hen using both 'back of cage' and 'front of cage' orientations. This was particularly apparent in the case of Group A hens. However, significant differences were found between strains in the frequency at which different orientation alternatives were recorded, which reflected dissimilar trends in results from the two groups. Group A, B x W hens tended to lay facing the back of the cage (B, F, E) more often than either R x W or B x R hens. The same tendency was not found in Group B hens.

Individual hens were equally conservative with respect to the nest or nest site that they would select to lay in. Nest b, which was the nest second of the four from the door, was most frequently selected by both Group A and B hens. Significant differences were found between strains in Group A in frequency of nest selection. B x R hens used the most popular nest and nest site alternatives more regularly than the other strains.

Several hens possessed particular idiosyncrasies with respect to their behaviour at oviposition. One B x W hen was observed to climb up the wire at the back of the cage in the last few seconds before laying (see Plate V) and usually dropped the egg from some height above the cage floor with at least one leg up the cage walls or with her head stretched out through the back bars of the cage. She was observed to lay in such positions on all but one of the observation periods. The observation that several hens drank from the trough in front of them while they were in the laying stance has already been mentioned.

While manipulations of eggs in the nest before or after oviposition were frequently seen for hens in floor pens, the same activities were also often observed following oviposition in laying cages. This was possible because eggs often did not roll away immediately after being laid and instead remained on the floor of the cage until disturbed by movements of the hen. Two B x W, two R x W and four B x R hens from Group A were observed on at least one occasion to manipulate the egg just laid in laying cages. Some of these hens repeated the activity after most observed nestings. One common occurrence was for the egg just laid to roll away and the hen to stretch her head down between her legs

PLATE V B x W hen pushing through cage bars at the point of oviposition

as if looking for it, and on finding the egg gone would turn around and appear to search for it. One particular hen, B x R 6, would turn around after laying and attempt to pull the egg back into the cage from under the feeding trough. Sometimes, if the egg had not rolled out into the collection tray and was caught under the feeder, her attempts would be successful. Another hen, B x R 3, could successfully sit on the egg she had laid without causing it to roll away. This particular hen would sit after oviposition for some considerable time before eventually rising, disturbing the egg in so doing and allowing it to roll away.

Post-lay cackles were given by three Group A hens following oviposition in laying cages. Two of these hens post-lay cackled during most of their nestings and also were noted to cackle before laying on one occasion. A different hen altogether became a post-lay 'cackler' when transferred to a floor pen, but none of the hens previously noted to cackle was found to continue with this activity following the transfer.

The nesting call was recommenced sometime after oviposition in a number of cases. The call given was of the same type and form as that which each of the hens uttered prior to lay during the nesting phase. Two of the hens, both

B x R birds, repeated the call at the same time after oviposition on most days. A regular pattern was established for one of these hens which involved the recommencement of calling between 20 and 60 minutes after oviposition which was generally associated with, or terminated by, a post-lay cackle.

Pacing after oviposition was also observed on several occasions in the case of one Group A hen. Material gathering in the pen after lay was observed on many occasions for three Group A, B x W strain hens.

3.5.4 Discussion

The approach taken in these studies was to detail all nesting behaviours which were performed from the time that nesting, of some form, was first noted until 30 minutes after oviposition, in preference to recording incidences of behaviours during, say, the 60 minutes immediately prior to oviposition. Although this technique introduces a certain level of additional subjectivity to the study in that some error could be incurred in the determination of the onset of nesting behaviour, it was considered to have several advantages. It was already obvious from previous studies that hens could begin to display nesting behaviours over a wide range of intervals prior to oviposition and that this coul be a function of the individual hen but also of the time that the oviposition is expected to occur. Since component activities of nesting behaviour tend to occur in a specific sequence, some could be totally overlooked in specific instances, or even in specific hens, if they generally occurred early in the nesting sequence and only data from a limited time period prior to oviposition were analysed. For example, Duncan (1970) reports the findings of studies in which hens were frustrated in nesting by either preventing their access to trap-nests, in which they were used to laying, or by caging. He found that although hens in either situation did not differ with respect to the number of stereotyped movements performed in the pre-laying hour, the hens frustrated by caging perform more stereotyped movements in total than hens in the pen situation. This was app rently attributable to a greater delay in oviposition time in the case of caged hens, which may have resulted in an extension of overall time in nesting behaviou

Most hens, whether laying in laying cages or in provided nests or floor sites in floor pens, tended to perform a sequence of activities leading up to and following oviposition which was quite stable in that environment and for eacl particular hen. The time at which the sequence started, and so the times that each component activity would first appear, was probably governed to a large exte by the time of day at which the oviposition eventually occurred, as would be predicted from the results of Study 3.3. However, the form that the sequence took was, in most cases, repeated with a high degree of consistency each laying day.

Although no direct comparisons could be made due to slightly different sampling techniques and unequal numbers of observations, it was obvious that the nesting behaviours of Group A hens and Group B hens in either of the environments was much the same. Many of the significant differences found in the timed data for Group B hens were also trends evident in the Group A results of which some were, however, not significant. Trends in sitting and escape behaviour were very similar. For several of the timed parameters, significant differences attributable to observation occasion were detected in Group B. This is likely to be a reflection of the way that data were collected in the case of these birds, resulting from the fact that the initial observations on each hen tended to be from late ovipositions, commencing after Group A observations had been completed for the day. The last few observations taken on each hen were usually from early nestings. Since time of oviposition has some influence on at least some aspects of nesting behaviour, as indicated in Study 3.3, the testing procedure used for these birds, in which late nestings were initially recorded when Group A hens had completed nesting and then early nestings observed towards the end of the study, probably produced this 'day', or testing occasion effect.

A comparison of the timed data attributable to Groups A and B suggests that Group B hens spent considerably longer in all activities and began to nest earlier than did Group A hens. This is probably an effect of the dissimilar sampling techniques for oviposition occasion, which resulted in average oviposition times of 10.14 am and 11.12 am for Groups A and B respectively. As previously indicated, the time from commencement of many pre-lay activities to oviposition increases as the time of oviposition grows later in the day. Thus, the difference in times spent in different activities by each of the two groups is probably a reflection of the relatively large difference in the average time of oviposition. This may also account for the larger differences obtained in timed data between strains and between environments for Groups A and B.

One oddity which is not so easily accounted for, is the high number of nest entries recorded for Group B hens of the B x W strain. Although Group B hens did spend more time in nest examination, probably by virtue of the relatively later oviposition times, and so they may have had more time in which to carry out nest entries, the mean number of entries per oviposition recorded for these hens still seems rather high in comparison with those obtained for their Group A counterparts.

Trends found for calling, pacing and escape intensity were nearly identical for Groups A and B, as were results related to frequencies of various initiating activities and post-lay activities. However, since fewer recordings were taken for Group B hens, differences and significance levels tended to be lower than was the case for Group A. Group A and B hens also tended to lay in the same way or the same places.

Overall, hens of Group A or Group B tended to react in much the same way to the nesting environment they were in. The prior nesting experience that the hens had received therefore had not differentially affected the behaviour patterns eventually established in either of the stable environments. It should be noted, however, that hens of both groups had all originally been reared on deep litter before being established in either cage or pen environments. All hens had therefore had some experience of a floor pen environment, but not of nests, and it is not known to what extent experience in the rearing period may have affected eventual nesting reactions to various environments.

Behaviour patterns related to nesting in laying cages and in floor pens provided with individual nest-boxes were similar in many respects. Most of the component activities of nesting in pens were also present in laying cages. Nesting tended to become obvious earlier in cages than in pens, although this effect was variable. Mean oviposition times were not very different for observed nestings of Group A hens, being 10.30 am and 9.49 am for cage and pen nestings respectively, but may have influenced the results to some extent. However, Brantas (1980) cites Martin (1975) as reporting that the duration of pre-laying behaviour is considerably extended in laying cages. Martin's results showed that the egg laying procedure lasted on average 16.4 minutes in a hen house (floor pen) with laying nests. When transferred to two-hen and then to one-hen cages, the time of pre-laying behaviour was extended to 74.2 and 51.4 minutes respectively. However, the 16 minute average time recorded in the hen house environmen seems extremely low when one considers results obtained in floor pen environments with nest-boxes in the present study and also those reported by others, including Turpin (1918), Wood-Gush (1954, 1963), Perry *et al.* (1971) and Fölsch (1980). Brantas (1980), in discussing Martin's results, suggests the possibility that some error in determining the beginning of the pre-laying behavioural period may have occurred. Nevertheless, the possibility that the time of onset of nesting behaviour is extended in laying cages can not be ruled out.

Several possibilities exist which may explain such a phenomenon. If the laying hen in a battery cage is subject to a greater level of stress during the pre-laying phase than is a hen in a floor pen in which she has access to nest-boxes, then it is possible that the oviposition may be delayed, resulting in an extended onset of nesting to oviposition period. Duncan (1970) reports delayed oviposition when hens used to laying in trap-nests were apparently frustrated in nesting by closing off the nests or being placed in cages. Hughes (1979) also reports the tendency for strange hens placed in with groups of other laying hens to retain their eggs. He suggests that this may result from their being in a stressful situation. Indeed, adrenaline has been shown to delay oviposition (Sykes, 1955; Draper and Lake, 1967), and a release of catecholamines resulting from stress or frustration could be involved in the lengthening of the nesting phase or a delay in oviposition in the present and other studies.

Beuving and Vonder (1977) reported increases in corticosterone levels in blood of individually caged laying hens from at least 100 minutes before egg laying and initially implicated the pre-lay state of agitation of the laying hen in a cage as being in some way involved. However, further investigation (Beuving, 1980) revealed similar increases in corticosterone concentrations when hens were housed in larger cages provided with nests containing nesting material, in which hens showed none of the signs of agitation, escape or restlessness that they did in nestless cages. Nevertheless, the increase in corticosterone was found still to occur at the predicted time of oviposition and in association with nesting behaviour when hens were induced to lay prematurely by vasopressin injection, indicating some connection between the timing of nesting behaviour and the increase in corticosterone concentration.

Retention of eggs resulting in delayed oviposition, regardless of the mechanism by which it is controlled, has been noted by a number of sources and may be involved in the trends noted for times of onset of nesting behaviour in the present study. However, if this situation was repeated day after day, one would expect that some change in ovulation times could eventually be involved, as occurs following heat stress (Wolfensen, 1979), and that this would eventually result in depressed production. However, production records of both Groups A and B suggest that productivity of hens in battery cages was at least as good as it was in floor pens, although it is also recognised that many other factors may have influenced production records obtained in the two environments.

Another possibility is that the actual time of onset of nesting was not detected accurately. While it is true that penned hens seemed to perform pre-laying activities less intensely than caged hens, particularly pacing and calling which were often associated with the onset of nesting, caged hens were not necessarily more obvious in their activities than penned hens, particularly since most activities occurred at low intensity early in the nesting and increased in intensity with time. It should therefore have been no more difficult to detect the onset of these common activities in one environment than in the other. However, it is conceivable that onset of nesting in pens may have been indicated by some other activity in many cases and the observer failed to recognise this as a nesting behaviour. Sitting, which was often recorded as the initial nesting activity in cages, may not, on occasions, have been that associated necessarily with nesting, and so may have influenced the results. Sitting in pens was more easily identified as nesting or otherwise, since nest 'sitting' took place only in specific areas in the pen or nests. However, equivalent sitting activity was considered to be generally fairly easy to distinguish in the cage situation by virtue of the fact that hens took on a typically 'firm' sitting position, not being easily disturbed, moving infrequently, often sitting for extended periods of time with the eyes closed, and often sitting with the feathers slightly 'ruffled' or raised.

It is more likely, therefore, that a hen experienced in the process of nesting in a 'satisfactory' nesting environment may simply forego some of the initial activities related to the search for a nest. Retention of eggs due to stress or frustration cannot be ruled out as a factor contributing to the observed differences however.

While calling and sitting were activities commonly observed to initiate nesting in cages, pacing and nest examination were more usual initiating activities in pens. Since nest examination is not possible in the cage situation, sitting may replace this activity in the case of hens accustomed to laying in battery cages, at least at the onset of nesting.

The amount of time spent in pacing did not differ in different environments. However, some trends seemed to exist in the pacing intensity between cage and pen environments, especially for B x W and R x W hens. Since one of the criteria for distinguishing the intensity of pacing was the number of paces taken in a period of time, the number of paces taken in the pre-laying period should be somewhat larger in cages than in pens. If, as suggested by Wood-Gush (1972), pacing is indicative of frustration in the pre-laying phase, then hens approaching oviposition in cages could be more frustrated than when they are laying in the floor pen environment. However, it is possible that pacing may be an important component activity in the nesting sequence in that it could represent the 'leaving of the flock' movement noted in feral fowl (McBride, 1969; Duncan *et al.*, 1978) and possibly also occurring in junglefowl. The apparent trends in the intensity of pacing recorded for cage and pen nestings would, however, be difficult to explain in terms of this.

It should be noted that the definition of pacing as applied in the present study is not necessarily the same as that stated or implied in other studies. Backward and forward escape movements were observed and recorded in the food-thwarting situation by Duncan and Wood-Gush (1972) who retermed the activity as a stereotyped or stereotypic pacing movement in the light of their later findings. Duncan and Wood-Gush (1974) define a stereotyped pacing movement as one back-and-forward movement without interruption along one side of the cage. This definition of pacing as a stereotypic movement has since been variously applied in several more recent studies by a number of researchers.

The pacing recorded in the present study included steps taken during the 'restless' phase of nesting in both pens and cages, and during a number of other movements which may or may not have been fixated stereotypes in the hens' behavioural repertoires. Undoubtedly a large number of the paces taken by hens in both environments were of the stereotypic pacing type. Also, many of the escape movements recorded, particularly in the cage situation, were stereotypic in particular hens. Therefore, both pacing and escape as measured in the present study are to some extent comparable to the pacing recorded in studies conducted at other institutes.

It could be argued that strain differences detected in the pacing and escape intensity data could be related to the relative agility of the different strains. For example, it could be possible that B x R hens pace less intensely because they are larger and less agile or active generally, or because they experience greater difficulty turning about in cages in particular because of their larger size. However, although one would expect the number of steps or the rate at which steps are taken to be reduced if this were the case, it is unlikely that pacing or the number of steps taken would be completely eliminated, as seems to have occurred as evidenced by the large differences in the numbers of 'no pacing' (-) recordings. It is therefore suggested that the strain differences in respect to these activities are not merely a result of relative sizes or agility of the different strains.

The apparent trend for calling to be more intense in cages than in pens (Groups A and B) and, at least in the case of one group (Group B), for more time to be spent on it in cages suggests several possibilities. Since nest calling is regarded as a response to a high level of motivation, then the results could suggest that hens in cages are more highly motivated to nest than are hens in pens. This, however, seems unlikely. If, however, nest calling is a response to a high level of motivation to seek out a nest specifically, then the higher levels of calling recorded for caged hens could indicate that they are failing to find or respond to stimuli involved in the next phase of the nesting sequence, which relates to sitting and 'nest building', or they are not responding as early in the nesting sequence as they do in the pen situation.

The significant tendencies noted for time spent in sitting during the pre-laying phase lend support to the suggestion that either hens in the two environments respond differently to those stimuli which release pre-lay sitting, or that the relevant stimuli are in some way lacking or inadequate in the cage situation. The higher incidence of escape type behaviours in cages as opposed to pens during the pre-laying phase would also appear to be in keeping with this suggestion. Hens, on being thwarted, respond with escape behaviour (Wood-Gush and Guiton, 1967; Duncan and Wood-Gush, 1972), at least in the feeding situation. It has also been shown that at least some strains of hen, when in a situation in which they are unable to find a suitable nest site, respond with behaviour indicative of frustration (Duncan, 1970; Wood-Gush, 1972; Hughes, 1979). The escape behaviour exhibited by some hens in the present study in the period shortly before oviposition may also be a response to frustration resulting from the inability of hens to find a suitable nest and/or to sit and nest-build, particularly in the cage environment.

The increased aggression noted for several hens towards their neighbours during the pre-laying phase in cages, or for one hen towards her flock-mates when approaching oviposition in a pen, may also have been a response to frustration. Duncan (1970) reviews some of the literature related to frustration and aggression in animals and reports increased aggression by dominant hens when pairs of hens were frustrated simultaneously. Duncan and Wood-Gush (1971) showed that hens frustrated in the feeding situation displayed more aggressive responses towards a subordinate cage-mate than did unfrustrated birds. Hughes (1979) also found that aggressive responses, stimulated by the introduction of an unfamiliar hen into a group of hens, increased during the pre-laying phase in the case of light hybrid strain hens in cages, but not of the same strain in pens nor in the case of medium hybrids in either cages or pens. He suggests that the increase in aggression in the pre-laying phase is a response to frustration. It is therefore possible that the increase in aggression demonstrated by at least several of the hens in the present study was in response to frustration resulting from the inadequacy of the nesting environment provided.

Perry *et al.* (1971) have also reported an increase in aggression and interactions with other hens in the case of hens moving about the pen prior to nest entry in large floor pens with nests available. They found that incidences of interactions with other hens increased as the nest-seeking hen approached oviposition. It has already been noted that at least one hen in the present study became engaged in interactions with other hens with increasing frequency and intensity with the approach of oviposition, at least up to nest entry, in the pen environment. It is possible that the floor pen environment or the nests in such an environment do not provide adequate stimuli to elicit some aspects of nesting in the case of some hens in some situations, and this may lead to frustration which in turn results in increased aggression. However, it is also possible that the high degree of motivation and level of general arousal may lend intensity to other activities which may include responses to and interactions with other hens. It may be that the apparent increase in aggressiveness of hens approaching oviposition in floor pens is directly related to this.

Displacement activities are often shown in frustrating situations (Duncan, 1970; Duncan and Wood-Gush, 1972) and it is probable that the increased 'wire pecking' activity of one of the hens in this study in the pre-laying phase was such an activity. It is also possible that the increased incidence of stretching pre-lay noted for another hen may have been an individual 'adaptation' to thwarting in the nesting situation, although insufficient evidence was obtained to investigate this possibility further.

For most parameters measured, strain differences which were apparent tended to indicate that the B x R strain hens were dissimilar in some way to the other two strains. The two white, lighter strains behaved similarly in most respects. In general, the B x R hens were less affected by the change in environment than either of the other strains, or at least their pre-laying behaviour was less affected. They spent more time sitting during the pre-laying phase than did the other two strains, particularly in the cage situation. These B x R hens also paced and called less intensely than other hens.

Wood-Gush and Gilbert (1969a) noted strain differences with respect to a number of parameters pertaining to nesting behaviour in laying cages. The strains that they studied were a medium weight hybrid strain of White Leghorn origin (group 1) and a hybrid strain of Rhode Island Red and White Sussex origin (group 2). They found that the onset of nesting was more difficult to assess in the case of group 2 hens. These birds spent a considerable amount of their time preening and sleeping on both laying and non-laying days. They also showed less of the restlessness and escape behaviour characteristic of the pre-laying behaviour of group 1 hens. Differences in the duration of pre-laying behaviour for the two strains were noted, but the point is made that this could have been an effect of the difficulty in determining the onset of nesting. While no strain effect was found in the duration of nesting data in the present study, difficulty in determining the onset of nesting in cages may have contributed to the observed differences for pen as opposed to cage nestings.

It is interesting to note that Wood-Gush and Gilbert (1969a) recorded a higher level of restlessness and escape in the group 1 hens than in the group 2 hens, which spent more time in 'nesting' and sitting activities. Wood-Gush (1969) made some attempt to quantify these differences and found large differences in the number of paces taken in the hour preceding oviposition. Subsequently, Wood-Gush (1972) was able to show that the White (group 1 type hybrids) and the Brown (group 2 type hybrids) did not differ significantly in the number of paces they took in the half hour preceding oviposition in floor pens provided with trap-nests. Both strains showed excessive pacing when frustrated in a feeding situation and Wood-Gush suggested that the White strain hens were more frustrated in the pre-laying phase in battery cages than were the Browns.

In the present study, the two white strains, both involving a White Leghorn parent, tended to pace and call more, or at least more intensely, than the black strain, particularly in the cage environment. The whites also tended to perform escape behaviours more intensely and sit less than the blacks in the cage situation. The similarities with the earlier studies (Wood-Gush and Gilbert, 1969a; Wood-Gush, 1969; Wood-Gush, 1972) are obvious. Since the strains used in the present study are not the same as those used by the other researchers, it is interesting to consider how these similarities have come about. Since the white hens used in both sets of experiments were of White Leghorn origin or involved a White Leghorn parent, it is possible that the observed tendencies are attributable to this breed. This suggestion seems all the more reasonable when the behavioural similarities of the two white strains of the present study, one a White Leghorn x Black Australorp cross and the other a White Leghorn x New Hampshire cross, are considered.

Wood-Gush's (1972) suggestion that the increased pacing and escape, and reduced sitting of the lighter White hybrid hens during the pre-laying phase in laying cages may be a result of frustration in the absence of suitable nesting sites, may also be applicable to hens of the present study. This possibility is given further credence by the finding that light hybrid strain hens of White Leghorn type become considerably more aggressive before oviposition in laying cages while the same trend is not shown by hens of the same strain in pens nor by medium hybrid hens in either environment (Hughes, 1979).

The results of this study, when considered with those of Wood-Gush and Gilbert (1969a) and Wood-Gush (1969, 1972), suggest that the White Leghorn breed may have lost the ability to respond to stimuli relevant to the sitting component of nesting, rather than the other strains, of various origin, generalising to sub-optimal stimuli in the cage situation, the explanations proposed by Wood-Gush (1972). However, the possibility that hens of different strains may differ in their motivation to nest should not be discarded. Wood-Gush (1972) attempted to study 'drive' strength of the two strains used in his investigations by measuring the time to re-entry for hens removed from trap-nests which they had just entered for the first time for any one nesting. However, hers were only tested on one occasion, only a limited number of hens were testec and large differences were found for individual birds. No significant differences were found between the strains for this measure of nesting 'drive' strength.

A number of factors may, however, influence time of first nest entry, and so probably time to re-entry also. Time of day at which the resulting oviposition takes place has already been shown to influence the time at which first and final nest entries take place in pens with open nests (Study 3.3) and it is also possible that it may affect times to re-entry in the case of hens removed from trap-nests. Hens of different strains may be disturbed to different extents by handling during removal from trap-nests, and this could also influence the resulting re-entry times.

It therefore seems that the rather limited evidence presented by Wood-Gush (1972) should not be taken to completely dismiss the possibility that the different strains have different tendencies to nest. It could well be that 'sitting' strains may in fact have a greater urge to nest and so are more responsive to stimuli and so nest in sub-optimal conditions. More detailed studies would be required before this possibility could be ruled out as a possible explanation of the differences between the strains observed in that, and the present study. It is worth mentioning at this point that B x R hens were far more frequently and persistently vacuum nest builders and paid more attention to their, or other's, eggs than did either of the white strains.

Possible explanations for the tendency of some hens to drink a great deal in the immediate pre-lay period are given in Study 3.6. Only one her was observed to drink frequently during this period in the case of pennec hens. It is likely that hens sitting on a satisfactory nest are very attached to the site as oviposition approaches, as evidenced by their tendency to sit tight and even defend the nest on the approach of an observer or another hen. This strong attachment to the nest site may be so great as to inhibit even very pressing alternative activities. Drinking may therefore be inhibited in the case of pen nestings where the hen must leave the nest site in order to drink. It is also possible that hens nesting in floor pens, because of their more passive pre-lay activities, require less water than the more active caged hens.

The tendency for hens to lay facing 'up slope' rather than 'down slope' was also noted by Wood-Gush and Gilbert (1969a). These researchers suggested that this may occur because it is easier for hens to lay in the 'up slope' position, as a result of the position of the observer, or because the back of the cage was relatively darker. The findings of the present study do not clarify this situation. The reason(s) for the observed trends in orientation at oviposition could only be determined by further research.

One interesting tendency also noted for orientation at oviposition was for B x W hens to lay facing the back of the cage more often than the other hens. It is suggested that this may have come about because this orientation would have given these hens direct access to the water troughs. B x W hens were particularly avid drinkers in the immediate pre-laying phase.

The finding that hens often turn immediately to feed after oviposition and are more commonly seen feeding during the 30 minutes after lay than in any other activity, was not surprising in the light of earlier reports in the literature concerning feed intake patterns related to oviposition. Food intake or feeding activity generally declines for several hours prior to oviposition and increases considerably for several hours post-oviposition. This trend has been found not only for hens under 14 hour photoperiods (Woodard and Wilson, 1970; Wood-Gush and Horne, 1970; Ballard and Biellier, 1975) but for hens maintained on a 14 hour photoperiod up until a week before being tested under continuous light (Duncan and Hughes, 1975) and for hens reared and tested under continuous light (Nys *et al.*, 1976; Savory, 1977). Wood-Gush and Horne (1970) and Savory (1977) suggest that the increase in food intake observed after oviposition is probably as compensation for the self-imposed reduction in intake preceding oviposition and possibly also in response to the high energy output due to the hyperactivity associated with the pre-laying phase. Although no actual records were taken, it was the definite impression of the observer that feeding activity was very low in the pre-laying phase in the present study.

The higher incidence of drinking as the initial post-lay activity in pens, probably reflects the tendency for caged hens, or at least some of them, to partake of water during the immediate pre-lay period, whereas hens in pens rarely drank when approaching oviposition. These hens therefore compensated for this deprivation by drinking immediately after laying.

Hens commonly sat down immediately after laying in a nest, whereas sitting immediately after lay was quite uncommon in cages. Hens in cages more often paid immediate attention to the egg just laid than they did after laying in a nest or nest site. Although it did appear that caged hens had in some way 'learnt' that they had to look for and manipulate the egg quickly, it is more likely that egg manipulations occurred sooner in this environment because the hens generally omitted the sitting which normally preceded it. The stimuli which release sitting behaviour, and which were probably inadequate to release full sitting behaviour in the pre-laying phase in cages, were probably also those which control post-lay sitting. Again, B x R hens showed a greater tendency to sit during the 30 minutes following oviposition. Alternative activities, other than feeding and sitting, were more often recorded during this post-lay period after pen nestings. This probably reflects the greater scope each hen had to perform different activities, whereas in cages activity options were more limited. However, battery hens have been reported to spend more time feeding than birds on deep litter (Bareham, 1972) and the present observation may be a reflection of this general tendency.

It is interesting to note that individual hens were as conservative in their selection of orientation in the cage at oviposition as they were in their selection of nest or nest site selected for depositing the egg in the pen situation. The strain effect on selection of nest site may have been related to social hierarchy of hens in the mixed strain flock. However, it was the author's impression that B x R hens were more protective of their nests in general, appeared to be more attached to them, and defended them more vigorously against intruders. In this way they managed to select and remain to lay in the apparently more attractive nests or nest sites for many eggs in succession.

This study was designed to compare gross behavioural changes associated with transfer of hens from one nesting environment to another. Unfortunately, any conclusions reached must be only tentative since the environments studied differed in many respects. Brantas (1980) listed some of these in his criticism of similar studies conducted by Martin (1975). These included differences in space available, the possibility of escape or lack of it, social environments and the existence of nests and nesting materials. One could add to these many other differences including proximity to other facilities, light intensity and other environmental conditions such as temperature and humidity which could also be influencing nesting patterns in the two environments. However, the study does indicate that differences due to environment and also to strain do exist. One advantage of the present study was that each bird served as its own control, so that effects of different environments on the behaviour of individual hens could be monitored. Although environmental and strain effects were detected in the data for particular parameters, different hens often responded to the nesting environments they were placed in in different ways.