3.1.3 Results

At the commencement of observations on 21st February, 1979, one hen, G34, had already come into production several days earlier. Although this hen was observed to nest and lay on 21st and 22nd February, complete records of nesting were not taken until 24th. The date on which each hen commenced laying and the total number of nestings which were observed during the period of study for each hen are given in Table 3.1.2.

Table 3.1.2 The date on which laying was observed to commence and the total number of nestings which were observed for each hen

Hen	Commenced Lay	Observed Nestings	Hen	Commenced Lay	Observed Nestings
G34	Pre 21/2	38	B97	15/3	22
G35	25/2	37	N.N	15/3	20
Y94	28/2	36	G43	19/3	20
B99	27/2	34	W82	19/3	20
B53	28/2	33	B71	21/3	19
G38	8/3	31	Y96	21/3	18
Y90	5/3	31	Y98	22/3	18
G39	6/3	31	W79	22/3	15
Y93	7/3	31	Y97	6/3	14
B00	7/3	31	W84	26/3	14
G41	5/3	30	Red	27/3	13
Y95	28/2	30	G37	30/3	11
Y99	8/3	29	B98	30/3	10
G42	8/3	28	Y92	28/3	9
B51	8/3	26	W83	30/3	8
G36	7/3	25	B54	1/4	8
W80	1/3	24	Y00	2/4	6
G40	13/3	22			

The small number of observations on several of the hens could not be avoided because of the considreable delay in the onset of maturity in these birds, subsequent poor production and the limited time available for the running of the experiment.

After several days of observation, the presence of the observer in the adjacent pen did not appear to disturb the hens, although she could obviously be seen by them.

Within one week, the observer was able to identify all hens by sight. Occasional visits into the pen by the observer were necessary from time to time, in order to check the identity of particular hens or to check if sitting hens had laid. These visits into the pen only very rarely altered the activity of nesting hens. Hens would continue to pace the same wall, or examine the same nest site as they had been before the observer had entered the pen, even if the observer had approached up to a distance of half a metre. Hens sitting on the nest could even be touched or picked up and replaced in order to read their leg bands and not subsequently leave the site. In general, the closer the hen was to laying, the less she reacted to the presence of the observer.

The observer was not able to record every laying by every hen in the flock during the period of study. However, only 23 eggs laid in the pen were unaccounted for, and an additional 28 nestings were discounted because of missed information. Since 840 nestings were observed and recorded, only 5.7% of the total possible nestings probably went unrecorded.

Some nestings were missed because they occurred outside observation hours or because the particular hen did not behave like a hen approaching nesting or did not behave as she typically did prior to laying on a particular day, and so her nesting went undetected until it was too late. Also, some nestings were discarded because it was considered that information had been missed because of the observer's inability to keep track of all nesting hens' activities during 'peak hours', i.e. those hours, generally between 9.30 am and 12.30 pm, when a large number of hens were actively performing pre-laying behavioural patterns and laying. Discounted recordings and cases of eggs being unaccounted for, were believed to be fairly evenly distributed among members of the flock.

. Nesting Behaviour

(a) *Components of the sequence*

A number of component activities of the pre-lay and post-lay behavioural repertoire of nesting hens were identified. A description of each activity will now be provided.

Nesting Call

One of the first indications of a hen's impending laying was often a persistent calling. The bill was open throughout the call, the lower mandible dropping slightly on each repeated note of the high intensity 'Qwa-a-a-a' call or lower intensity 'Qwa-qwa-qwa' call. As the intensity of calling

increased, the bill was opened further, the volume of the call increased and the bouts of calling tended to increase in length and frequency. Not only was concomitant movement of the abdomen evident in cases of high intensity calling, but most of the trunk was seen to move with the calling.

The call given sounded similar to calls given by hens when their caretaker entered the shed, or was occupied in some form of activity outside their pen as they looked on, particularly if they were hungry and hens were being fed in an adjacent pen. However, the characteristic which distinguished nest calling from other calls very similar to the human ear given in other contexts was its intensity and persistence.

Generally, the intensity of calling increased gradually as the hen approached oviposition. However, calling did not usually continue right up until oviposition, but terminated some time before it. Often, calling ended when the hen changed from pacing and nest examination activity to nest entry and sitting. Calling was frequently associated with wall pacing and 'escape' activities and was often heard between nest examinations. However, as a hen approached a potential nest site in the nest-examination stance, which will be described later, her calling tended to die away.

Calling tended to be accompanied by pacing, particularly over the first few days of a hen's laying history. A number of the pullets were observed to call for some time for one or two days prior to their first oviposition. In such cases, calling was not usually associated with pacing or locomotion of any kind. Calling intensity of such pullets was generally quite low and they would utter the calls as they stood facing out beyond the pen.

While calling, hens were invariably looking outside their pen and never called with eyes fixed on fellow flockmates. While calling, the tendency appeared to exist for hens to be not so much facing away from their flockmates, but to be fixating on something beyond their immediate pen. Thus, they often appeared to be looking 'through' their flockmates as they faced the pen walls or what was beyond them, and movements of flockmates in the foreground of their field of vision did not distract their attention. In the pen in which these broiler hens were kept, pacing and callingwere highly concentrated along the eastern pen wall, where hens could easily see through the upper, wire-mesh section of the eastern wall and into the adjacent pen, where the flock of White Leghorns was kept. The next most popular areas for calling and pacing activity were along the northern wall and door-section of the southern wall, where, again, the hens could easily see through the wire mesh to the grassed area outside or shed aisle and wall respectively.

Pacing and calling were rarely seen along the windowless galvanised iron shed wall which formed the western wall of the pen.

The occasions or laying days on which each hen was heard to utter the nesting call as part of its pre-laying behavioural sequence are given in Appendix 3.1.1.

Pen Pacing and Restlessness

Another early and reliable indicator of approaching oviposition was a noticeable restlessness and increased locomotion about the pen. This activity tended to place the hen in areas of the pen in which she would not generally be found on non-laying days at the same time of day. As stated above, the hen would gravitate towards the walls of the pen and would pace backward and forward along them, eyes directed beyond the pen. Photographs of layer strain hens from a later study performing such wall pacing activity are shown in Plate I.

Initially, this activity would take place at quite a steady walk with the hen making one pass down the wall every so often, preening, feeding, scratching in the litter and so on in between. However, pacing activity tended to become more intense as oviposition approached. Pacing steps would become more rapid and the hen would move one way then back along the wall, almost always in such a way that she would be facing the wall throughout the movement. Changes of direction would often become even more frequent, with the hen pivoting on the one spot but changing her orientation along the wall every few seconds. The hen in this state would often fly or jump up the wall, as if trying to push herself through the wall or escape from the pen.

Quite frequently, a hen reaching a corner or an obstructing group of hens would dash across the pen to another pen wall or potential nest site, where she would continue to pace. In many cases, hens were observed to be running in an extremely agitated manner about the pen.

As noted before, pacing was most frequently carried out along the pen wall shared with the White Leghorn flock. If, while pacing along a pen wall, a hen came to a less favoured section of wall or pen for pacing, such as the western wall, she would turn and dash back to her more favoured site across the pen. Several hens were often observed to lay during this activity, 'on the run' as it were, particularly as inexperienced layers. However, pacing activity and 'escape' behaviour generally ended with nest entry.

Individual hens varied considerably in the extent to which they performed pacing and 'escape' activities. The intensity of such activities changed considerably as the hens became more experienced with laying or with their laying environment, as will be discussed later. The occurrences of pre-lay pacing activity of differing intensities for each hen are given in Appendix 3.1.2.

Nest/Nest Site Examination

The hen, when approaching a potential nest site, tended to stretch her neck and head out towards the site and, with eyes fixed on the site, quite slowly, almost 'carefully', step towards it, bringing the feet up high underneath her body as she did so. Several photographs of layer strain hens exhibiting this approach to the nest or nest site are shown in Plate I.

This exaggerated approach to the nest site was again more evident in some hens than in others. Hens also tended to become more casual in their approach to the nest site as they became more experienced.

Hens approaching and examining the provided nest-boxes adopted a slightly different stance which tended to be slightly less exaggerated or cautious. However, before examining a nest, hens had first to fly to the perch outside the nests, from which they would examine the nests. This proved quite a difficult procedure for many of these broiler hens and it was not uncommon for hens which had had previous experience with the nest-boxes to be seen repeatedly flapping desperately, trying to get a grasp of the wire perch. Some more agile hens, on the other hand, would make a number of flights to the perch before examining any nests, or between examinations or nest entries. A photograph of one layer strain hen from a later study examining a potential nest is shown in Plate I.

Both floor-laying hens and nest-box layers exhibited increased interest in nest sites and in nest examination and partial nest entry as time went by and oviposition neared. All hens on almost all occasions exhibited some form of nest examination behaviour.

Nest Entry

Most hens, whether nest or floor-layers, at some stage in the pre-laying behavioural sequence, entered a nest/nest site or several nests/nest sites. The exceptions were those hens, mentioned previously, which laid 'on the run'. Usually, nest entry was preceded by a number of partial entries, in which the hen would move only part of her body into the nest. However,

PLATE I

PLATE I

Top left: Layer strain hen pacing along the pen wall whilst calling and facing out of the pen at the onset of the pre-laying phase

Top right: Pacing of the pen wall whilst facing away from the pen during the early stages of pre-laying behaviour

Second row, left: Hen moving along a pen wall with exaggerated high feet lift action characteristic of the nest examination phase

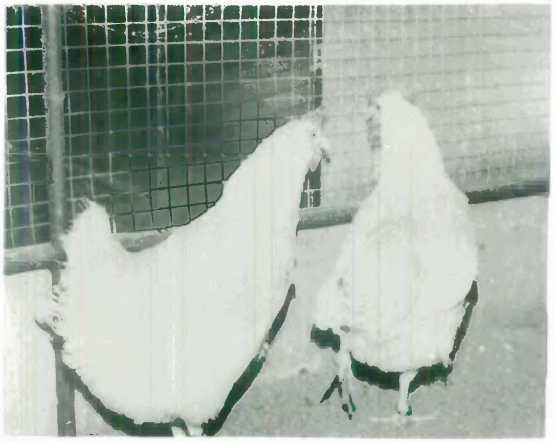
Second row, right: Hen 'examining' pen walls with characteristic slow steps and high feet lift action

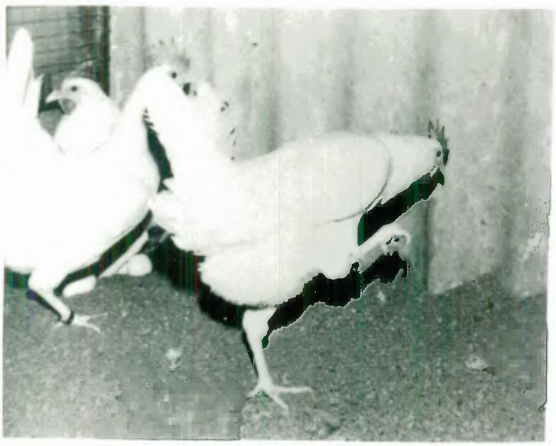
Third row, left: Hen approaching potential nest site in horizontal body position with head and neck stretched towards the site and slow, exaggerated high foot lift action

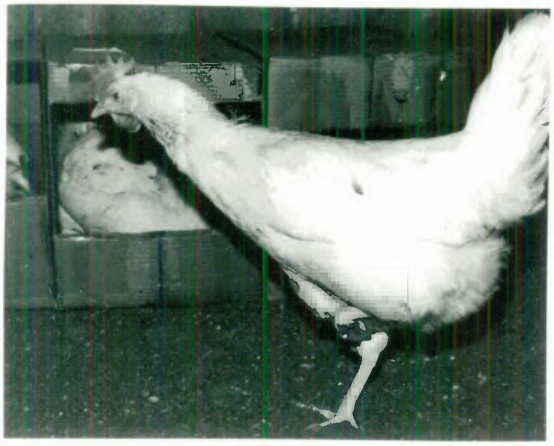
Third row, right: Hen approaching potential nest-site during the nest examination phase. Two hens already occupy the site, one (sitting) about to lay, and the other (standing) having just laid

Bottom left: Hen approaching nest-boxes

Bottom right: Hen 'examining' a nest-box. At this point only the head is stretched into the nest







the approach to and entry into nests became more direct as the hens became more experienced. Having entered a nest, a hen did not necessarily settle down within that nest. It was far more common for a hen to enter a number of nests, examining and sometimes pacing in between entries, than to sit in the first nest entered.

Sitting

Usually only after several nests had been entered did a hen sit for the first time. Having once sat, it was most unusual for the hen to remain sitting in that nest up until oviposition, except in the cases of several individuals when they had become quite experienced layers. Most hens would sit within several nests before laying or would at least leave the one nest several times and re-enter and sit at later stages. Initially, the length of stay in the nest was short but gradually increased with oviposition nearing. Of course, there were the exceptions to this general case. Several hens repeatedly sat for quite extended periods up until the last 20-30 minutes before oviposition, at which point they would start moving from nest to nest in a rather excited state, sitting for short periods, generally under a minute per stay, then moving to another nest and so on until they laid.

The nesting hen sitting within a nest site or nest was very difficult to dislodge. She sat firmly and was not easily moved by either another hen or a person, sometimes repelling the approach of either by vigorous pecking, similar to a broody hen sitting on a clutch. More often, however, she would simply refuse to be distracted by the intruder and paid little attention to her presence. Several hens would ruffle the feathers and give a particular call, a prolonged, shrill 'growl' usually lasting several seconds, when approached by a potential intruder.

One hen in particular, G90, repeatedly 'protected' her chosen nest site in this way. She would sit firmly in the nest facing out into the pen and call in this manner at any hens on the perch or in adjacent nests and even at hens below her on the pen floor beneath the perch. Although only a middle ranking hen in the social hierarchy of the flock, she quite successfully deterred other hens from attempting to usurp her from the nest and was only rarely observed to be forced from the nest by another hen, or even joined in the nest by another during the pre-laying period.

Firmly sitting hens could be picked up and replaced into the nest without disturbance and on being lifted up kept their legs tucked up underneath the body. While considerable egg rolling and nest building activities took place during this sitting phase, the final stages of sitting, until oviposition, were normally very firm, involved little activity, and although the hen was generally alert through this period, consisted of several phases of sitting with eyes shut. Sitting was exhibited by both floor and nest layers and followed essentially the same pattern, except perhaps that floor nesters were more likely to be disturbed than were nest layers in this phase.

Nest Building and Other Activities on the Nest

(i) Body rotations and foot scraping

The most commonly observed form of nest building involved these two activities. One of the first movements performed involved a quick left-right, left-right movement of the chest of the hen on the nest floor. The movements were rapid, a bout consisting of three or four changes in direction in under four seconds and the maximum range of angle through which the body changed throughout the movement was about 15°.

Once settled into the litter in this manner, the more elaborate rotations would take place. The hen would crouch in the nest and rotate around via pushing movements of her feet on the floor/in the litter, her feet scraping out to the side and away from the body and slightly backwards from it. These rotations might proceed through anywhere up to 360° in one direction and changes in direction of the rotations occurred at apparently random intervals. The movement of the feet producing the rotations gave the body a rather unsteady rocking motion throughout the procedure. The foot scaping and rocking produced quite a loud and characteristic sound when performed by these large hens in the sheet metal nests. These rotations were often performed with the breast down in the litter and the hind part of the body raised, but were also produced with the breast not in contact with the floor. The foot scraping and rotating activities resulted in the formation of a circular depression in which the hen sat. A rim was usually formed up around the sides of the hen's body.

Individual bouts of foot scraping and rotations lasted anywhere between several seconds and half a minute.

(ii) Litter raking

While sitting within the nest site, and usually between bouts of foot scraping and rotations, the hen would look down at her chest, first to one side, then the other, and by stretching her neck and head out, scrape litter towards her body in quick, jerking head motions. Material was thus 'thrown' back onto the edge of the formed depression about her body using the underside of the bill in these jerking movements. Usually only one, but sometimes several of these movements occurred in succession. Usually the hen would pause and look down at the chest and the litter again between these raking movements, as if assessing what litter to collect next or where it was to go.

Litter raking only occurred while the hen was sitting and did not occur with any other form of body movement. It did, however, tend to lead on to another form of nest building activity, that being material gathering to the chest.

(iii) Material gathering - dropped at the chest

This activity always took place when the hen was sitting in the nest in the depression formed by her rotations. The hen would fixate on some object, usually a piece of litter just beyond the rim of her nest, then stretch her neck and head out, grasp the object in her beak, and in the same movement pull her head back and drop the item at her chest on the rim of the formed depression. She would pause and fixate on another object momentarily before repeating the movement. Such gathering movements occasionally occurred singly, but more frequently a number of movements would occur in sequence.

(iv) Material gathering to the back or sides

Material gathering activities occurred in several different situations but the retrieval movement itself was always of a constant form. The hen would stretch her neck out, eyes fixed on the object to be collected, usually a feather or larger particle in the litter such as a piece of bark, pick the material up in the beak and in one flowing movement turn the neck back, as if attempting to look right back over the body, and drop the piece of material. The head tended to be held in such a way that it was directed out or away from the body, rather than directly back towards the tail, and the feather/litter was usually dropped anywhere from just over the shoulder to right onto the back.

The hen would not be moving any other part of her body during the material gathering movement. Several such movements would usually occur together, often with a pause between each as the hen fixated on the next object to be collected, but sometimes in quick succession. If a handful of feathers was placed in front of a sitting hen, she could often be stimulated to perform the gathering movements. Faced with a number of feathers, the hen would initially pick several up in rapid succession before beginning to pause between collections. She would not necessarily pick up all the presented feathers. Material gathering activities would occur with highly variable frequency during the nesting period of any one hen.

Material gathering activities of this sort occurred in three different situations:

. Material gathering to the back on the nest (henceforth referred to as 'M.G. to back'). In this situation the hen would be sitting within the nest formed by her previous nest building activities, see the desired materials to be collected, then reach out and begin to collect them. Plate II shows a layer strain hen from a later study in the act of transferring material to her back.

PLATE II Layer hybrid hen in the process of transferring material to the back using the material gathering movement, whilst on the nest before laying.

. Material gathering to the back while walking about the shed prior to laying ('M.G.in shed'). In such cases the hen would rise from her nest and begin walking slowly away from it, looking down at the floor as she went, pausing to collect items as she went. While collecting each item, the hen would be standing but not actually in motion at the time. She would frequently destroy her previous construction during such expeditions. This would occur where the hen, having just left the nest, would turn back to the nest, or chance upon the nest as she walked about the pen, and commence to pick up whatever lining she had previously gathered to the site and throw it on her back or over her shoulder away from the nest. Despite this destructive activity, she would invariably return to the same site and continue nest building activities and eventually lay within it later. Such material gathering 'expeditions' often followed on from gathering activities within the nest. The hen would become engaged in a bout of gathering activity and would be attracted to material further away from the nest. When the distance to a desired item was greater than the hen was able to reach by stretching from the nest, she would stretch out towards it and rise from the nest, then continue on walking and gathering as she moved through the pen.

. Material gathering to the back after laying ('M.G.after lay'). Although material gathering occasionally occurred while the hen was sitting on the nest after oviposition, it was much more frequently observed after the hen had left the nest. The hen would begin to walk slowly about the pen as in the previous situation, gathering items as she went. Usually when this activity occurred after the hen left the nest, it was continued for under a minute before the hen became distracted and went to feed or water.

The occasions on which each hen performed any of these manipulative activities are given in Appendix 3.1.3.

Egg Rolling

Although in this study eggs were collected as soon as possible after they were laid or after the hen laying them had vacated the nest, hens approaching oviposition would occasionally come in contact with another hen's egg. On so doing they often paid the egg considerable attention. This took

the form of manipulations of the egg in which the hen would stretch her head out to and over the egg and draw it back to her breast. She would do this by rolling the egg with her bill, which she would place over the egg and then draw back. Several photographs of hens of a layer strain used in a later study attempting to roll eggs or move the breast over the eggs are shown in Plate III. In two of these photographs, one of the hens can be seen attempting to roll an egg out from underneath another hen and inspecting underneath another hen which is just about to lay an egg.

Flicking movements of the head and beak were often seen when the egg was in materials in which it was easily lodged. The hen appeared to be pecking at the egg but would actually be performing quick, flicking movements with the beak which again would be applied above and slightly over the egg. A number of these flicking movements would usually be seen in a sequence.

Additionally to rolling eggs, hens would position eggs at or under the breast by moving forward over them. In doing so, a hen would ruffle her feathers and, while still in a sitting position, lift herself up slightly, settling down again over the egg. The egg was then usually in a position under the hen in contact with her breast. The feathers ruffled, wings slightly out posture of hens covering eggs in this fashion resembles that of an incubating hen covering her clutch.

Hens sitting on the nest after laying often performed these manipulations of their, or others' eggs which happened to be in the nest. It was also common to observe hens having just laid and while still in the laying stance, look down underneath themselves, or reach right back under the body, between their legs, and roll the egg forward towards the front of the body before sitting.

Laying

Experienced layers usually sat quite firmly for a period of time just prior to laying. They would raise themselves into a squatting or half-crouch position in preparation for the dropping of their egg and begin straining to expel the egg. On each pushing movement the cloaca would be lowered further towards the floor and the thorax raised higher. Straining movements were sometimes accompanied by bill-closed squeaks or 'groans'. The actual stance of the hen while laying varied markedly between individuals. While the most common stance was a squatting position with legs bent, a few hens regularly remained in a sitting position throughout the process. Others, particularly hens which tended to spend a longer period of time straining, would lay in

a standing position with the body almost vertical. Plate III shows two laying hens from a later study, one just raising itself to lay and the other in the laying stance after just having laid an egg.

The whole process, from raising themselves into the laying stance to oviposition, took anywhere from several seconds to a minute. Having expelled the egg, the hen would raise the body slightly, lifting the tail higher off the floor, and remain immobile in this position for several seconds. This period is referred to as the 'relaxation phase'. The hen would then either begin to leave the nest or sit down within the nest again.

Sitting on the Nest After Lay

After laying, most hens remained for a variable length of time sitting within the nest. During this period the hen would manipulate the egg and perform some nest building activities, but mostly she would sit quietly, sometimes alert, sometimes with eyes closed. She would eventually stand, sometimes as a result of disturbance by other hens, but mostly of her own volition, and leave the nest. Her movements out of the nest were generally slow. Having left the nest the hen would either head straight for food or water, carry out the previously described material gathering activities for a short period and then feed or drink, or cackle for some time before feeding or drinking.

In most instances, feeding and/or drinking signalled the end of nesting for that day. After feeding or drinking the hen would resume non-nesting activities. Very occasionally, such nesting related activities as calling, nest examination, nest entry or sitting were repeated by particular individuals some time after laying.

Post-Lay Cackling

This widely recognised call was sometimes heard as a hen sat within the nest after laying, left the nest, or moved into the pen area after laying. It was usually repeated for anywhere up to several minutes and was usually associated with a redirection of activity, for example a hen would move from the nest into the pen when cackling.

In all, 56 out of 158 nestings which took place in elevated nest were accompanied by post-lay cackles. Corresponding figures for ground est and floor site nestings were 9 out of 131 and 3 out of 289 nestings respectively.

Of the eight hens which were seen to lay in elevated nests, five were observed to give post-lay cackles. Ten hens were observed to use ground nests and of these two performed post-lay cackles. Only two of the 32 hens which at some time used floor sites were observed to cackle after laying in such

PLATE III

PLATE III

Top left: Layer strain hen attempting to roll an egg whilst in a standing position

Top right: Hen moving over a group of eggs

Second row, left: Hen (centre field) attempting to roll an egg from under another sitting hen

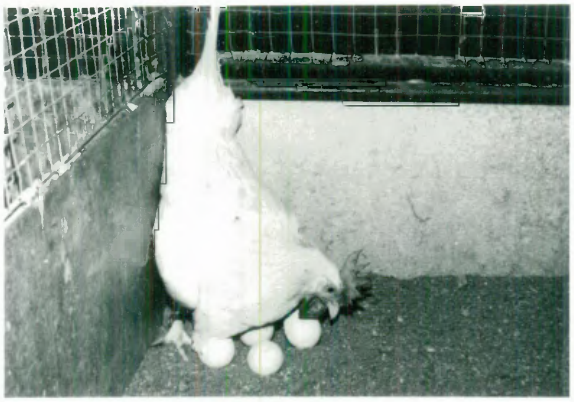
Second row, right: Hen (left of field) examining underneath another hen which is on the point of oviposition. As the second hen dropped her egg, the first hen immediately rolled the egg away

Third row, left: Hen (right of field) creeping or 'nuzzling' under another hen which has just laid

Third row, right: One hen attempting to nest under another which has just laid

Bottom left: One hen climbing over the top of another to get to a preferred nesting site on the pen floor. The top hen has just laid

Bottom right: Hen laying in one corner of the pen, showing typical laying stance, and orientation into the corner. In this instance the hen's head is directed into a corrugation formed in the fibro wall of the pen





sites. Analysis of these data (see Appendix 3.1.4) indicated that post-lay cackles were given significantly more often by hens using elevated nests rather than ground nests or floor sites.

Occasionally, a call indistinguishable from the cackle given after laying was performed by hens as they sat on the nest prior to laying. Such calls were not initiated by either post-lay cackles or ground predator alarm calls from within the flock and did not stimulate the flock to give the ritualised flock warning call. In fact, as in the case of post-lay cackles, other flock members appeared to pay little attention at all to the caller. Like hens uttering post-lay cackles, the caller usually would stand, leave the nest and feed and drink after performing this 'pre-lay cackle'. The hen would always return to the nest, although not necessarily the same nest, and continue nesting some time later.

Other Activities Associated with Nesting

Before assuming the firm sitting position described previously, nesting activities were interspersed with other activities such as feeding, drinking, preening, scratching in the litter, or more rarely, dust-bathing. However, with the approach of oviposition such activities became more and more infrequent. Dust-bathing in the nest was not observed to occur in any cases of nest occupancy in relation to nesting.

'Nuzzling under', the term used for a behaviour described by Wood-Gush and Gilbert (1969b) was probably the same as a behaviour observed in this study. Young hens were often observed to attempt to crawl under other nesting, or even standing, hens, when approaching oviposition. Usually the other hen would move away when disturbed in this way and the first hen would remain in the same position, looking around momentarily, and then move off to try another hen. Two photographs of layer strain hens from a later study engaged in 'nuzzling under' are presented in Plate III.

After 'nuzzling under' a flockmate, the hen would remain with head down, sitting under the other bird. A list of all hens in the flock and the occasions on which each was observed to exhibit 'nuzzling under' behaviour, if ever, is given in Appendix 3.1.5. Twenty six hens were observed on some occasion to perform this activity.

In older hens the tendency to 'nuzzle under' other hens was less evident. However, a number of hens continued to exhibit a preference for laying sites

which were occupied by other hens and would do so repeatedly, even in the presence of adjacent vacant nests. A number of floor laying hens would repeatedly move from one hen or group of hens to another, attempting to nest next to her/them. There the hen would remain until the other hen moved away or chased her away, or until she laid. If unable to lay near another hen, such birds would run in an apparently distressed state from flock-mate to flock-mate. They sometimes dropped their eggs at random in the pen while pursuing such activities.

Nest laying hens with a preference for occupied nests would also move from nest to nest attempting to nest with other hens. Once such a hen had entered an occupied nest she would quietly sit or stand, disturbing her nest-mate very little, and usually faced into a corner or away from the nest-mate. Frequently, the intruding hen was quite vigorously repelled and would be evicted from the nest. Occasionally, the occupier of the nest would leave the nest and enter another. Hens preferring occupied to vacant nests were termed 'sociable' nesters. Hens displaying the opposite tendency, that being a preference for vacant nests, were called 'solitary' nesters. The existence of these two factions in the flock often contributed to a somewhat chaotic situation in which solitary nesters were continually forced from nest to nest by the attentions of a sociable flock-mate. Squabbles over nest sites were frequent and changes in nest occupancy common as a result of this. However, solitary nesters, when very close to oviposition, would often become very tolerant of other hens in their nests, at least until they had laid their eggs.

Floor and nest layers exhibiting such preferences for occupied nest sites are listed in Appendix 3.1.6, along with a description of the manner in which the preference was expressed. Twelve of the 37 hens were confirmed sociable nesters, although several other hens exhibited these tendencies on one or two occasions. The remaining hens were either totally solitary nesters, or individuals which preferred to enter vacant nests but were tolerant of other hens entering the nest. Several examples of layer strain hens from a later study nesting together or 'communally' in a favoured site are shown in Plate III.

(b) *Effect of Individual Differences and Experience*

The total number of nestings observed for each hen and the number of these that were accompanied by pacing, nest calling, pre- and post-lay cackling and various nest building activities are given in Table 3.1.3.

All but seven hens were found to have performed at least one activity either more or less frequently than would have been expected from total flock frequencies of occurrence, i.e., greater than 2 S.D. above or below the expected value calculated from mean flock frequencies of each activity and the number of observed nestings for that particular hen. No particular trends were evident except, perhaps, that where calling was either more or less frequently recorded than expected, pacing tended to follow the same trend. Similarly, if the observed frequency of one nest building activity was higher or lower than that predicted, other nest building activities would tend to react in the same direction. In addition, nest building activities appeared to occur at a lower frequency where hens had completed fewer nestings before the completion of the study. However, it is quite evident from the data recorded on Table 3.1.3 that each hen behaved differently, or at least used each component in the nesting sequence to a different extent, in its behavioural pattern leading up to and following oviposition.

The results of pairwise correlation coefficient calculations performed on the data contained in Table 3.1.3 are given in Table 3.1.4. Only coefficients significant at the 5% level or higher are given. Correlation coefficients were not calculated between pre-lay cackles, post-lay cackles, M.G. to the back, in the shed, after lay with any other activity because of the large number of hens which were not observed to perform these activities.

As previously suggested, calling and pacing were found to be highly correlated with litter raking and material gathering to the chest. Significant positive correlations were found between nest building activities and material gathering. Significant positive correlation coefficients were also found for litter raking and material gathering to the chest with the number of observed nestings. The longer the hen had been in lay, the more likely she was to perform these activities, at least within the time span of this study. Although the data is limited and cannot be analysed, similar associations between the number of observed nestings and other material gathering activities and both pre- and post-lay cackling are suggested by the data. Calling was negatively correlated with the number of observed nestings. The tendency was for nest calling to decline in importance the longer the hen had been in lay.

Further information on the influence of age or laying experience of hens on the occurrence of various nesting behaviours can be extracted from Appendicies 3.1.1, 3.1.2 and 3.1.3. When the data for all hens were pooled and the frequency of occurrence of each activity on each laying day (L1, L2, ... Ln) is calculated (Appendix 3.1.7) the trends in occurrence of each activity with 'time' (or experience) could be studied in greater detail.

Table 3.1.3 The number of observed nestings for each hen, and in total, which were accompanied by pre-lay pacing (Pacing), the nesting call (Calling), pre- and post-lay cackles, rotations and foot scraping in the nest (Rotations), litter raking on the nest (Raking) and material gathering, in the nest/dropped at the chest (To Chest), in the nest/placed on the back (On Back), off the nest before laying (In Shed) and after laying (After Lay)

		Number of Observed Layings Accompanied by These Activities									
Hen	Observed Nestings	Pacing	Calling	Pre-Lay Cackle	Post-Lay Cackle	Rotations	Raking	To Chest	Material Gathering On Back	Material Gathering In Shed	After Lay
G34	38	33	26	20+	20+	38+	36+	26+	4	0	4
G35	37	34	28	4+	14+	35+	31	23+	3	0	2
Y94	36	36	33+	0	0	36+	32+	10	1	0	0
B99	34	34	30	0	0	30	28	15	2	4+	1
B53	33	32	24	0	3	31	19	10	2	0	4
G38	31	19-	8-	0	2	31+	28+	21+	11+	5+	3
Y90	31	31	27	2	19+	31+	29+	9	0	0	3
Y91	31	29	27	2	2	30	21	11	4	4+	3
G39	31	19-	3-	0	0	30	30+	19+	6+	2	0
Y93	31	31	18-	0	0	9-	6-	2-	0	0	0
B00	31	26	26	0	0	28	25	18+	2	0	5+
G41	30	25	19	0	0	29	24	13	2	0	2
Y95	30	28	25	0	0	20-	10-	6-	0	1	2
Y99	29	29	29+	0	0	29+	28+	17+	0	1	2
G42	28	26	28+	0	0	27	24	13	1	0	0
B51	26	22	23	1	0	26+	23	14	8+	2	2
G36	25	17-	12-	0	0	25	23+	19+	2	0	0
W80	24	24	24+	0	0	22	16	9	3	3	3

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Table 3.1.4 Significant correlation coefficients for each activity with every other and the number of observed nestings

	Observed Nestings	Pacing	Calling	Rotations	Raking	Material Cathering to Chest
Observed Nestings						
Pacing						
Calling	-.375 *	.703 ***				
Rotations						
Litter Raking	.437 ***	-.361 *		.835 ***		
M.G. to Chest	.602 ***	-.533 ***	-.331 *	.680 ***	.815 ***	

Table 3.1.3 (cont.)

Hen	Observed Nestings	Number of Observed Layings Accompanied by These Activities: Pacing	Calling	Pre-Lay Cackle	Post-Lay Cackle	Rorations	Raking	To Chest	Material On Back	Gathering In Shed	After Lay
G40	22	22	18	0	0	2-	1-	0-	0	0	0
B97	22	18	18	0	7+	22	11	9	0	0	5+
N.N.	20	16	10-	0	0	20	11	7	2	3+	2
G43	20	20	19	0	0	19	17	10	5+	3+	0
W82	20	20	16	0	0	18	10	4	1	2	0
B71	19	17	16	0	0	17	15	11	8+	3+	6+
Y96	18	18	18+	0	0	18	13	6	1	2	2
Y98	18	15	13	2	1	18	14	6	3	1	0
W81	17	10-	8-	0	0	6-	2-	1-	0	0	0
W79	15	15	13	0	0	14	6	2-	0	0	1
Y97	14	14	7-	0	0	7-	4-	2	0	0	0
W84	14	14	13+	0	0	7-	5-	1-	0	1	1
Red	13	13	13	0	0	7-	2-	1-	1	0	0
G37	11	8	8	0	0	11	11	4	1	1	0
B98	10	10	9	0	0	8	3	2	0	0	0
Y92	9	9	9	0	0	9	8	2	0	0	0
W83	8	8	8	0	0	2-	1-	0-	0	0	0
B54	8	8	8	0	0	6	3	1	0	0	0
Y00	6	6	6	0	0	6	3	0	0	0	0
Total	840	756	640	31	68	724	573	324	73	38	53
% of all		90.0%	76.2%	3.7%	8.1%	86.2%	68.2%	38.6%	8.7%	4.5%	6.3%

+ = value more than 2 S.D. above the expected value; - = value more than 2 S.D. below the expected value

Regression equations calculated for each activity are given in Table 3.1.5. The untransformed data and corresponding lines of best fit for each activity are plotted in Figures3.1.5 to 3.1.13. The figures show that the incidences of both pacing (Figure 3.1.6) and nest calling (Figure 3.1.5) activities were very high for the first few days after the hen began to lay. The first six or so eggs ever laid by hens were in nearly all cases preceded by pacing and/or nest calling activities. However, thereafter the incidences of both activities declined as the number of nestings/laying experiences increased. Within the 'time' span studied, i.e. to 31st occasion on which each hen laid, both activities were still declining in frequency, although the decline in incidence of nest calling with time was levelling off.

Not only was the incidence of pacing dropping significantly over time, but the intensity of pacing preceding oviposition was also undergoing change (Figure 3.1.7). While pacing was, at the onset of laying, generally performed at intensities of either classification *** or **, the incidence of pacing at such intensities dropped off steadily (***) or more gradually (**) the more nesting experiences a hen had completed. Concomitant with this was a steady increase in pacing activity which never advanced beyond the intensity * stage. There was an increase in the incidence of intensity *** pacing towards the end of the study.

Rotations and foot scraping (Figure 3.1.8) were observed in the pre-laying behavioural repertoire of about half the hens at their very first oviposition. The occurrence of these activities increased throughout the next six or seven occasions on which the hens laid, and levelled off for the rest of the study. Hens at that stage were performing rotations and foot scraping activities in association with approximately 90% of all their nestings.

Litter raking (Figure 3.1.9) was observed to be performed by only one hen when laying its first egg. However, the incidence of this particular nest building activity increased sharply thereafter, so that after ten nesting experiences, approximately 80% of nestings were accompanied by litter raking. A second increase in the frequency of litter raking, starting at the 23rd laying day and resulting in the significant cubic component of the calculated regression equation given in Table 3.1.5, is apparent.

Material gathering to the chest by hens sitting on the nest was not observed to occur on the first five days on which any hen laid (Figure 3.1.10). However, its incidence increased steadily throughout the study to the point where it was occurring in the pre-laying behaviour of hens in about 80% of all cases. The pattern of increase in incidence of this activity indicated

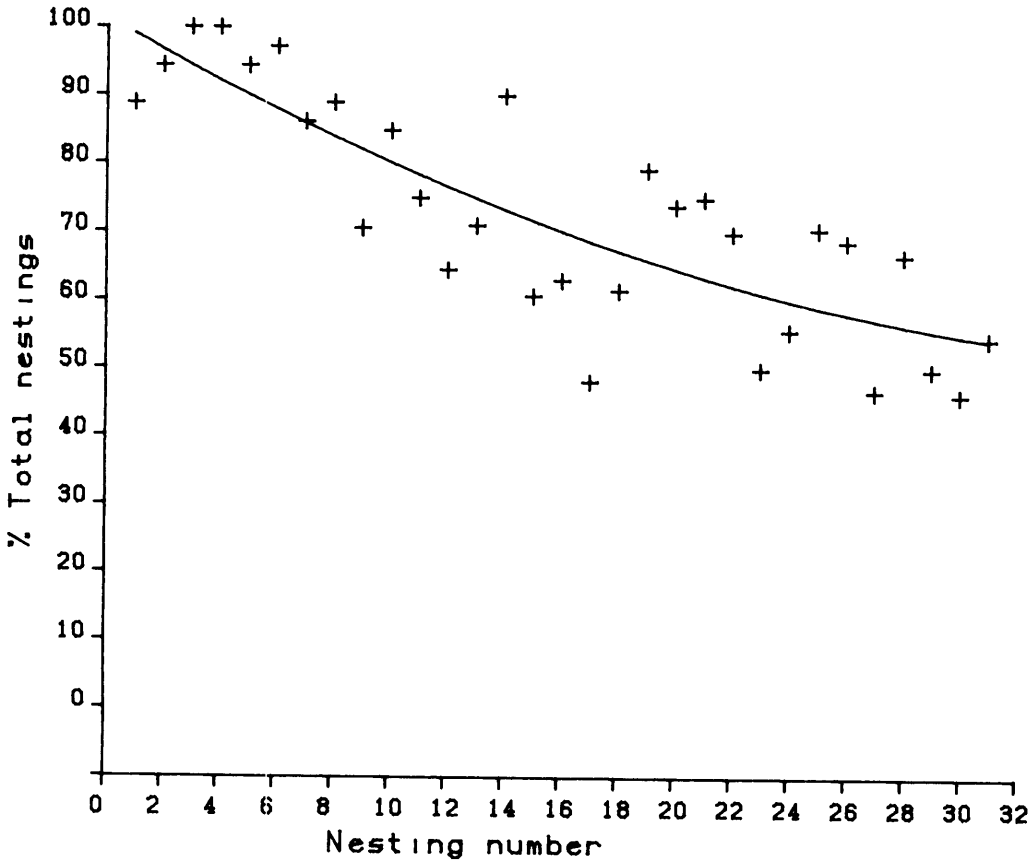

Figure 3.1.5 Frequency of occurrence (% of total nestings) of nest calling for each nesting from laying days 1 to 31

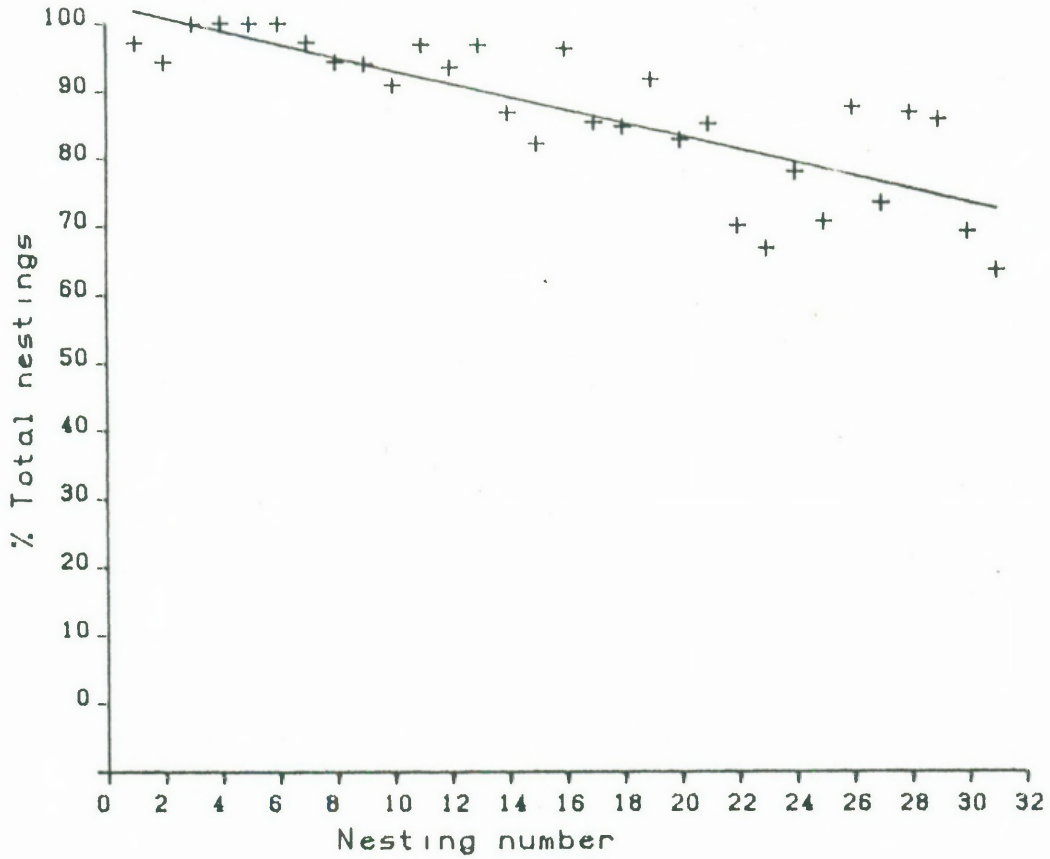

Figure 3.1.6 Frequency of occurrence (% of total nestings) of pacing for each nesting from laying days 1 to 31

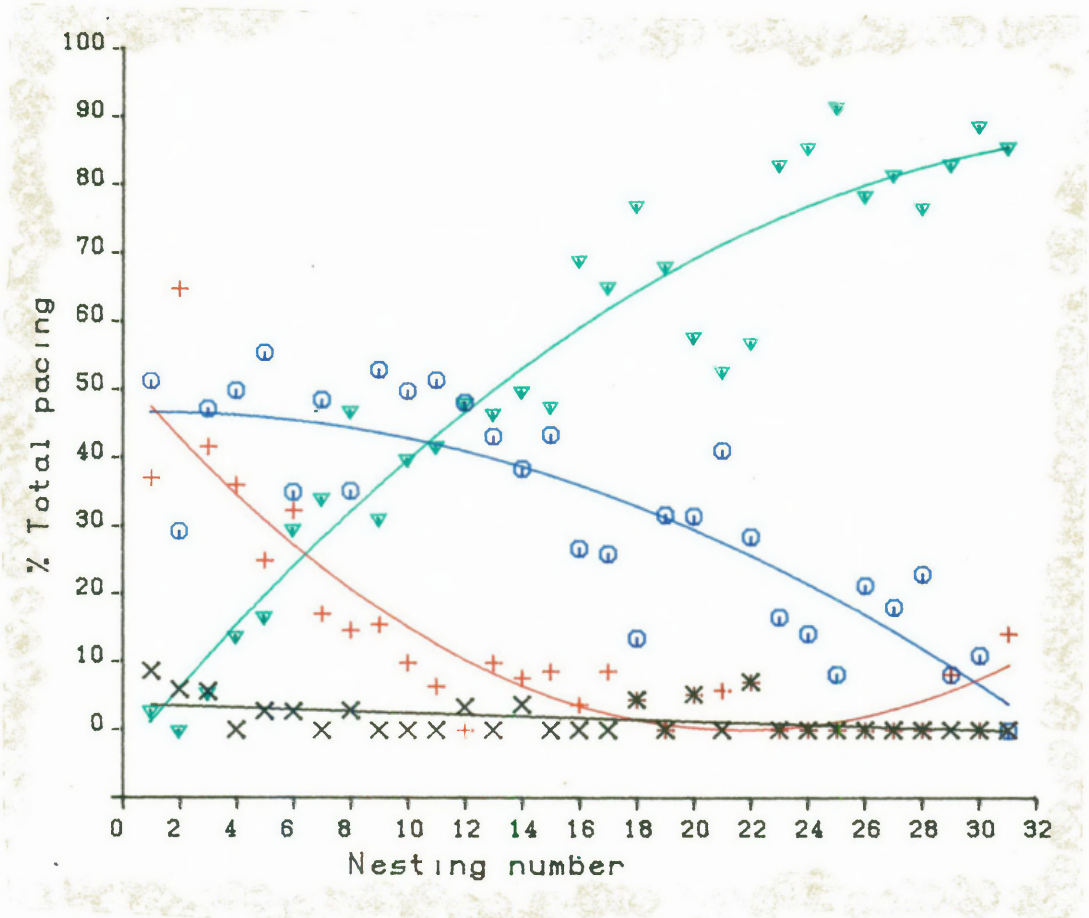

Figure 3.1.7 Frequency of occurrence (% of total nestings) accompanied by pacing of intensity *(▼green), ** (o blue), *** (+ red) and **** (x black) for each nesting from laying days 1 to 31

Table 3.1.5 Regression equations calculated to describe trends in the frequency of occurrence of nesting activities with increasing maturity

Activity	Regression Equation	Significance
Nesting Call	$y = 1.4897-0.04135x+0.000663x^2$	P<.1
Pacing	$y = 1.5251-0.01743x$	P<.001
Pacing Intensity		
****	$y^1 = 0.1674-0.00566x$	
***	$y^1 = 0.08614-0.06407x+0.001343x^2$	P<.001
**	$y^1 = 0.7248+0.00807x-0.000799x^2$	P<.01
*	$y^1 = 0.1019+0.0661x-0.001032x^2$	P<.001
Rotations	$y = 0.9657+0.02686x-0.000489x^2$	P<.001
Litter Raking	$y = 0.1982+0.1431x-0.007316x^2+0.0001262x^3$	P<.001
M.G. to Chest	$y = -0.2977+0.1435x-0.006185x^2+0.000097x^3$	P<.05
M.G. to Back	$y = 0.0355 +0.0145x$	P<.001
M.G. in Shed	$y = 0.0234+0.0096x$	P<.01
M.G. After Lay	$y = -0.0201+0.01506x$	P<.001

where: y = % of total nestings which were accompanied by that particular activity, transformed by arc sine $\sqrt{p}$

y^1 = % of total nestings accompanied by pacing which were performed at that particular intensity transformed by arc sine $\sqrt{p}$

x = laying day number (1 to 31)

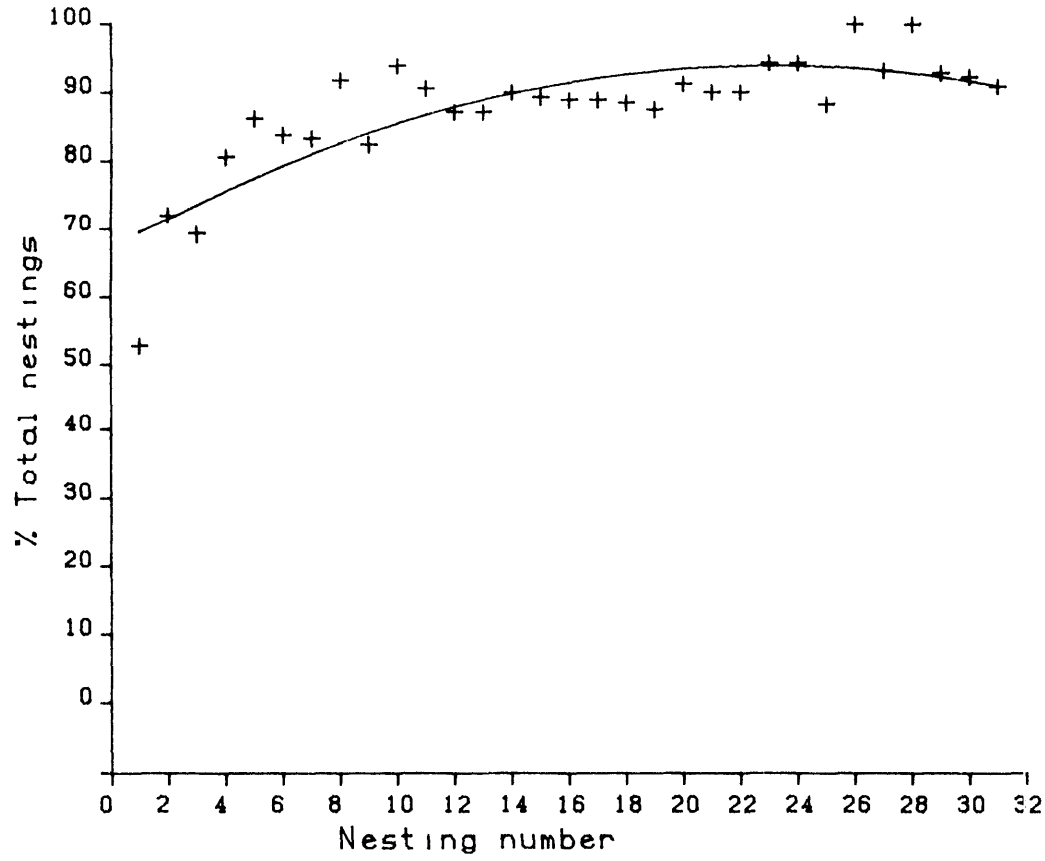

Figure 3.1.8 Frequency of occurrence (% of total nestings) of rotations and foot scraping for each nesting from laying days 1 to 31

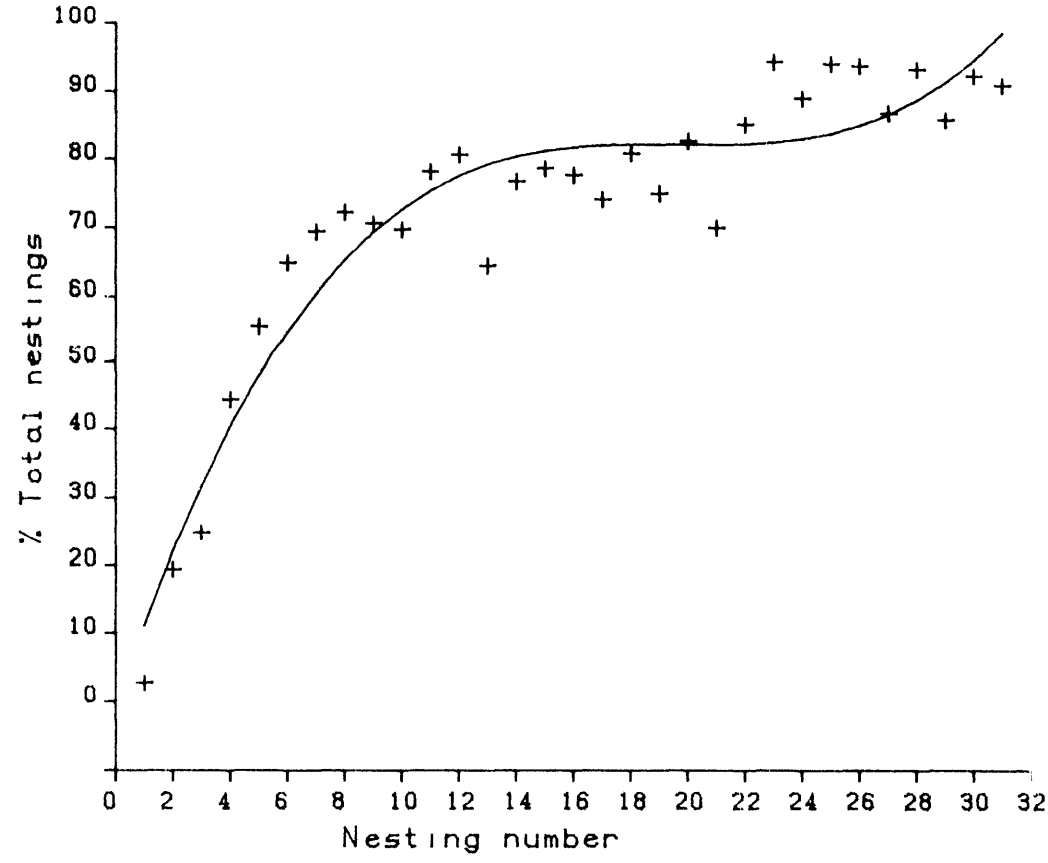

Figure 3.1.9 Frequency of occurrence (% of total nestings) of litter raking for each nesting from laying days 1 to 31

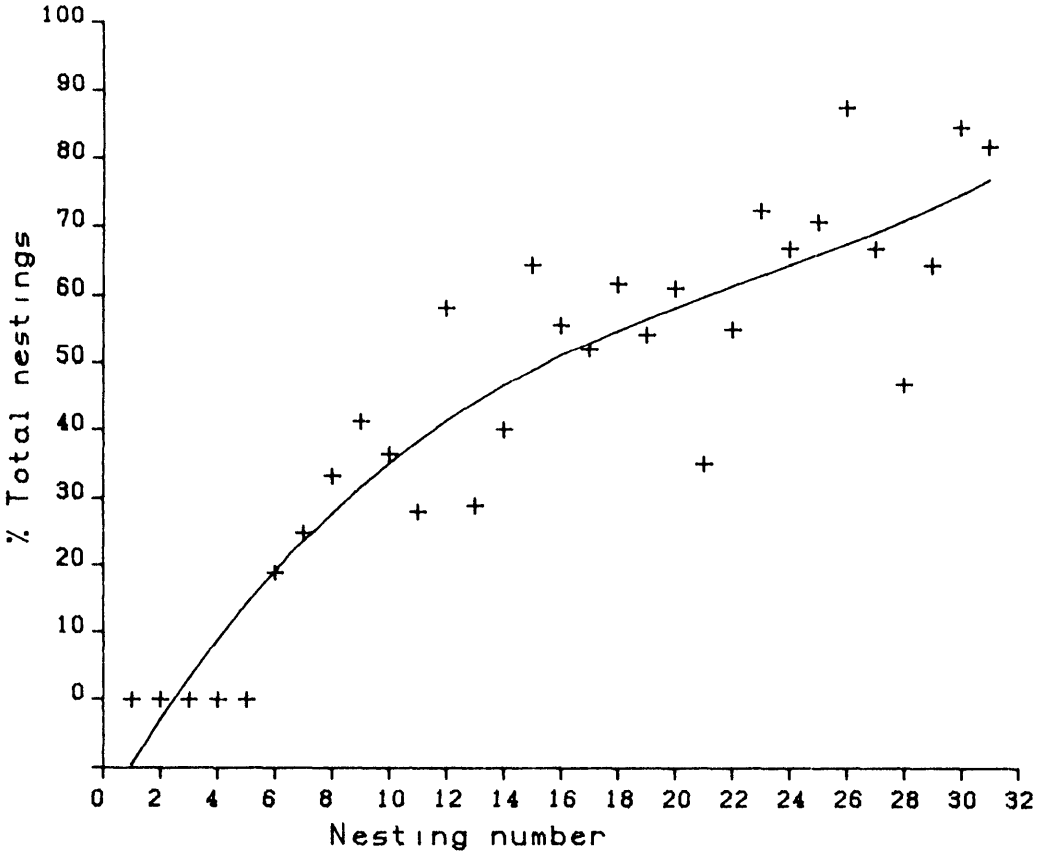

Figure 3.1.10 Frequency of occurrence (% of total nestings) of material gathering to the chest for each nesting from laying days 1 to 31

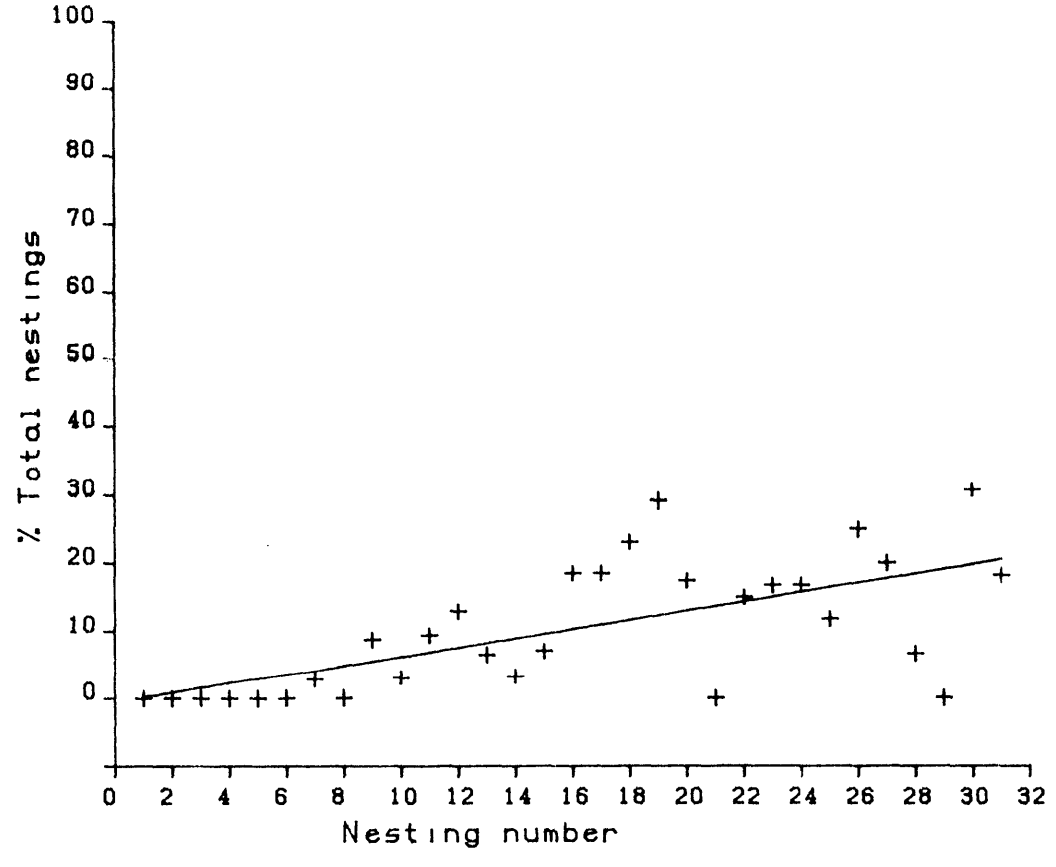

Figure 3.1.11 Frequency of occurrence (% of total nestings) of material gathering to the back, on the nest, for each nesting from laying days 1 to 31

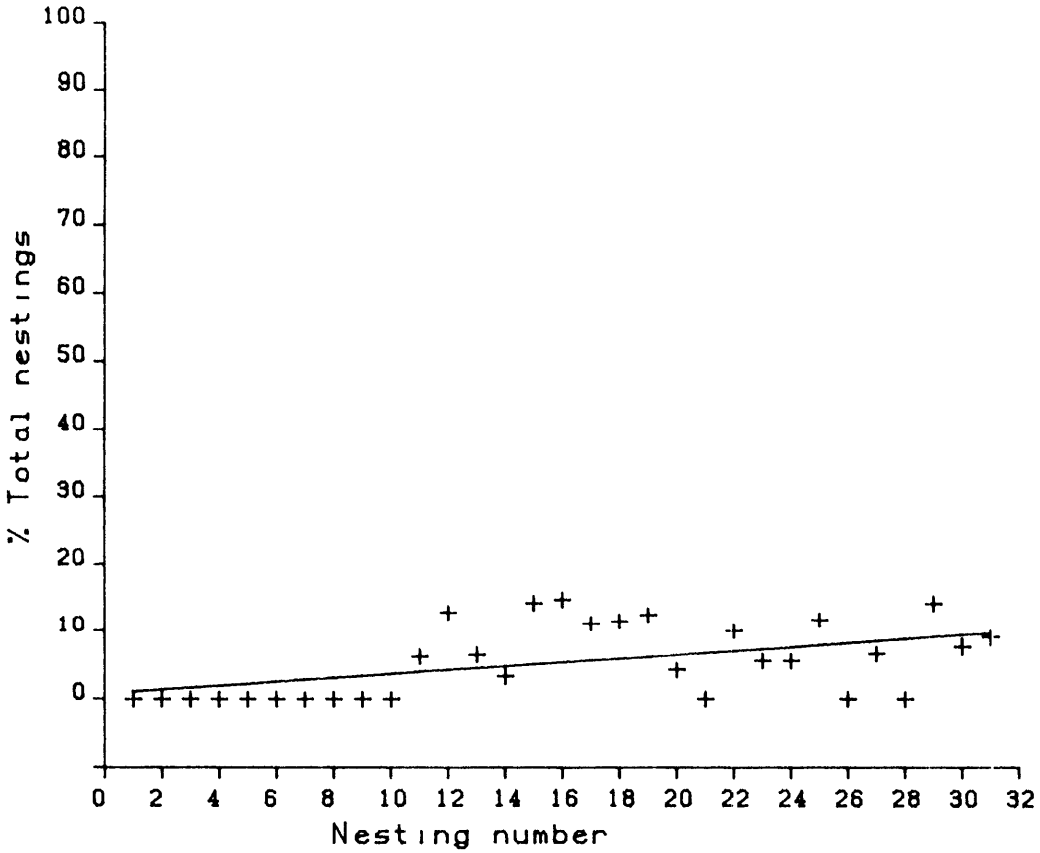

Figure 3.1.12 Frequency of occurrence (% of total nestings) of material gathering in the shed for each nesting from laying days 1 to 31

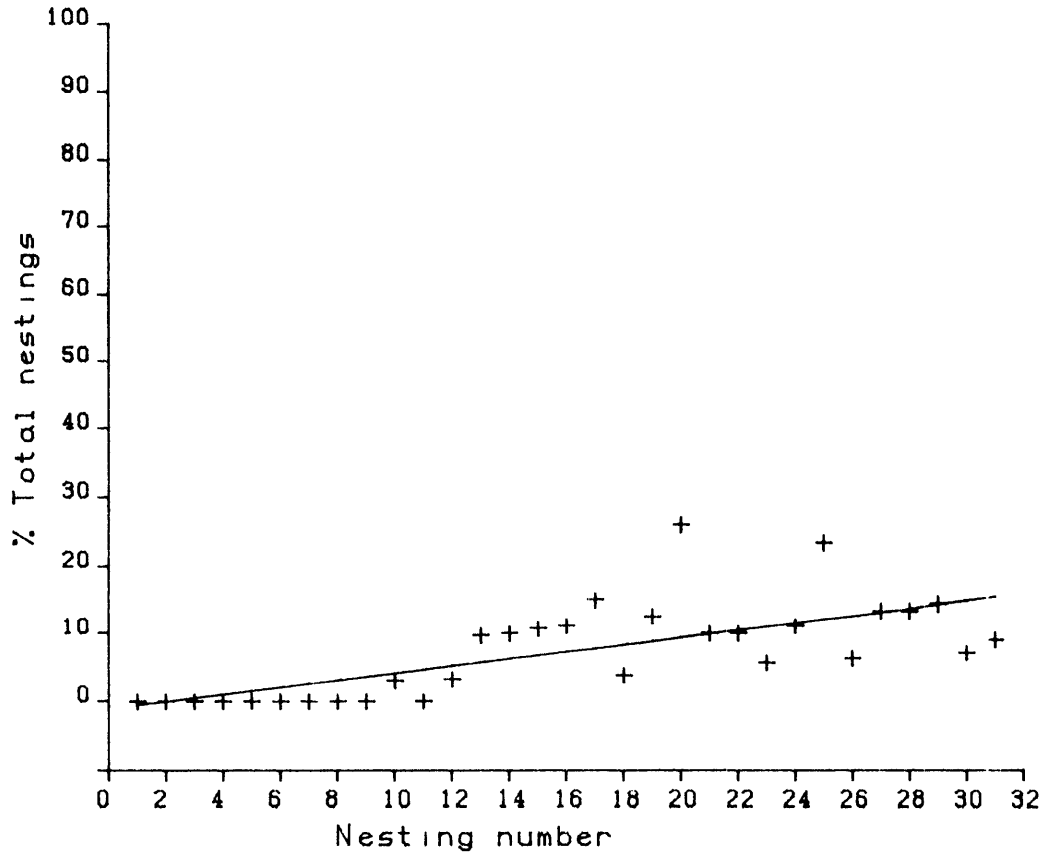

Figure 3.1.13 Frequency of occurrence (% of total nestings) of material gathering after lay for each nesting from laying days 1 to 31

Table 3.1.6 Dominance-subordinance relationships existing between hens in the broiler flock. Hens in left hand column (vertical axis) are either dominant to (■) or subordinant to (□) hens across top row (horizontal axis). Therefore, hens are ranked in decreasing social status order across and down the page

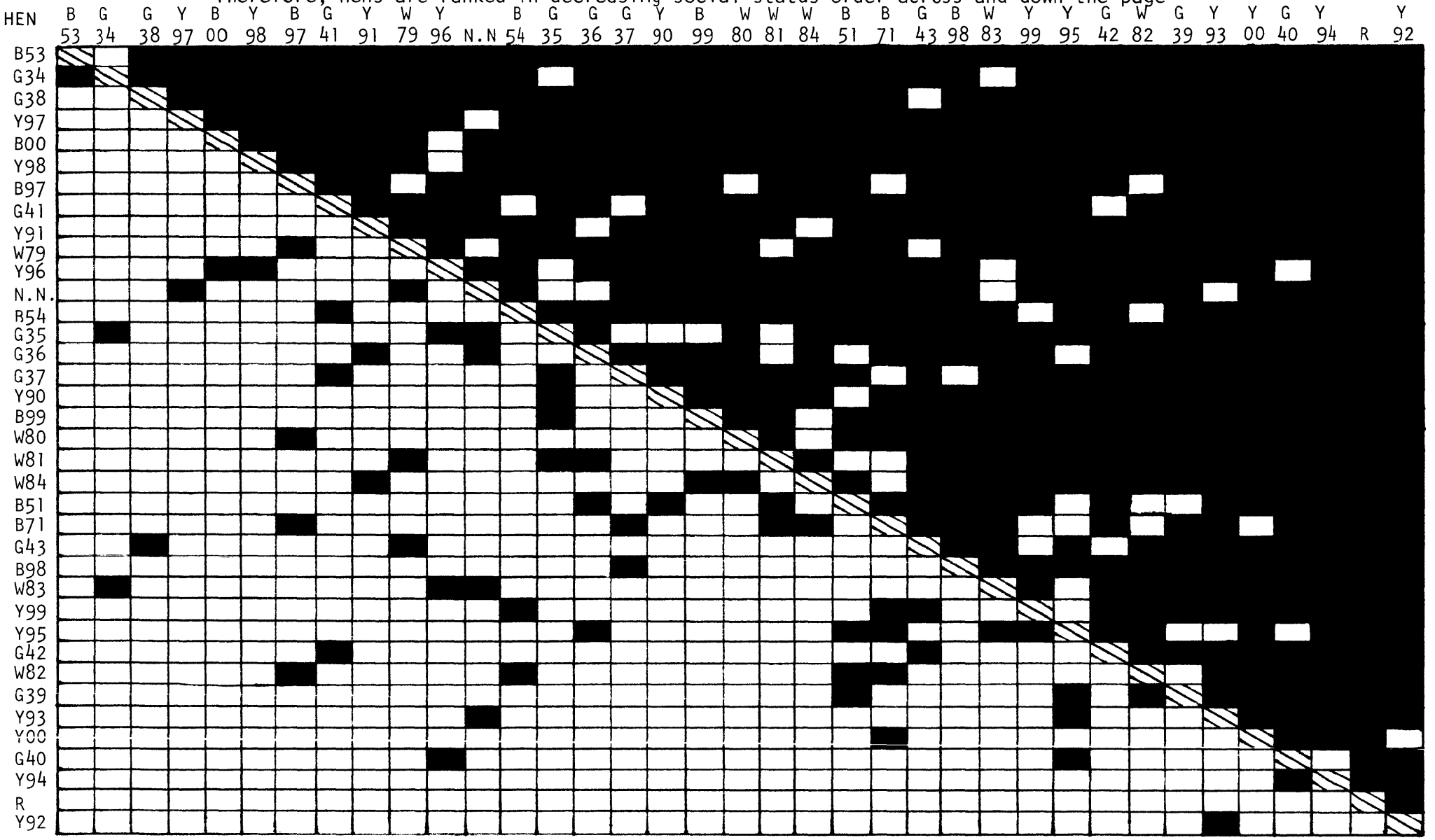

Table 3.1.9 Distribution of nestings by individual hens between elevated nests, ground nests and floor sites

Hen	Elevated Nests										Ground Nests										Floor Sites'		
	I	II	III	IV	V	VI	VII	Total	Nestings	χ^2	A	B	C	D	E	F	G	H	Total	Nestings	χ^2	Total	Nestings	χ^2
G34	35	3						38	L6-43	***													
G35		2	10	7	6	7	1	33	L4 5 7-37	-												4	L1-3 6	
Y94			1					1	L1		1		7	1	2	18	2		31	L6-36	***	4	L2-5	
B99																						34	L1-34	***
B53			1	1		1		3	L5 9 14													30	L1-4 6-8 10-13 15-33	***
G38																						31	L1-31	***
Y90		5	4	10	10	1		30	L1 3-31	***									1	L2				
Y91													3	1	16				21	L11-31	***	10	L1-10	***
G39																						31	L1-31	***
Y93																						31	L1-31	***
B00																						31	L1-31	***
G41					1	3	20	24	L1 8-30	***		1							1	L2		5	L3-7	***
Y95													3		2	2		2	9	L22-30	-	21	L1-21	***
Y99		2	1		3	5	15	26	L4-29	***												3	L1-3	
G42											1					3	3	19	26	L2 3 5-28	***	2	L1 4	
B51																						26	L1-26	***
G36																						25	L1-25	***
W80																						24	L1-24	***
G40																						22	L1-22	***
B97											22								22	L1-22	***			

continued next page

Table 3.1.9 (cont.)

Hen	Elevated Nests I	II	III	IV	V	VI	VII	Total	Nestings	χ^2	Ground Nests A	B	C	D	E	F	G	H	Total	Nestings	χ^2	Floor Sites' Total	Nestings	χ^2
N.N.																						20	L1-20	***
G43																						20	L1-20	***
W82																						20	L1-20	***
B71																						19	L1-19	***
Y96																						18	L1-18	***
Y98																						18	L1-18	***
W81																						17	L1-17	***
W79																						15	L1-15	***
Y97																						14	L1-14	***
W84																						14	L1-14	***
Red																						13	L1-13	***
G37																						11	L1-11	***
B98											1	6	1	1				1	10	L1-10	***			
Y92													4	1	1	2		1	9	L1-9	*			
W83																						8	L1-8	***
B54		1	1				1	3	L6-8													5	L1-5	
Y00												1							1	L3		5	L1 2 4-6	
Total	35	13	18	15	20		17	37			26	8	18	19	7	25	5	23						

' For breakdown of where floor layings occurred, see Appendix 3.1.5

- = (.05< P < .10); * = (.01< P < .05); *** = (P < .001)

that it may have become even more frequently observed had the study been continued.

The activity, material gathering to the back before lay by hens sitting on the nest, was not observed in any hens until the seventh laying day and increased gradually thereafter (see Figure 3.1.11). Similarly, the same material gathering movement was not observed prior to laying as the hen moved about the pen (M.G.in Shed, Figure 3.1.12) until the 11th laying day, or as material gathering after laying (M.G.after Lay, Figure 3.1.13) until the 10th laying day. However, these results should be viewed with some scepticism as the observer had not identified this activity prior to the first day it was recorded for hen G38 on 17th April, at which point a number of hens had been laying for up to three weeks. Once recognised as a material gathering activity it was always easily detected because its form was so constant. After this initial occasion on which the activity was noticed, it appeared again on several occasions in other hens on subsequent days. The observer could not be certain that this was because some members of the flock had just begun to perform the activity, or because the activity had simply gone unnoticed previously. The activity may have gone unrecognised because it was infrequently performed and even then only for a relatively short duration, and also because the activity often appeared purposeless, the material gathered never having been successfully picked up, or dropped along the way, with the pattern continuing on to its completion regardless.

Despite the fact that early material gathering activities may have gone unrecognised, 16 hens who commenced to lay after the day that this activity was first identified failed to perform the various forms of the activity early in their laying history. In these hens, the earliest occasion on which material gathering before lay, on the nest (M.G.on back) occurred was during one hen's L7 nesting. In the 21 hens which commenced laying before this date, the earliest recorded instance of this activity was in association with an L9 nesting. The earliest recorded case of material gathering in the shed before lay (MG. in shed) in the 16 later maturers was during an L11 nesting, where prior to 17/3 it had also been in association with an L11 nesting. In the case of the activity, material gathering in the shed after lay (MG. after lay), its earliest occurrence was during an L10 nesting in the later maturers, while previously it had never been observed before 12th laying day. Thus, although the behaviour pattern was easily recognised by the time the 16 later maturers commenced to lay, it was still not recorded until at least the seventh occasion on which a hen laid.

(c) *Effect of Position in the Flock Hierarchy*

The social hierarchy of the flock is represented in Table 3.1.6. The peck order was certainly not linear and was quite complex. Even B53, the hen classified as the alpha bird by virtue of the fact that it dominated more hens in the flock than any other individual, was itself dominated by one other hen. Similarly, the two hens ranked lowest in the social hierarchy were both dominant over one other hen in the flock.

It is interesting to note that all bar one of the hens classified in Appendix 3.1.6 as predominantly sociable nesters were from the bottom half of the flock hierarchy. In fact, five of the six lowest ranked hens were found to be committed sociable nesters.

Pairwise correlation coefficients calculated between social rank index of each hen and the percentage of total nestings accompanied by each activity are given in Table 3.1.7.

Table 3.1.7 Pairwise correlation coefficients, and their levels of significance, calculated between social rank index and percentage frequency of each nesting activity

Activity	Correlation coefficient with social rank index	Significance
No. nestings recorded	0.248	N.S.
Pacing - all intensities	-0.388	*
Nest calling	-0.377	*
Rotations/foot scraping	0.270	N.S.
Litter raking	0.205	N.S.
M.G. to Chest	0.416	*

N.S. = not significant ($P>0.1$); * = ($.01<P<.05$)

Correlation coefficients could not be calculated between the frequencies of pre-lay, post-lay cackles, M.G. to the back, in the shed and after lay with social rank index because of the largs number of zero recordings.

Significant negative correlations were found between social rank index and pacing and nest calling. On the other hand, hens higher in social status tended to perform cackling, nest building and material gathering activities to a greater extent than did hens lower in the flock hierarchy. This tendency could be substantiated statistically in the case of material gathering to the chest. No significant trend was found for social rank index and the number of nestings performed.

. Nest Sites Selected

All but four untrained hens laid at least their first few eggs in floor sites. One hen, G34, laid her first five eggs on the floor before selecting an elevated nest. Thereafter she repeatedly selected elevated nests, and was the only hen to do so of her own volition without training, throughout the period of the study. The four untrained hens that did not lay their first few eggs in floor sites selected ground nests instead. Seven hens in all became regular ground nest layers. For the duration of this study, 24 hens were persistent floor-layers.

Hens tended to select a range of sites in which to lay their first few eggs before settling on one or several sites as preferred nesting areas. This is evidenced by the range of nests and nset sites used on at least one occasion by each hen, as shown in Table 3.1.9 and Appendix 3.1.8. This settling in phase occurred throughout a period of up to 12 to 15 nestings in the case of some hens. However, other individuals did not show such random selection of nest site in the early stages of lay and tended to form an attachment to a particular site shortly after coming into lay.

The hens subjected to the nest-training procedure, the day (laying day) on which training was attempted, the acceptance or otherwise of elevated nests on the day of training and subsequent use of elevated nests are listed in Table 3.1.8. Training was 'successful' for five out of the ten hens for which training was attempted. Four of these hens accepted the elevated nests on their training day and on most subsequent occasions. Of the five unsuccessfully 'trained' hens, two elected to remain in the elevated nests and lay on the day of training, but for all or most subsequent nestings did not return to elevated nests. The other three hens for which training was attempted did not accept the elevated nests on their training day and never returned to them to lay.

The numbers of eggs each hen laid in any of the elevated nests, ground nests or floor sites, and the laying days on which nestings occurred in these three alternative areas, are given in Table 3.1.9. The areas of the pen in which floor nestings occurred are given in greater detail in Appendix 3.1.8.

Table 3.1.8 The acceptance of elevated nests on training day and the number of subsequent selections of elevated nests by 10 broiler hens subjected to nest-training procedures

Hen	Training Attempted	Acceptance -Training Day	Subsequent Nestings	
			Total	Elevated Nests
G35	L5	✓	33	32
G41	L1	✓	29	23
Y90	L1	✓	30	29
Y99	L4	✓	26	26
B54	L5	X	3	3
Y94	L1	✓	35	0
B53	L5	✓	28	2
W80	L1	X	23	0
Y97	L4	X	10	0
G40	L2	X	20	0

Perusal of the total numbers of eggs laid in the different nests of both the elevated and ground nest-sets (see Table 3.1.9) suggests that egg layings were not uniformly distributed between nests and that end nests were, perhaps, most used. However, if the number of hens showing a 'preference' for each nest (preference meaning that the bird selected that nest on more occasions than any other) is taken into consideration, disregarding the number of times that each hen selected the nest, there were no significant differences between nests. It was noted, however, that hens forming strong attachments to a sole, particular nest (e.g. hens G34, G41, B97) tended to do so only with end nests.

Although the expected values obtained for the analysis of the numbers of hens showing a preference for each of the floor-laying areas (see Appendix 3.1.9) were mostly small, the magnitude of the resulting Chi-square value allows us to have considerable faith in the significance of the differences found.

When the numbers of hens showing a preference for each of the different floor-laying areas were compared (see Appendix 3.1.9) certain sites were found to be more likely those sites for which hens formed attachments. The corners, and in particular corner 4, were preferred in this respect.

When the distribution of all eggs laid in floor sites was studied (see Appendix 3.1.10) further information on the usage of different floor areas became apparent. Although these results are subject to serial correlation, the generally high levels of significance attained allows us to have considerable faith in the findings. Corners were most frequently selected as sites in which to lay, reflecting the forementioned tendency for hens to form attachments to or preferences for these areas. The areas under feeders and waterers were next most popular floor laying sites, followed by sites along the walls or in front of ground nests, with areas in the middle of the pen or under the pen door rarely used. Since all these areas were only used as a permanent nest site by one, if any, hen, these results seem to indicate the relative importance of such areas as subsidiary or 'second preference' sites.

Light intensities in different areas of the pen varied. Light intensity in corner 4, the most popular floor-laying area, was measured at 8 lux. Light intensities in corners 3, 12, 16 and 24 were 7, 10, 13 and 12 lux respectively. The most popular floor site was therefore not the darkest, of all the corners available in the pen. Light intensities under feeders or waterers, along walls and mid-pen averaged 11, 13 and 15 lux respectively.

Almost all hens exhibited a high degree of conservatism when selecting nest sites. Highly significant differences, as shown in Table 3.1.7, were in almost all cases found for the distribution of a hen's eggs between nests or floor sites. Not only did hens exhibit 'preferences' for certain types of floor areas over others when selecting a floor site in which to lay, but they were also able to distinguish particular nests in a set which they would regularly return to. Some hens displayed a preference for only one particular nest. Such was the case with the hen G34, who invariably selected nest I and only laid in the alternative, II, when forced to by unusual circumstances, such as when nest I was occupied by another hen. Other hens had several preferred nests.

The original data suggests that there was no particular pattern in the way these hens distributed nestings in several such 'preferred' nests over time. Hens tended to lay in a rather 'indiscriminate' fashion during the first few days to weeks and the tendency to return to particular nest sites to lay on consecutive days usually only emerged after this initial period. However, there was no particular tendency to lay in the one nest, say, for all of a

clutch of eggs and then at the start of a new clutch select another. In fact, the nest selected on any one day would often depend on which nests of the preferred set were occupied at the time of nest selection. If a preferred nest was already occupied when a particular nesting hen was very close to oviposition, she would generally enter and lay in another. If, however, a less preferred nest was occupied while a hen was selecting a nest, and vacated some time later before the hen had laid, she would often leave even her most commonly used nest and resume sitting and lay in the recently vacated nest. A hen would often select different alternatives of a preferred group of nests on consecutive days even if there were no other hens examining or occupying the nest-set at any stage during her visit to the nests. Even 'sociable' nesting hens exhibited preferences for particular nests over others, preferentially electing to enter occupied nests of a particular group of nests to others, or entering and laying in particular vacant nests when prevented from laying in other, occupied nests by their occupants.

Like nest laying hens, floor layers also tended to return to a particular site day after day, or one of several preferred sites on different occasions, to lay. Despite the fact that there was a large amount of pressure on several sites in particular, for example corner 4, hens would repeatedly succeed in nesting and laying in the site each day. Competitive pressure was higher in several of these sites than it ever became for any of the provided nests. Generally, if a hen's preference for different floor-laying positions was divided between several sites, the type of site was similar. For example, G34 generally laid in one of two different corners. No clear pattern was evident in the distribution of an individual's selection of different alternatives of a group of several preferred nesting sites over time.

3.1.4 Discussion

The calling associated with nesting is undoubtedly the same as that recorded by Wood-Gush (1954) which he later referred to as the 'pre-laying call' (Wood-Gush and Gilbert, 1969b; 1970b) or 'nesting call' (Wood-Gush, 1971b; 1975a; Wood-Gush and Gentle, 1978). The author prefers the use of the latter term, because this particular vocalisation was occasionally heard for some time after laying and because it is a widely recognised term. Although a similar call was heard in other situations, this term was selected to describe the particular vocalisation associated with nesting, rather than a less subjective, descriptive term such as the "qwa-a-a call" both for the sake of simplicity and to encompass the range of variations of the vocalisation that did exist between hens and even within the range of individual hens.

The call uttered by hens in this study followed the description provided

by Wood-Gush and Gilbert (1969b) quite closely in form and also in terms of the deportment of the hen when uttering it. The similarity of this call with that uttered by hens in highly motivated states, such as when hens in adjacent pens are being fed, has also been noted by Wood-Gush (1954). The orientation of hens away from flock-mates or from the flock area may represent the tendency to leave the flock in less confined conditions, as noted for feral fowl (McBride *et al.*, 1969).

In the present study, pullets were occasionally observed to call for periods of time during the day or two prior to their first oviposition. Wood-Gush and Gilbert (1969b) and Wood-Gush (1975a) have also indicated that nest calling is sometimes heard several days before the first egg is laid by young pullets. Wood-Gush and Gilbert (1969b) provide evidence implicating the role of oestrogen in the control of this vocalisation. Also consistent with the findings of the present study is this report of Wood-Gush and Gilbert (1969b) which showed that while immature, non-ovulating pullets stimulated to call by oestrogen treatment rarely showed restlessness, 296 out of 420 of the calls uttered by adult hens were accompanied by locomotion. Calling by immature pullets in the present study was noted to occur without the pacing or restlessness usually accompanying it during the laying phase.

The purpose of the nesting call is somewhat unclear. McBride *et al.* (1969) report that the call of captive feral hens appeared to attract a male if the hen was away from the flock area. The cock apparently led the hen to examine nest sites. The authors suggested that the whole routine, involving participation of the male in the nesting sequence, ensures that the hen is escorted to and from the nest.

Kruijt (1964), in describing some aspects of the nesting behaviour of captive junglefowl, noted that the hen called often throughout the process of selecting a nest. Her activities, although not necessarily her calling, were found, sometimes, to attract a male who would accompany her in the search for a nest. However, her calling was not dependent on the presence of the male. Duncan *et al.* (1978) report that in the population of feral fowl studied by them, pre-lay calling was sometimes heard, but was never loud or persistent. Males were not noted to participate in the nesting sequence.

On the other hand, most reports of nesting by junglefowl in the wild (e.g. Baker, 1930) suggest that the activity of hens about the nest is extremely furtive and quiet, although junglefowl hens are capable of producing nest calls (Henry, 1959). The calling of nesting hens may therefore have a role in attracting cockerels, but it is also probably indicative of a high

degree of motivation. The fact that hens in the present study performed the call in the absence of cockerels, that it may not be specific to the nesting situation, and that it would appear to be performed under conditions of captivity or confinement of some sort to a greater extent than it would appear to occur in wild birds, would seem to suggest that level of motivation to search for a nest may be the major factor controlling the expression of nest calling.

A restlessness component in nesting behaviour of captive junglefowl has been noted by Kruijt (1964). In both studies of feral fowl (McBride *et al.*, 1969; Duncan *et al.*, 1978) this restlessness or increased locomotion took the form of the hen leaving the flock and moving towards the nest, or examining nests. It is difficult to say to what extent the restlessness and pen pacing observed in hens in the present study and by others (e.g. Wood-Gush, 1954, 1963) is a parallel of this activity in a more limited environment. Since there is little scope for leaving the flock area in a pen situation, hens may compensate by expressing the locomotory phase of nesting as apparently aimless locomotion about the pen, or pacing of walls. It is interesting that the feral hens described by Duncan *et al.* (1978) were noted to approach the nest by a circuitous route. To what extent this affects the locomotory component of the behaviour pattern, and whether or not the direction or means of locomotion and approach are important in this phase, is not known.

The decline in the frequency of pacing and calling and the intensity of pacing as hens became more experienced layers suggests that these activities, which are components of the nest seeking phase, are of less importance once hens have developed preferences for particular sites or have become more familiar with the nesting process or environment. Perhaps the motivation to search for a nest site or examine potential sites declines once hens have established their own nest site or nest preferences. If motivation to search for a nest is diminished, then it would also be likely that those activities associated with that particular phase, such as locomotion and calling, might also decline in frequency.

It is of further interest that significant negative correlation coefficients were found for social rank index with both pacing and calling incidences and that pacing and calling were positively correlated. If hens higher in the social hierarchy have priority for nesting sites, it may be difficult for lower ranked hens to establish preferred sites and so these individuals may go on searching for a nest day after day and so pace and call to greater extents. However, one should be cautious when suggesting a relationship between social rank and priority of access to resourses, as indicated by studies reported by Banks *et al.* (1979). On the other hand, it could also be that low

ranking hens have a lower affinity for specific sites and do not form attachments to nests as readily as do higher ranking individuals. This could account for the finding that most 'sociable' nesters which showed attachment to occupied nests as opposed to particular nest sites, tended to be individuals from the bottom of the flock hierarchy. Both possibilities could ensure that hens higher in the social order of the flock in a natural or competitive habitat would have access to the best nesting sites, particularly in situations in which pressure on potential nesting sites is high. It is particularly interesting to note that Wood Duck (*Aix sponsa*) hens which tend to dump nest were found to exhibit less nest attachment than normal nesters in terms of the times they spent on nests (Clawson *et al.*, 1979).

The existence of these 'sociable' nesters may ensure that the maximum usage of more suitable nesting sites is achieved. In a natural habitat, this may provide a mechanism by which maximum use is made of all eggs laid by the flock where nesting habitats are limited. Clawson *et al.* (1979) concluded from their studies on Wood Ducks that dump nesting is a response to the limited availability of suitable nesting sites. Although their findings supported others who found that overall production of a population was enhanced by dump nesting, other workers (Jones and Leopold, 1967) also showed that with increasing population, dump nesting increased and the productivity of the population decreased as a result of desertions and a declining hatching success.

The possibility that dump nesting, or failure to establish own nests, may be a response to high population pressure or crowding has also been suggested for Ring-necked Pheasant at free range (Einarsen, 1942; Baskett, 1947). They also report that the incidence of single eggs dropped promiscuously or of eggs dropped in odd places not conducive to incubation also increased in times of high population pressure. Since it is unlikely that all available potential nesting sites were taken, this would tend to suggest that such responses were to crowding or overpopulation itself. It is proposed that the existence of individuals which prefer to lay with others rather than to establish their own nest, and of hens tolerant of this, in the present study, may also be a symptom of the high population density and lack of suitable nesting sites in the pen situation, or of an increased tolerance of nest sharing which may have come about through domestication and selection in such an environment. The existence of hens which do not appear to be dissuaded from nesting in a preferred site by its prior occupance in a large flock situation has been reported by Turpin (1918). Perry *et al.* (1971) also refer to cases in similar situations in which the opposite tendency was invoked and some dominant hens were seen to prevent other hens from using entire nesting areas while other hens were thwarted in their attempts to enter particular nests as a result of their prior occupance.

The sequence of activities associated with 'examination' of potential nest sites by the hen as observed in this study closely parallels that described by Wood-Gush (1975a). Wood-Gush (1963) interpreted the apparent examinations as intention movements to enter the nest. However, results of a later study (Wood-Gush and Gilbert, 1973) suggested that nest entry and nest examination may be quantitatively different and possibly controlled differentially since oestrogen treatment alone was found to stimulate nest examination but only infrequently stimulate nest entry. The point is made that nest examination may be homologous to the nest site selection of the feral fowl described by McBride *et al.* (1969) which is not always followed by sitting. Instead, hens may visit a number of nests before finally sitting and completing the nesting.

It was the author's impression that nest examination as performed by broiler hens in the present study was more than just intention movement to enter the nest, particularly since hens seemed to examine many nests but usually only enter a selected few. Later studies (see Study 4.1.3) indicated that hens could identify preferred types of nests during examination from outside the nests. Once hens were familiar with the nest options, they tended only to enter certain types, although all types were examined.

It would therefore seem possible that hens actually respond to stimuli from the nest during examination and that their response determines nest entry. Therefore, it could be that some nest assessment and decision making component of examination exists.

The observation that hens, at least early in their laying history, tended to enter a number of nests before settling may represent the tendency for hens to investigate a number of sites before founding a nest. This tendency has been noted in captive junglefowl (Kruijt, 1964), feral fowl (McBride *et al.*, 1969) and in other gallinaceous birds (e.g. Watson and Jenkins, 1964; Watson, 1972). The feral hens observed by Duncan *et al.* (1978) did not obviously examine other nests on their approach to their own nests, although they did often move to their nest by a circuitous route. However, these hens were presumably moving to established nests and it seems likely that examination of alternative sites may decrease in importance or become completely superfluous once a nest is established. The observations of birds in the present study did suggest that hens approached nests more directly after they had some experience of them and had developed attachments to particular sites. It would certainly seem maladaptive for a hen in a natural habitat to spend time examining and scratching in other sites once a nest has been founded. This could leave the hen prone to detection by potential predators, whereas

a stealthy approach to an established nest would minimise detection of both the hen and clutch.

The failure of hens to remain and sit in the first nest entered, particularly early in their laying history, and even though all nests were much the same, would suggest that hens may not initially respond to stimuli from the nest. This was apparently overridden by experience, since hens tended to approach particular nests more directly as they became more experienced layers.

The activity of hens once on the nest involved a large nest building component. Wood-Gush (1975a) described many of these activities extremely well and most of them seem to have been present in the nesting behaviour of hens in both that study and the present one.

Foot scraping and rotations resulted in the formation of a shallow depression in the nest site. The use of such natural or formed depressions for nesting of junglefowl and other gallinaceous birds is well documented (see review, Chapter 2). The formation of such a depression in an otherwise unconfined site would be of importance to nesting hens in the wild. Placement of eggs in such a nest cup would ensure that eggs were not lost by rolling away from the site, or would not attract predators to the site if they did happen to roll away, and would also facilitate coverage of eggs during incubation through keeping eggs together at the centre of the depression. It would therefore appear that hens have not lost this behavioural tendency to form such depressions, despite the fact that nest-boxes naturally confine eggs within the site anyway.

Nest building in Black-headed Gull (*Larus ridibundus*), also a ground nester in certain environments, has been described in some detail by Moynihan(1953). In scraping out a nest, birds are described to sit with the hind part of the body elevated, and then rapidly kick or scrape backwards with their feet, so creating a shallow saucer-shaped depression. Beer (1963) also describes this scraping activity in the same species. In scraping, the bird is said to drop to its chest with its rear end kept somewhat raised so that the long axis of the body makes an angle with the horizontal. The legs are then described as alternating in pushing or kicking backwards with extreme vigour. The force from the driving legs is said to act at an angle to the long axis of the bird's body so that the body swivels on the chest and the tail swivels from side to side. This activity is presumably performed by both males and females, since in Black-headed Gulls the male initiates and builds most of the nest but both male and female maintain and improve it.

These descriptions of nest building by gulls are remarkably like those performed by domestic hens in the present study, except, as pointed out by Wood-Gush (1975a), that the leg movements are directed backwards from the bird as opposed to sideways as is usually the case in domestic hens. It would be interesting to establish the distribution of this type of nest building activity amongst other ground nesting species which do not construct elaborate nests. The preparation of a nesting depression in such species would seem to be of considerable importance. The role of the environment in determining the form of the behaviour pattern shown with respect to nest construction will also be of considerable importance. It should be noted here that the Black-headed Gull, used here to illustrate similarities in the pattern of nest construction between other ground nesting species and domestic fowl, in some environments constructs more elaborate nests (Kearton and Kearton, 1913) and is even known to build nest rafts over the water.

Litter raking activity, and possibly material gathering to the chest as described in the present study, would also seem to be involved in the building of a rim to the nest or possibly in the lining of the nest. These activities, or activities very similar to them, are also reported in Ruffed Grouse (Bump *et al.*, 1947), Willow Grouse (Pulliainen, 1978) and White-tailed Ptarmigan (Giesen and Braun, 1979a), although they are not necessarily described as component activities of nest building. Similar activities have also been described in Black-headed Gulls by Beer (1963).

It was particularly interesting to note that the occurrence of the activities rotations and foot scraping, litter raking and material gathering to the chest, were all found to be highly correlated in the present study. This would tend to suggest that these activities may be functionally related and possibly even occur in such a way that performance of one leads to or predisposes the hen to performance of another. The occurrence of material gathering to the chest, but not of the other two activities, was found to be significantly correlated with social rank index. This would appear to be in line with the suggestion, made earlier, that hens higher in the flock hierarchy may show greater attachment to nest site and so may spend more time in such activities related to attention to the nest. On the other hand, hens higher in social status may simply be able to remain longer in the nest and perform such activities by virtue of their position, than hens lower in social status. Rotations and litter raking were activities which tended to accompany entry and sitting in nest sites almost immediately upon moving into and settling in sites and so tended to occur regardless of how long hens remained in nest sites. Therefore, these activities could be expected to be less affected by social status as most hens were observed to enter nests and sit at some stage. The finding that litter raking and material gathering to the chest were negatively correlated with pacing, and material gathering to

the chest, also negatively correlated with calling also suggests that hens which form attachments to nests and so spend more time in nest building activities are less likely to perform nest-seeking activities.

The incidence of all three activities tended to increase as hens became more experienced layers or aged. This was less true for rotations and foot scraping, for which the occurrence of the activity was found in over 50% of first nestings. The general tendency towards a gradual increase in the occurrence of nest building may relate to an initial lack of attachment to nest site in young hens laying their first eggs. It is interesting to note in this respect that different species of gallinaceous birds expend differing amounts of effort in the preparation of a nest site before initial clutch establishment or during the first few visits to an established nest site. For example, Kovach (1974) indicates that very little nesting activity is performed before the first egg is laid by Japanese Quail hens and that the hen only starts to add material after the first egg is laid. Nest building then continues until the cessation of laying. Red Grouse, on the other hand, may make nesting scrapes for up to a fortnight before laying (Watson and Jenkins, 1964). It would seem, therefore, that domestic fowl belong to a group in which development of the nest occurs only after nest establishment. This could be a characteristic of potentially higher producing species in which the time available from deposition of a first egg of a sequence until completion of a clutch could be long enough to allow for adequate building of a nest structure after initiation of the clutch.

The increase in incidence of litter raking activity observed in the present study at about the 23rd laying-day, and resulting in the significant cubic component of the calculated regression equation given in Table 3.5.1, seems odd. Since any hens attaining 23 or more observed laying days would have done so at very different times (21 days separated the first and the last hens which did so) changes in the hens' physical environment are not likely to have produced this effect. The author is unable to explain this trend adequately. It is an unfortunate inadequacy of these studies that all hens could not be studied for a specified number of laying days because of time limitations imposed. As a result, fewer, and possibly insufficient, hens contributed to the data as the study progressed and this may have indirectly been responsible for this trend.

The purpose of the activities involved in material gathering to the back or sides is less clear. Apparently similar movements are described in the nesting behavioural sequence of a number of gallinaceous species (see Chapter 2). These activities are referred to in the context of egg covering after the hen has laid and before the onset of incubation. These activities in wild birds in most cases are reported to occur as the hen sits in the nest after laying or stands to leave the nest. The extent of egg coverage

apparently varies considerably with and between species. It could be involved in camouflage of the eggs and may have a role in insulation from low temperatures, as suggested by Giesen and Braun (1979a). One report by Allen (1934) suggests that this activity may also be involved in camouflage of the grouse hen herself, while sitting on the nest, possibly before egg laying takes place. The material gathering activities may also have a role in uncovering eggs on the return of hens to the nest each day for laying. The fact that ptarmigan may uncover eggs on return to the nest is reported by Giesen and Braun (1979a). However, removal of vegetation from covered clutches by a grouse hen was not recorded by Pulliainen (1978).

Material gathering to the back or side may also have a function in nest building, particularly where it occurs before egg laying while the hen sits on the nest. Material which is gathered in this way would fall to the base of the nest and, in situations in which a nest was used over successive nestings, could result in the formation of a fairly thick nest lining. It is interesting to note in this respect that material gathering activities to the back or side before lay,as observed in the present study, appeared to be associated with nest building activities such as rotations, litter raking and material gathering to the chest, but not with material gathering to the back or side after lay. Material gathering to the back whilst on the nest before laying also seemed to be inversely related to pacing, once again suggesting an inverse association between attachment to the nest and nest seeking behaviour.

Since hens in this study did not actively carry material back to the nest in the beak, material gathering off the nest may be a means of retrieving material to the nest for the purposes of egg coverage or nest building. There is no indication that wild gallinaceous birds gather material at any great distance from the nest. This is probably adaptive, as the vegetation from the immediate vicinity of the site probably would have the greatest camouflage value. In the present study, most material gathering off the nest occurred in the immediate vicinity of the nest. Such activities were often destructive as a result of this.

The occurrence of material gathering activities off the nest, while they do occur in wild birds often during egg covering, may also be related to disturbance during the nesting phase. It is interesting that displaced egg covering activity was observed to occur in a ptarmigan hen by Giesen and Braun (1979a) after a hen had been flushed from her nest after laying. The behaviour pattern was identical to that performed during egg covering but occurred about eight metres from the nest.

Beer (1963) describes an activity he calls sideways building in the Black-headed Gull which appears to be very similar to that described for domestic hens in this study and of gallinaceous birds in the wild. The gull is said to pick up a piece of material in its bill, turn its head over its shoulder while standing or sitting, and place the piece of material along the side of its body. If the gull fails to pick up the piece of material pecked at, or if it drops the material just after having picked it up, the bird will carry through the full sideways movement with nothing to deposit. The similarities between this behaviour and that described for domestic hens are obvious and suggest that the motor patterns involved may be widespread in the behavioural repertoire of a number of bird species.

Material gathering to the back or side in any situation tended not to occur during early nestings in the present study. The frequency of occurrence of these activities in the nesting sequence gradually increased the longer the hens had been in lay. It is again suggested that such activities may not occur until attachments to particular nest sites are established. The reports of such behaviours in gallinaceous birds in natural habitats suggest that birds may perform these activities increasingly as the clutch accumulates. In such birds, these activities are usually not continued after the commencement of incubation, but in domestic strains of fowl in which the incubation phase does not necessarily follow the accumulation of a clutch, performance of such behaviour patterns may be continued.

A relationship appeared to exist between social rank index and the occurrence of material gathering to the back or sides after lay, although this could not be tested. Such a trend could again relate to relative attachment to the nest by high as opposed to low ranking individuals. However, it is also likely that lower ranking individuals had less opportunity to perform the activity because they were frequently disturbed on the nest or forced from the nest after laying.

The occurrence of post-lay cackles would seem to be indicative of the hen's highly developed motivational state at the time of nesting. Wood-Gush and Gentle (1978) suggest that the reasons why White Leghorn hens with hyperstriatal ablations do not show the usual gravitation towards corners during nesting may be because they are less responsive to fearful stimuli than are control birds. They go on to suggest that fear may normally be a contributing motivational force in nesting behaviour and hens may seek out nest sites having seclusion, enclosure and darkness as a result of this. This motivational force may lend intensity to some activities, such as cackling, and it is interesting to note a possible connection between fear, alarm cackling and the acoustically

similar, if not functionally similar, post-lay cackle.

While some reports suggest that junglefowl hens may cackle after laying (Wood-Gush, 1954, citing Hume and Marshall, 1878) the majority indicate that no such cackle is given (e.g. Baker, 1930; Henry, 1959). The activities of other gallinaceous birds after leaving the nest as reported in Chapter 2 would also seem to occur without such rowdy vocalisation. It would therefore seem that the tendency to perform such activities may have been increased during domestication. The captive feral hens studied by McBride *et al.* (1969) would leave the nest, cackling, after they had finished laying and move away from the nest. This appeared to attract the male, who would join the hen and return with her to the flock. However, hens from the feral fowl population established on an island off the coast of Scotland (Duncan *et al.*, 1978) were not observed to cackle after laying. This may indicate that post-lay cackling may not be so much the product of domestication as it is of the environment or situation in which nesting takes place.

In a natural habitat, cackling would appear to be maladaptive, as it would advertise the presence of the hen, and possibly of the nest, to potential predators. If, on the other hand, hens cackled after they had moved away from the nest, the cackling could possibly draw attention away from the clutch of eggs to the hen. While it would seem more adaptive for a hen nesting under some type of cover to leave the nest as quietly and stealthily as possible, so as not to draw attention to herself and the clutch, it was decided that the position of the hen at commencement of cackling and her movements throughout cackling would be observed in a later study (see Study 3.2).

It is also possible that the feral hens studied by McBride *et al.* (1969) had adapted the cackling tendency to suit their particular environment. As pointed out in that report, the main threat to the fowl population on the island was from feral cats, which could be repelled by a cock. The role of cackling in ensuring that cocks accompanied hens back to the flock area could therefore have been significant. This again indicates the role of environment in the releasing of cackling.

While post-lay cackling could possibly have some adaptive value in some situations, it is difficult to imagine the same would be possible of pre-lay cackling. Since the hen remains within the nesting area after cackling and until she lays, this activity would be likely to draw the attention of potential predators and leave both the hen and clutch prone to predation or attack. Pre-lay cackling was also reported for the feral fowl studied by McBride *et al.* (1969).

It would therefore seem that the pre-lay cackling observed in the present study may indicate the highly motivated state of the nesting hen and the modification of this behavioural response by domestication or environment. The apparent relationship, which again could not be tested statistically, between pre- and post-lay cackling suggests that both are controlled similarly and that level of motivation, rather than context, may control their expression.

Post-lay cackles were found to be associated with elevated nestings more so than with nestings in ground nests or in floor sites. Hens cackled to about the same extent after either of the latter. While the nature of the nesting environment or stimuli from the nest may influence the expression of cackling, it may be that hens in the more secluded nesting conditions provided by nest-boxes, and particularly the less often used elevated nests, may have allowed hens to follow through with the complete nesting sequence, including cackling. Certainly, hens in nest-boxes, particularly elevated ones, usually left nests of their own volition and it seemed to be in such circumstances that cackling ensued. Hens nesting in floor sites were often displaced from their nests by passing hens and may not have followed through to cackling as a result of this. It is worth noting in this respect, that post-lay cackling and material gathering to the back or side after lay often occurred together, suggesting that the expression of both could have been affected by disruption during the post-lay period on the nest. However, it is also possible that the tendency to cackle and to select certain nest sites or types may both have been a function of the individual hen. Certainly, cackling frequency varied markedly amongst individual hens.

Both pre- and post-lay cackling seemed to have been performed more frequently by hens accumulating high numbers of observed nesting-, indicating that the expression of both tended to increase in incidence as hens aged or became more experienced nesters. Both seemed to be related to social rank index suggesting that hens that were able to remain in their nests until the completion of nesting, by virtue of their social status, may therefore have been able to leave the nest of their own volition and so to complete the nesting phase with cackling.

Considerable individual variation was found between hens in the extent to which they performed each of the described component activities of nesting. While some of this may have been attributable to social status, to age at first nesting or to whether or not they had managed to find elevated nest facilities, an individual hen effect was apparent beyond this. All but seven

hens were found to exhibit at least one of the common nesting activities to a significantly greater or lesser extent than would be predicted from average flock frequencies. Individual variability amongst hens of a flock in a natural habitat could contribute to flock adaptability to environment and also ensure the distribution of nests and therefore clutches throughout an area, which could function as an anti-predator device.

One other vocalisation noted, the prolonged, shrill 'growl' performed by hens sitting on the nest, is worthy of mention. It may be equated with the vocalisation named 'Nestabwehrlaute' and described by Baumer (1962). Its primary function would seem to be the defence of the nest from intruding hens. Although only produced by a couple of hens, it was effectively used to disuade other hens from entering the nest occupied by the particular hen uttering it, regardless of her status in relation to the potential intruder.

Egg rolling behaviour and general attentiveness to eggs observed in this study has also been reported for Rhode Island Red hens nesting alone on the litter floors provided in small pens (Wood-Gush, 1975a). Most hens in that study showed interest in their own eggs after oviposition and some even showed such interest in their previous day's egg before laying. After laying, hens usually rolled the egg so that it would be in contact with the breast when the hen sat. In order to do this, the head sometimes had to be completely turned so that the comb was on the ground. If the egg was in front of the hen it was rolled towards the breast with the bill. Hens sometimes went through the motions of egg rolling shortly before laying even in the absence of the previous day's egg. Hens showed a remarkable attentiveness to their previous eggs, which they would sometimes roll considerable distances to their selected nest.

Egg rolling behaviour would appear to be a motor pattern widespread among other bird species, at least in the context of incubation behaviour. What would appear to be the same activity is described in some detail for the Greylag Goose (*Anser anser*) by Lorenz (1970) and also as 'shifting' in Black-headed Gulls by Beer (1963). Its function would appear obvious, to keep eggs of a clutch together during incubation so that all may be covered by the hen and warmed by her body. During the collection of eggs of a clutch or sequence, the same behaviour pattern would ensure that all eggs remained in the nest site until incubation and did not roll away from the nest to provide clues to potential predators of the whereabouts of the nest and the rest of the clutch, or be completely lost.

'Nuzzling under' was only usually observed in naive pullets nesting for their first one or two occasions. It has been described in young pullets

approaching oviposition by Wood-Gush (1954) who first used the terminology, and by Wood-Gush and Gilbert (1969b) who comment that it seems most common in hens about to lay and without much experience of artificial nests. It is probably related to the 'creeping under' behaviour reported by Brantas (1977) to occur during the pre-laying phase of hens housed in conventional cages. Brantas (1980, citing Martin, 1975) also reports the occurrence of this activity in caged hens and notes a case in which one hen repeated this pattern more than 100 times. The occurrence of this 'creeping under' behaviour in mature hens in conventional laying cages, along with its apparent infrequency in 'get-away' cages (Brantas, 1977) suggests that the activity may result from a hen's inability to find seclusion or isolation of any other form elsewhere in the environment. In the case of pullets laying for the first few times in pens in the present study, 'nuzzling under' may also be a response to inability to find appropriate stimuli to release nest entry, complicated by the pullets' lack of familiarity with the nesting process and the nesting facilities.

Training of hens to use elevated nests by placing the subjects on the wire perch outside the nests proved to be reasonably successful in encouraging hens to use such nests, despite the possible 'trauma' associated with the handling involved. It is therefore suggested that the reason why elevated nests were not used by the broiler hens in general, was because they were not aware of the facilities and/or because they did not or could not get up to the approaches to them. Once hens had nested in such elevated nests, they did usually use them, or attempt to use them, thereafter, in preference to nesting in floor sites.

Almost all hens, whether elevated nest, ground nest or floor site nesters, demonstrated a marked conservatism in selection of nest site during the period of this study, but usually only after a period of somewhat random egg-laying. Wood-Gush (1954) found that hens tended to return to a particular nest or nests to lay for successive ovipositions. Perry *et al.* (1971) also noted that broiler hens in controlled environment shedding tended to lay in the same site day after day, but that this was more the case for floor-laying hens than for nest users.

Attachment to a nest site, at least for the period of deposition of a clutch of eggs, occurs in almost all gallinaceous hens nesting in a natural habitat and ensures that maximal use is made of all eggs laid. Although a tendency exists for such birds to avoid previously used sites for re-nests, or for clutches in subsequent seasons (see Chapter 2), there was no indication that hens observed in the present studies would change nests between sequences of eggs to a greater extent than they would within sequences. In fact, some hens

used the same nest throughout the entire observational period. The tendency for hens to avoid previously used sites may have been diminished during domestication, or may simply be complicated by the 'sameness' of the pen or nesting environment, the availability of nest sites, or disruption during nesting by other hens.

Conservatism in the use of particular nests or nest sites tended to develop only after the first few eggs were laid by individual hens. The reason for the sometimes rather 'indiscriminate' nesting often noted in the first few days or weeks of laying is not known. Such tendencies may also occur in populations of other ground nesting bird species in a natural habitat, as suggested by reports of promiscuous egg laying in Ring-necked Pheasant which occurs at highest frequency in the early part of the breeding season (Baskett, 1947; Seubert, 1952). Dump nests of Wood Ducks also tend to be initiated earlier in the season than normal nests (Clawson *et al.*, 1979), suggesting that attachment to particular nest sites may develop only after an initial laying period in individual birds. Perhaps unfamiliarity with the potential nesting environment may be involved. Birds may have greater opportunity to seek out and respond to more suitable nesting sites if establishment of a nest does not occur during initial nesting days, at least in those species which do not actively perform nest seeking and nest building activities until the day coinciding with first oviposition.

Domestic hens apparently base their conservatism in nest site selection on nest site, rather than the previously constructed nest itself (Wood-Gush, 1975a). In this respect, the apparent 'end-nest' effect detected in the use of nests in both elevated and ground nest-sets, may be a result of the hens' possible requirement for a certain degree of distinctiveness in the nest established. It may be important for hens to be able to identify their previously selected nest site, and presumably selection of an end-nest, which is distinctive from other nests, may be a means of doing this. The stimuli from the nest which could be used to determine this are not known.

On the other hand, the observed 'end-nest' effect could also be a result of hens' requirements to move away from the flock area in nesting, as evident in feral fowl (McBride *et al.*, 1969; Duncan *et al.*, 1978). Once the nest-set has been approached, hens may move to the furthest ends of the set in an attempt to do this under the somewhat confined conditions provided by the study environment. Gallinaceous birds nesting in the wild display a marked tendency to gravitate to the periphery of the flock territory and to nest towards the edges of blocks of cover (see Chapter 2). Such sites may facilitate both recognition of the site and observation of the direction of likely approach

of predators or escape from the nest site if threatened.

Floor sites used most frequently in nesting tended to have the characteristic of being areas of enclosure or confinement. This may also have been associated with the tendency to gravitate towards the edge or periphery of the environment. However, the effectiveness of visual and/or physical barriers in determining site selection must be noted. If one considers an area of wall or the solid face of an object as a dimension of confinement, floor sites with the greatest numbers of dimensions of confinement were most popular. Hence, corners were more popular than walls, which in turn were more popular than areas in the middle of the pen. However, of such sites, some areas which were identical in terms of confinement were selected more often than others. For example, corner 4, which was the corner of the pen formed by the side-wall of the pen and the pen wall shared with the adjacent White Leghorn pens, was more popular than any other corner or floor site for that matter. This corner was not the darkest in the pen. However, it did occur at the junction of the two walls along which most pacing and attempted 'escape' from the pen occurred in nest seeking hens. Perhaps if unable to achieve isolation from the flock area, hens selected this site because of its proximity to what was apparently the most desirable direction in which movement from the pen would take place.

Areas under feeders or waterers were popular sites for floor-laying. Overhead confinement may have some added attraction to nest seeking hens. Certainly, overhead confinement may provide ideal cover for several reasons. In a natural habitat, overhead cover may afford protection from inclement weather. Overhead cover may also provide concealment, particularly from avian predators. Loss of duck eggs has been found in several studies (e.g. Dwernychyk and Boag, 1972; Doty, 1979) to be closely related to the amount of overhead cover provided at nesting sites. However, this seems only to relate to avian predation and it is not known to what extent this might be relevant to the wild ancestors of domestic hens. Also, it may be adaptive to leave eggs under overhead cover to shield the egg contents from solar radiation, particularly in the case of such ground nesting species that lay relatively large clutches of eggs and do not begin incubation until clutch completion (Montevecci, 1976).

Finally, it was not known why some hens persisted as floor site nesters even when ground nests, which possessed many dimensions of confinement, were available. Possibly, lack of usage of elevated nests was a result of inability of the hens to find or reach the set. However, this could not be the case for ground nests, for they should theoretically have been as easily found as any other floor sites. However, it is possible that ground nests were not as

widely accepted as might have been predicted because they were introduced when the flock, or at least some members of it, had already come into production. Hens which had begun to lay prior to their introduction may have already developed preferences for particular nest sites elsewhere in the pen. Hens commencing production after this point may have avoided ground nests because they were insufficiently familiar with them.

Study 3.2
Responses of Hens to Changes in the Nesting Environment

3.2.1 Introduction

In the previous study, it had been noted that hens might initially select several different nests on successive days during the first few days/weeks of their laying life but thereafter tended to become very conservative in their selection of a nest site. During these first few days hens tended to pace and call a great deal and infrequently performed nest building activities. Gradually, however, hens incorporated pacing and calling less and less, and nest building activities more and more, into the nesting sequence as they became more familiar with the egg laying process or with their nesting environment. It was of interest, therefore, to find out how changes in this environment would affect the mature hen's subsequent nest-related behavioural sequence.

It would be expected that a hen's nesting behaviour in two very dissimilar environments, say a floor pen as opposed to a laying cage, would be very different, although certain behavioural components could be expected in both environments. However, not a great deal is known about how hens react to changes in their nesting environment within their normal home environment. In order to establish how mature hens respond to slight changes in their environment and, in particular, their nesting environment, the nesting behaviour of hens was studied before and after movement from a stable pen environment to a new pen in which the availability of nest sites was continually changing.

A secondary purpose of this study was to see if nest selection habits could be modified by alterations of the environment. This was attempted by moving hens out of the environment in which their habits had formed and forcing them to select alternative nest sites within their new environment. In this way, the nesting behaviour of mature hens which were going through the process of reselecting a nest, rather than using a particular nest out of 'habit', could be studied. It was also hoped that such a procedure would encourage hens, who in their home pen had been regular floor site nesters, to change their floor-

laying habits and accept a new set of elevated nests which were to be used in subsequent studies.

3.2.2 Materials and Methods

(a) *Hens and Recordings*

The same 37 hens that were observed in Study 3.1 were used in this experiment. Feeding and lighting conditions were the same as described in that study and were kept constant throughout this study.

Hens were studied in three environments. The first (BM) was that in which the hens had come into lay and had been laying in for the previous two months, during which time they had been under observation in relation to Study 3.1. The second environment (AM) was identical to the original pen except that certain nest-boxes and floor sites were either excluded or available from day to day. The third (AR) was the same pen environment as originally studied but in which hens were not allowed access to the previously used nest-set. Instead, they were allowed to use a new set of nests with which the birds were not familiar.

In the initial environment the flock was observed daily for nine days (observation period 1, BM) commencing on 27th April, 1979, at which stage the hens were 35 weeks of age and had therefore been in lay for between four and nine weeks. The birds were in the original home pen environment described for Study 3.1 and had available to them the elevated and ground nest-sets provided in that environment and also described in Study 3.1. Wood shavings, to a depth of 3 cm, were spread in the nests and topped up regularly. Each day on which each hen was observed to lay, a record was taken of the maximum pacing score attained (* to **** as defined in Study 3.1), and whether or not calling, rotations and foot scraping, and material gathering (M.G.) to the back and sides, either whilst on the nest or moving about the pen before lay (previous classifications M.G. to back and M.G. in shed as defined in Study 3.1) occurred during the pre-laying phase. When this data had successfully been recorded on five occasions, no further records were taken for that hen. After nine days had elapsed no further observations were taken on the flock for a period of ten days. Records were then collected again for the following nine days (observation period 2, BM), no further records being taken for any hen after five nestings had been observed. At 3.00 pm on the evening of this ninth day, after all the hens had laid for that day, the hens were all moved to a new pen, the third in the same shed, on the other side of the White Leghorn pen.

The pen into which the flock was moved was identical to the original pen (see Figure 3.1.1). Nest-sets, feeders and waterers were all placed in the same positions as in the original pen.

Each morning, three of the elevated nests and four of the ground nests were excluded by taping cardboard over the entrance to the nests. The nests to be closed off each day were allocated at random. At the same time, two of the corners in the pen were blocked off by placing two 45 cm x 35 cm mirrors across the corner. Again, the corners to be blocked off each day were allocated at random. This procedure was undertaken in an attempt to force hens into nests or sites which they would not perhaps have otherwise used, assuming that their previous preferences for nest sites had carried over from the old pen to the new. It was hoped that this procedure might 'break the habits' of more conservative hens and force them to reselect nest sites.

The morning after the hens were moved to their new pen, observations commenced again. As previously, hens were observed for a period of nine days (observation period 1, AM), with observations ceasing on particular hens once five complete nestings had been recorded. The same parameters were recorded as those in their home pen. After nine days, observations ceased for ten days and then recommenced for a further nine days (observation period 2, AM). Throughout the entire 28 day period during which the hens were in their new pen, nests and corners were being randomly excluded each day.

Early in the evening of the 28th day in the new pen, after all hens had laid, the flock was moved back into its original pen. However, the original set of ground nests had been removed from the pen, and both the upper and the lower tiers of nests in the elevated set had been closed off. The wire mesh approaches had been swung up to block off the entrances to these nests and had been tied up so that they could not be pulled down by hens. A completely new nest-set had been installed in the pen. It consisted of two tiers of nests, although the top tier of nests was closed off, and each tier consisted of six, 30 cm x 38 cm x 35 cm sheet metal nests. The nest fronts were adjustable, but for the purposes of this study nests were fitted with 10 cm high nest fronts. The set was positioned half-way along the western pen wall, that being the galvanised iron end wall of the pen. The bottom tier of nests was 18.5 cm above the ground and accessible via a two level approach made of boards, one 15.5 cm above ground and the next 18.5 cm above ground and extending out 35 cm and 20 cm respectively from the front of the nest-set. The nests were lined with wood shavings to a depth of 3 cm, as were all nests which the hens had come in contact with. The nest-set is illustrated in the following Chapter (Figure 4.3.1), but with modified nest entrances not used in this study. Apart from the removal of

the previous nests and the installation of the new nest-set, the pen was the same as it had been when the hens had occupied it previously.

Observation of the flock recommenced the morning after hens were reintroduced into the pen. Again, the hens' activities were recorded over a nine day period (observation period 1, AR), each hen being studied during five complete nestings. After a ten day break, hens were again observed for nine days (observation period 2, AR) and again, five nestings were recorded for each hen.

Six sets of data were thus recorded for each hen:

28-20 days before moved (BM1)
9- 1 days before moved (BM2)
1- 9 days after moved (AM1)
20-28 days after moved (AM2)
1- 9 days after returned (AR1)
20-28 days after returned (AR2).

(b) *Analysis of the Data*

Hens for which a laying record of five days had not been reached in any one or more of the observational periods were not included in the analyses.

The results obtained for all hens were pooled to give the total number of nestings during which the activities occurred throughout the flock. The numbers of nestings accompanied by each of the activities were then calculated as a percentage of total observed nestings. The percentages of pacing given at each of the four pacing intensities were also calculated for each observation period.

In addition, the most common response was also determined for each hen. If a hen was observed to perform a particular activity on three or more of the five occasions on which her behaviour was recorded, she was said to 'typically' perform the activity. If the hen failed to record the activity on at least three of the five occasions observed, she did not typically perform the activity. The most commonly performed pacing intensity was said to be that which was recorded on more of the five occasions than any other intensity for that particular hen.

In order to test the null hypothesis th-t any one activity was occurring in the nesting sequence of hens to the same extent throughout all six observation periods, Chi-square analyses were carried out on the numbers of hens which either did or did not typically perform the activity in each period.

The numbers of hens which either did or did not typically perform any one activity in either the first or second observation period in each of the

three pen environments were compared by analysing BM1 vs BM2, AM1 vs AM2, AR1 vs AR2 data for that activity. Chi-square analyses were also carried out on the pacing intensity data to yesy for uniformity in the occurrence of the most commonly performed activity between observation periods in the same pen environment. These were then used to indicate whether data for observation periods 1 and 2 could be pooled to give single BM(1+2),AM(1+2) and AR(1+2) values

After pooling the data for both observation periods in each of the three pen environments, analyses were performed on the BM(1+2), AM(1+2) and AR(1+2) data in order to determine if the occurrence of any of the activities was homogeneous over the three environments.

Data gathered from the first observation period in each environment, i.e. BM1, AM1 and AR1, were then analysed, with similar tests being performed on the data gathered from the second observation period in each environment, i.e. BM2, AM2 and AR2. Each activity was again analysed separately.

Finally, three-way Chi-square analyses were performed on the data in order to establish whether the proportions of hens typically performing an activity in observation period 1 as compared with 2, were the same in the pen environment before flock movement (BM) as in the two pen environments after movement from the original pen (AM and AR). These analyses were also carried out to test the null hypothesis that the proportions of hens typically performing an activity during the first as compared with the second observation period, were the same in the pen environment after the flock was returned to its original pen (AR) as they were after being moved to the new pen (AM).

For each set of analyses performed on the data pertaining to the five activities, calling, pacing, rotations, litter raking and material gathering, similar tests were also carried out on the pacing intensity data. However in these tests the numbers of hens most commonly performing each of the intensities was compared. The previously described analyses of activity data compared the numbers of hens typically performing an activity with the numbers of hens which did not typically perform the activity.

3.2.3 Results

Five hens, G41, B97, Y92, B54 and G36, failed to reach the required number of five observed and recorded nestings for one or more of the observation periods Therefore, the reported data were attributable to 32 hens. Since each hen provide nesting records on five occasions during each observation period, the total numbe of observed nestings reported for the flock as a whole for each observation period was 160 nestings.

The numbers of nestings during which each of the recorded activities was observed to occur and the numbers of hens which typically performed each activity in each observation period are given in Table 3.2. The percentage of total nestings which were accompanied by pacing, nest calling, rotations, litter

raking and material gathering in the six observation periods are shown as histograms in Figure 3.2.1. Figure 3.2.2 shows the number of occurrences of each pacing intensity in each period as a percentage of total nestings accompanied by pacing.

Table 3.2 The number of occasions on which pacing of intensity ****,***,**,* or no pacing (-), nest calling, rotations and foot scraping (Rotations), litter raking (Raking) and material Gathering to the back and sides before lay (M.G.) were recorded during two observation periods before movement to a new pen (BM1,BM2), after movement to a new pen (AM1,AM2), and after being returned to their original pen (AR1,AR2);numbers of hens typically performing these activities are given in italics

Observation Period	Number of Times Activity Performed/*Number Hens Typically Performin* Pacing ****	***	**	*	Activity -	Calling	Rotations	Raking	M.G.
BM1	1 *0*	6 *1*	27 *3*	94 *24*	32 *4*	107 *25*	144 *31*	132 *28*	39 *3*
BM2	0 *0*	5 *1*	25 *3*	96 *24*	34 *4*	103 *25*	143 *30*	134 *28*	35 *1*
AM1	5 *0*	42 *8*	71 *18*	36 *6*	6 *0*	144 *32*	119 *27*	103 *24*	18 *0*
AM2	2 *0*	20 *3*	60 *13*	60 *16*	18 *0*	134 *31*	133 *29*	113 *24*	20 *0*
AR1	2 *0*	25 *3*	68 *16*	53 *13*	12 *0*	137 *32*	126 *27*	104 *23*	20 *0*
AR2	1 *0*	11 *1*	41 *7*	83 *21*	24 *3*	118 *30*	138 *29*	120 *28*	29 *3*

For the first two observation periods (BM) while the birds were housed in their home pen, the numbers of nestings accompanied by each of the recorded activities were remarkably similar. The hens at this stage were about eight months old and had begun to lay between one and two months earlier. Individual hens tended to be quite stable in their nesting habits. Approximately 80% and 65% of all observed nestings were accompanied by pacing and calling respectively (see Figure 3.2.1). However, some individuals within the flock tended to pace or call all or most of the time, and other individuals none of the time or very rarely. Pacing intensity tended also to be very similar for both observation periods in the home pen before flock movement. High intensity pacing (**** or ***) tended to be performed only by a few individuals. Hens G40 and Red were responsible for nine of the 12 instances of high intensity pacing observed in the two pre-movement observation periods. Low intensity pacing (*) or no pacing at all tended to be characteristic of the nesting sequence of quite a large group of hens.

Rotations and foot scraping were activities regularly practised by the majority of individuals. Approximately 90% of all nestings in the flock were accompanied by these nest building activities in both pre-movement observation periods. Litter raking was observed almost as frequently (82.5% and 83.8% of nestings in observation periods 1 and 2 respectively). Material gathering to the back and sides before oviposition was observed for 24.4% and 21.9% of all nestings in pre-movement observation periods 1 and 2. Although this activity did also tend to be characteristic of only some hens, its occurrence

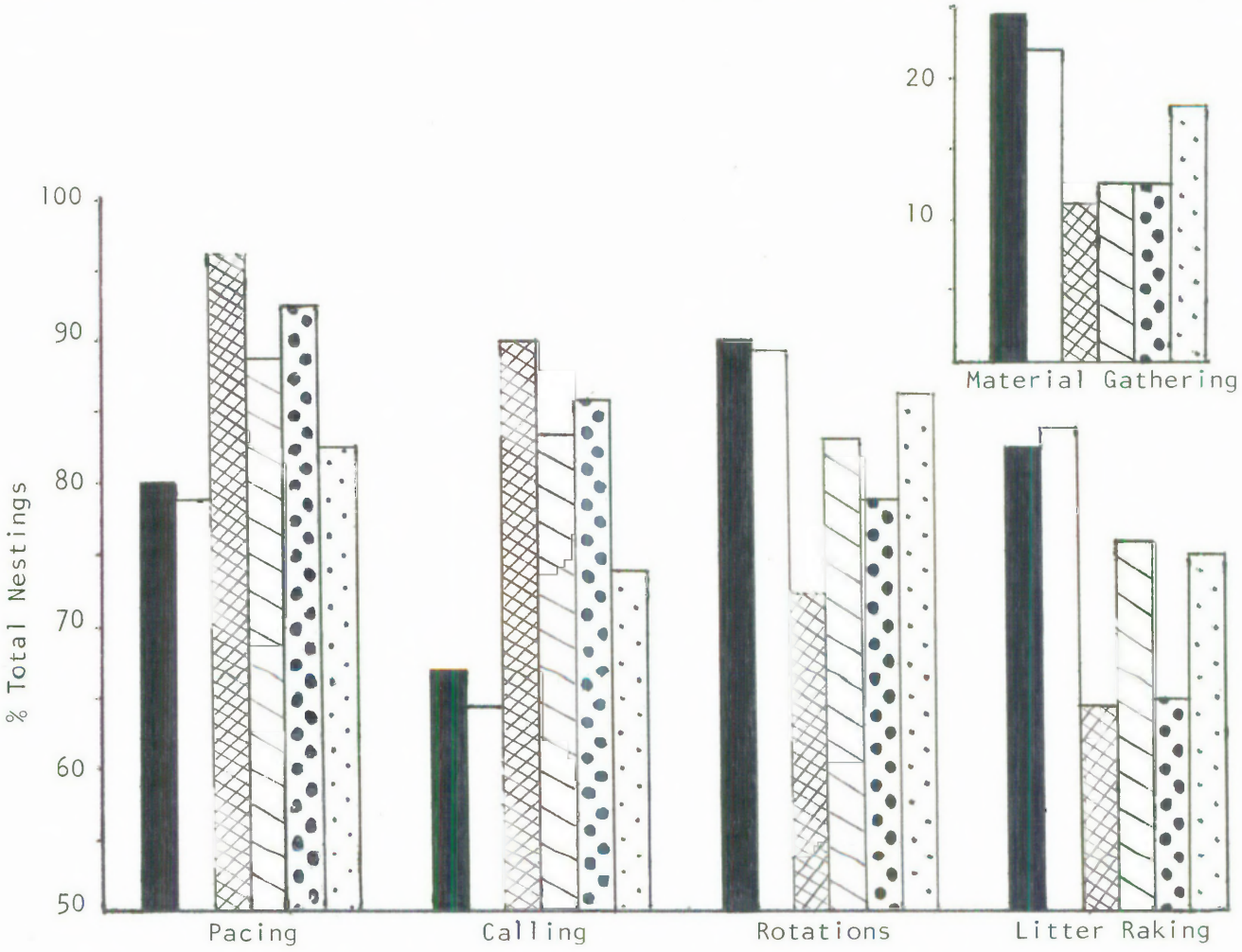

Figure 3.2.1 The % of total nestings which were accompanied by pacing, nest calling, rotations and foot scraping, litter raking and material gathering to back and sides before lay (inset), 28-20 days and 9-1 days before being moved to a new pen, 1-9 days and 20-28 days after being moved to a new pen and 1-9 days and 20-28 days after being returned to the original pen.

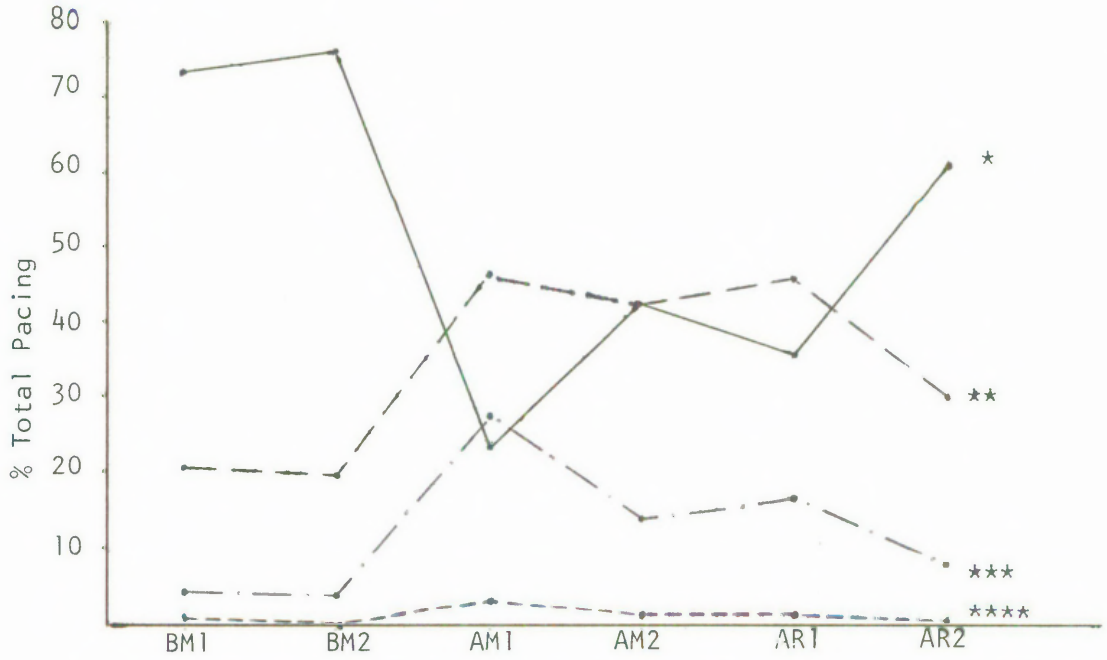

Figure 3.2.2 The % of total pacing which was performed at intensity **** (- - - - -), *** (— · —), ** (— — —) and * (———), 28-20 days and 9-1 days before being moved to a new pen (BM1, BM2), 1-9 days and 20-28 days after moved to the new pen (AM1, AM2) and 1-9 days and 20-28 days after returned to the original pen (AR1, AR2).

tended to be more random than was that of other activities. It is possible that instances of this activity were undetected because, as pointed out previously, this activity tends to occur in bouts of short duration which are only infrequently repeated.

The nesting behaviour of hens after movement to the new pen in which the availability of certain potential nesting sites was continually disrupted, (AM), was altered considerably. The first few days after movement to the new pen saw a number of hens behave quite atypically in the pre-laying phase even if the identical nest or floor site type preferred in the home pen happened to be available to them in the new pen.

Hens paced the pen quite vigorously and frequently performed 'escape' movements up the pen walls. On encountering an excluded nest or corner while pacing, a hen would 'examine' it closely, move about it repeatedly and often return to it. If a hen was confronted with an excluded nest or floor site in the position in which she had previously preferred to lay, her reaction tended to be even more agitated.

Hens' reactions to mirrors across corners tended to be of two types. Either the hen continued to walk right past the mirror as if it and the corner behind it were just a continuation of the wall she was pacing, or she would perform a peculiar activity as if attempting to enter the mirror or what was 'behind' it. She would push herself up against the mirror, moving her head up and down the mirror and pacing from side to side along it. The general impression gained by the observer was that the hen's activities looked very much as if she was trying to find a way through the mirror. If a preferred nest or site was excluded hens would either go to another similar site or nest and lay, lay in a site along the wall next to the excluded site, lay in a rather agitated state 'on the run' anywhere in the pen, or, more rarely, lay in front of the mirror excluding the site or on the approach outside the nest.

Concomitant with the general increase in locomotory and calling activity in the pre-laying phase following movement to the new pen, was a decrease in the time spent actually sitting on the nest and so in the frequency of nest building activities. The frequency of rotations and foot scraping, and litter raking activities during the first observation period after movement dropped by about 16% or more on their pre-movement values. The increase in occurrence of pacing activity, after movement to the new pen, was of the same order, whereas the increase in calling activity amounted to approximately 25%. Incidences of material gathering in the nesting sequence were about half as frequent as they had been prior to movement.

Most affected by the change in pen, and alterations within the new pen, were those hens who had previously displayed a high degree of repeatability in their selection of a nest. Amongst these, the very conservative hens who had established a preference for one particular nest or floor site, such as hens G34 and G38, appeared most disturbed by the changes. Such hens became particularly agitated in the pre-laying phase, although they usually eventually selected a nest of some sort in which to sit and lay when nearing oviposition. It was also noted by the observer that the less conservative hens, and also the 'sociable' nesters identified in Study 3.1, tended to be less affected by the change in environment.

The second observation period, which commenced 20 days after the flock was first moved to the new pen, showed that hens had adjusted to a certain extent to their new, but continually changing environment. Incidences of pacing and calling activities had declined somewhat and rotations and litter raking increased above the values obtained during the observation period immediately after flock movement. Changes were of the order of 5-10% above or below those values established in the first observation period following movement. While high and medium pacing intensities had increased in prevalence immediately after flock movement, they were less commonly observed during the second observation period after movement. Low intensity pacing (*), which, prior to flock movement, had been most commonly performed, declined substantially after flock movement as hens performed their pre-laying activities in an apparently agitated state. It had increased somewhat by the time the second observation period had begun.

In the case of all activities and of most hens, the 'adaptation' to the new pen environment was not complete. The incidences of occurrence of all of the activities had not returned to the values obtained in their original home pen. Some individuals at this stage appeared to be little affected by alterations in the availability of different nests or floor sites from day to day. They would simply move to an available site to sit and lay. Others, however, continued to be disturbed by the exclusion of certain nests. Not only were the more conservative hens, as established in Study 3.1, apparently most affected by the change in pen environment, but they were slower to 'adapt' to the new environment; their pre-laying behaviour tended to be influenced over a greater period of time.

When the flock was returned to its original pen (AR) from which the previously used nests had been removed or excluded and a new set installed, there was a further, immediate change in pre-laying behaviour throughout the flock.

During the first one or two nestings after return to the home pen, pacing and calling again increased slightly while rotations and litter raking were less often recorded for individual hens. The increase in pacing and calling and the decrease in rotations and litter raking were not as dramatic as they had been when the hens had first been moved from their home pen to the new pen. Nevertheless, pacing and calling were performed during more nestings, and rotations and litter raking during less nestings than they had been during the second observation period after movement to the new pen.

The data collected from the final observation period, commencing 20 days after return of the flock to its home pen, indicated that the hens' pre-lay behavioural patterns were becoming increasingly like those they had displayed in their home pen before they had been moved about. Flock values for the frequency of occurrence of calling and pacing had decreased to levels approaching those of the pre-movement period. Similarly, rotations, litter raking and materia gathering were more frequently observed and, although still below pre-movement values, appeared to be returning to their earlier frequencies.

Several of the hens who had previously been elevated or floor nest-box layers failed to use the new set of nests initially. These hens laid their eggs in floor sites. Some hens, which previously had been exclusively floor-layers, began to use the new set of nests. One hen, G34, who had been a highly conservative elevated nest layer and who had been laying longer than any other hen in the flock, remained in a highly agitated pre-laying state throughout the study. She persistently threw herself at the closed nest-set which she had used previously and would do so for the entire pre-laying period. Eventually she would lay on the floor under the nest-set or 'on the run' somewhere in the pen. She never attempted to nest in any other nest or site, and in her agitated pre-laying state paid very little attention to any other potential nests even in passing. Her relentless efforts to gain access to the closed off nests invariably led to physical damage, such as cut feet and lacerated wattles and comb, but she persisted in her attempts to use these nests.

Calculated Chi-square values corresponding to the previously described analyses of numbers of of hens typically performing certain activities during the different observation periods are given in Appendix 3.2. Chi-square analyses of the numbers of hens typically performing, or not typically performing, each particular activity during each observation period indicated significant differences between the probabilities of hens usually performing some activities in the six different observation periods ($P<.001$ for calling and pacing intensity; $.01<P<.05$ for pacing.

For all activities, the proportion of hens typically performing the particular activity during each of the two observation periods in the original home pen were not significantly different. On the other hand, when the two observation periods in the two pen environments, after movement into a new pen (AM), and after return to the original pen (AR), were compared, some significant changes were found to have occurred.

The pattern of pacing intensity typically performed by hens changed significantly between the first and second observation periods in both environments AM and AR ($.01<P<.05$). In general terms, the change was from higher to lower intensity pacing between observation periods.

Significant changes were not detected between first and second observation periods after movement (AM) and after return to the original pen (AR) for other activities. However, there was some evidence that an increase in the proportion of hens typically material gathering, and a decrease in the proportion typically pacing, had occurred between observation periods after return to the original pen ($.05<P<.10$).

Since some of the abovementioned analyses of the change, if any, in occurrence of activities between observation periods 1 and 2 in any of the environments, BM, AM, or AR were significant, any analysis of the effect of pen environment on the occurrence of activities, pooled over both observation periods, is not strictly correct. Hence, Chi-square values obtained for such analyses of data pooled over both observation periods are not given in Appendix 3.2, although they were performed, and significant differences were found between BM, AM and AR data for calling ($P<.001$), pacing ($.001<P<.01$) and pacing intensity ($P<.001$).

Significant differences were found in the proportion of hens usually calling ($P<.001$), pacing ($.01<P<.05$), material gathering ($.01<P<.05$) and pacing intensity ($P<.001$) in the first observation period of each pen environment, ie. BM1 vs AM1 vs AR1. Investigation of the original data reveals that most of this effect is produced by the transfer of the flock from the original pen to the new pen. When the second observation periods in each environment were compared, the effect of pen environment was found to have been less dramatic than it had been for the first observation periods. The numbers of hens typically calling were significantly different in the three experimental periods ($.01<P<.05$) and there was some indication of a trend in pacing intensity ($.05<P<.10$).

When the effect of observation period within pen environment was compared for theoriginal home pen (BM) and the two pen environments after flock disruption (AM + AR), the analysis was, in all cases, significant (see Appendix 3.2). This result indicates that while hens were quite stable in their pre-laying behavioural patterns prior to movement, the type of nesting sequence displayed changed over time, gradually approaching that which it had been in a stable pen environment.

When the observation period effect was compared for the two pen environments after movement, significant differnces were found for the activities pacing, and its intensity, and material gathering. Some indication of a trend in calling was also found. Thus, the manner in which the behavioural patterns changed over time was different for the environment AM, than it was after flock movement to environment AR.

Except in the case of material gathering, differences in the effect of observation period were greatest between before moved (BM) and after moved (AM + AR) data than they were when the two environments after movement, AM and AR, were compared.

Analysis of pacing intensity data indicated that the ratios of numbers of hens typically displaying each pacing intensity were indeed very different during the six observation periods ($P<.001$). As for other activities, there was no change in this ratio between observation periods 1 and 2 in the original pen environment. However, a change having the effect of returning frequencies of pacing intensities towards their pre-movement values, was found to be significant following disturbance resulting from placement in the two post-movement environments AM ($.01<P<.05$) and AR ($.01<P<.05$). When data obtained from observation period 1 were compared for each pen environment, the results were agsin found to be highly significant ($P<.001$). This result reflects the general decline in the occurrence of low intensity (*) pacing and the slight increase in medium and high (**,***,****) pacings in the period immediately following movement into a new environment. The difference between pen environments was not significant, or at most constituted a trend ($.05<P<.10$), when observation period 2 data were compared.

As was found in the case of other activities, the proportions of hens which typically paced at each intensity were found to change in a different manner between observation periods within environments, following movement to either of the new environments (AM + AR), than it had been prior to movement ($P<.001$). In fact, as indicated above, the number of hens typically pacing at each intensity was relatively stable in observation periods 1 and 2 in the original home pen, whereas it tended to return to greater proportions of low intensity pacing and lower proportions of medium and high intensity pacing between observation periods in the environments after flock movement. The rate of change, or return towards lower intensity pacing, was greater during the AR phase than it was for the AM phase ($P < .001$).

Not all Chi-square analyses performed in this study were independent. However, it was realised by the author that not all were orthogonal contrasts and, as such, the results are interpreted with some caution.

3.2.4 Discussion

Comparison of the occurrences of recorded behaviours in the two observation periods in the original home pen failed to indicate an effect of observation period. It would therefore appear that the hens, which were then between 35 and 37 weeks of age, had formed fairly stable behavioural displays associated with nesting, and little change in these patterns occurred over the period between observation periods. Nesting behaviour seems, then, to be fairly stable in the individual by, on average, about the sixth or seventh week after commencement of laying, if not before.

After introduction into a new pen, in which the availability of certain nesting sites was continually altered, the flock as a whole showed more pacing and nest calling. This may have been associated with an increase in the tendency to carry out behaviours appropriate to the nest-seeking phase, as opposed to the nest building and attentiveness phase, resulting from inability of some hens to use preferred nest sites and the subsequent need to find new sites. However, it is also possible that the increase in pacing and in pacing intensity may have been partly attributable to a certain degree of frustration resulting from hens being thwarted in their attempts to enter preferred nesting sites. This suggestion would seem to be supported by the previously noted tendency for hens which had, in the original environment, exhibited a high degree of conservatism in selection of nest site, to pace more and at a higher intensity. Duncan (1970) reported that Brown Leghorn hens experienced in the use of trap-nests in deep litter pens reacted with increased stereotyped pacing in the hour before laying when frustrated by closing all the trap-nests in the home pen or

removing the birds to cages, as compared to their behaviour in the same situations on non-laying days. He reports that the pacing in the cage was very similar to that which occurs in the food-thwarting situation and that in the pen it usually occurred along the front of the shut nest-boxes. The tendency for hens to pace about the excluded nests or nest sites was also noted in the present study. Brantas (1980) also reported an increase in paces taken during the pre-laying period by hens in cages without access to nest-boxes as compared with occasions when the birds were allowed access to nest-boxes.

Upon introduction to the original pen with a new nest-set available, a similar, but smaller, increase in pacing and pacing intensity occurred. Possibly the increase that did occur was mainly attributable to those hens which had previously used elevated nests and were unable to do so on return to the original pen. While this may again have been partly a response to frustration resulting from the inability of such birds to use their previously preferred nest-types, it was probably also connected to a general increase in nest-seeking behaviour, as indicated by an increase in calling also, in response to being placed in a 'new' environment.

Hens appeared to 'adapt' to their new environments, at least to some extent, over the four week periods after placement into such environments. This probably reflected a tendency for hens to reform attachments to particular nests or nest sites. A tendency for hens to pace or call less during the second observation period after movement to either pen than during the first could not be supported statistically, although a change in pacing intensity could. Hens seemed to settle down more readily in the AR situation. This is not surprisin for it would be much simpler for hens to form attachments to particular nests or nest sites if these were always available. Hens nesting in the continually changing environment would either have to learn to accept other alternatives on occasions on which the preferred nest was not available, or to form preferences for two or more distinct sites.

Apparent trends exhibited for nest building activities tended to be the reverse of those noted for pacing and calling. This is not surprising in the light of results obtained in Study 3.1 which suggested that in situations, or individual hens, in which the nest-seeking phase was extended or more intense, as indicated by occurrences of pacing and calling, less nest building was performed. Therefore, when hens were placed in new environments in which they were forced to reselect nest sites, they tended to show less nest attentiveness. However, analysis of numbers of hens usually performing these activities failed to indicate differences between observation periods or environments in this respect, except where the observation period effect was compared for before movement (BM)

and both after movement (AM + AR) environments. This result indicates an increase in the numbers of hens typically performing nest building activities with exposure to the two new pen environments which was not apparent in the original, stable environment. This suggests that such activities may have been increasing in importance in the pre-laying phase as the hens became more familiar with the new environment or, perhaps, as they were less frustrated by their inability to use previously preferred sites as they developed attachments to new sites.

Trends in occurrences of material gathering activities tended to follow those for nest building activities, reaffirming the connection between material gathering and nest building suggested in Study 3.1. However, changes in total numbers of material gatherings were considerably smaller than those observed for other activities and hens apparently took longer to recommence material gathering activities after movement to a new environment than to recommence nest building activities. This may reflect a tendency for such gathering activities to occur only after hens have developed attachments to particular nest sites. In a natural habitat, gallinaceous birds tend to perform the gathering activities as their clutches accumulate (e.g. Watson and Jenkins, 1964).

The results of the present study further indicate the inverse relationship which seems to exist between nest-seeking activities, such as pacing and calling, and activities associated with nest building and nest attentiveness such as rotations and material gathering. Furthermore, they show that mature hens, when forced to reselect nest sites in a new environment, will tend to exhibit nesting behaviours similar to those exhibited by naive nesting pullets, in that the frequencies of pacing and calling are elevated, while nest building and material gathering frequencies are low. It would therefore appear that the changes observed in the form of the behavioural pattern accompanying oviposition as hens mature may be more an effect of experience with nesting and formation of attachments to particular nest sites rather than of age *per se*.

A possible connection of pacing occurrence and intensity with frustration is also suggested by this study. It is not known, however, to what extent the pacing and restlessness exhibited by hens during the pre-laying phase in pens is a response to frustration, and to what extent the activities represent the locomotion involved in moving away from the general flock area or flock itself which tends to accompany nest-seeking.

It should be noted that the analyses applied are rather conservative. Had total numbers of recorded occurrences of each activity in each observation period been analysed, larger differences would have been evident. However, since each hen contributed five items of data to each of these totals, the

results would not be strictly independent, even though some some change in the behavioural pattern of each hen throughout the five nestings in each observation period was anticipated and indeed indicated. The 'change' in the expression of the nesting sequence accompanying the move to a new environment di- not necessarily coincide with the first nesting recorded for each hen, particularly in the AM environment where hens may not have found their preferred nest site excluded until their second, or later, nesting in that environment. Hence the decision to use the most commonly recorded response, or typical response, in the first five days as the criteria on which analyses were based. However,this approach underestimates the effect of pen change on those activities for which hens were highly motivated to perform, such as nest building activities, as changes would tend to ba immediate but short-lived. For example, rotations and litter raking tended to be eliminated from the nesting sequence of most hens the first or second nesting in a strange environment, but reappeared during the next nesting. Therefore, while many hens were affected in this respect for one or two nestings, most still recorded the activities for at least three of the five testings, they were classified as 'typically' performing these activities and the changes that occurred would therefore go undetected.