4.4 The Sense of 'Confinement' of the Nest/Light Intensity

Introduction

There seems to be a general acceptance in the poultry world that hens prefer 'dark' sites in which to lay and that the provision of dark nest-boxes will adequately cover the requirements of all hens for nesting environment (see, for example, Smith, 1963; Anon., 1972). However, there is some suggestion that hens may not prefer dark nests unless they have had some previous experience with them (Wood-Gush and Murphy, 1970). It has also been noted by Perry *et al.* (1971) that the most popular floor-laying sites that they found in large, deep litter floor pens were not the darkest floor-laying sites possible. It is therefore possible that hens do not respond to light intensity itself but to some other feature of the nest that may be in some way connected with light intensity under normal circumstances. Murphy (1969) concludes that the progenitors of domestic fowl, and probably also present breeds of domestic fowl, seem to respond to the presence of a wall, corner or enclosed area of some kind in the selection of nest site. Others have recognised the possible importance of 'privacy' to the nest seeking hen in a commercial situation (Smith, 1963; Anon., 1972). However, the stimuli which operate to control such preferences are not known.

The object of the present studies was to investigate further the possible role of light intensity and the provision of isolating or confining barriers at the nest in releasing nest entry, sitting or remaining in the nest during nesting.

Study 4.4.1
Responses to Light Intensity and Confinement

The purpose of this study was to determine whether hens could distinguish between light intensity and 'confinement' of the nest in their nest selection and whether this would be influenced by their environmental experience.

Materials and Methods

Hens used were six B x W, six R x W and six B x R strain hens (described in General Materials and Methods). Half the hens of each strain were housed in individual laying cages and the remainder were housed together in a small, deep litter floor pen.

Hens were tested in a test-pen situation. Nest options available involved a combination of two different nest angles and the presence or otherwise of

nest illumination. The two nest angle options were 40° or 60° and two of each angle were offered. Two nest lighting options were also offered, one in which a 25 watt light globe was inserted into the socket in one panel of the nest recess and the other in which neither panel of the nest recess was fitted with globes. One 40° and one 60° recess were illuminated and the other 40° and 60° recesses were left unilluminated. Additional light was supplied in the pen by way of 25 watt globes on each of four mid-recess panels. This was provided to ensure that the amount of light that would fall in any of the nests, apart from that actually provided in the nests, would be much the same and also to encourage hens to lay in the recesses rather than in other parts of the pen.

Because of the differential areas that recesses of different angles provided, light intensities in nests formed by 40° angles tended to be slightly higher than those occurring in 60° angles. The light intensity in illuminated 40° recesses was 30 lux whereas in 60° recesses it was 26 lux. In unilluminated nests, the light intensity in 40° recesses was 21 lux while that in 60° recesses was not more than 1 lux different from this. Thus, the factors light intensity and relative 'enclosure' of the nest could not be completely dissociated in this test.

An effort was made to record the nests selected by the hens on their first day of oviposition.

Each hen was placed in the test-pen and her subsequent selection of nest site recorded on five occasions. These did not include instances in which the hen laid on the pen floor outside all of the nest options. The results from all hens, all strains and both home environments were analysed with Chi-square analysis to determine whether different nest types were used to different extents.

Observation of these hens was conducted on a casual basis throughout the study. Notes were made of any peculiarities of the nesting of hens during the testing period in these cases.

Results and Discussion

It proved impossible to test all birds from their first day of oviposition for five consecutive days since only one pen was available at the time and considerable difficulty was initially encountered in determining the presence of a hard-shelled egg in the oviduct, by palpation, due to the inexperience of the operator. As a result, most hens were only tested after they had laid several eggs. Difficulty was also experienced when attempting to test all

hens that were to lay on each day, since, at the time that these studies were conducted, only one test-pen was available. This problem was further aggravated by the fact that many hens, particularly the B x R hens from pen environments, often withheld their eggs when placed in the test-pen and could occupy the pen for over a day at a time. As a result, hens tended to lay in their home pen for several days or even weeks between subsequent testings.

The numbers of times that the different nest options were selected by all hens of each breed from each home environment, and the number of hens which predominantly selected each option are presented in Table 4.4.1.

Table 4.4.1. The numbers of occasions that different nest options were selected by hens of three strains from pen or cage environments and the numbers of hens predominantly selecting each option (in italics)

Strain	Home Environment	Number of Times Selected/*Number of Hens Selecting* Dark Nests 40°		Dark Nests 60°		Light Nests 40°		Light Nests 60°	
B x W	Pen	7	*1½**	7	*1½*	1	*0*	0	*0*
	Cage	5	*1*	5	*1*	1	*0*	4	*1*
R x W	Pen	9	*2*	6	*1*	0	*0*	0	*0*
	Cage	3	*1*	7	*1½*	4	*½*	1	*0*
B x R	Pen	2	*½*	7	*1½*	0	*0*	6	*1*
	Cage	5	*1*	7	*1*	0	*0*	5	*1*
All	Both	31	*7*	37	*7½*	6	*½*	16	*3*

* ½ 'hens' recorded in Table arise from situations in which individual hens selected two options on each of two occasions

Analysis of the number of eggs laid indicated a significant difference between selections of light (illuminated) and dark (unilluminated) nests (χ^2_{1df} = 23.0***) which is substantiated by analysis of numbers of hens predominantly selecting each option (χ^2_{1df} = 6.7**). Dark nests were selected on 75.6% of testings. There was some suggestion that this tendency was stronger in the case of hens from pens than for those from cages (χ^2_{1df} = 3.9;P<.05). Although this was not substantiated by analysis of the number of hens predominantly selecting each option, it was considered interesting enough to warrant further investigation (see Study 4.4.2). In any case, even hens which had only had previous experience of laying in cages laid most (about two thirds) of their eggs in the unilluminated nests.

The results of nest usage of 40° and 60° options by each breed are shown in Figure 4.4.1. Analysis suggested that B x R hens tended to use the 60 options more often than either of the other strains (χ^2_{2df} = 6.2;P<.05). Again, although this trend was not supported by analysis of the numbers of hens predominantly selecting either option it was considered worthy of futher study (see Study 4.4.3).

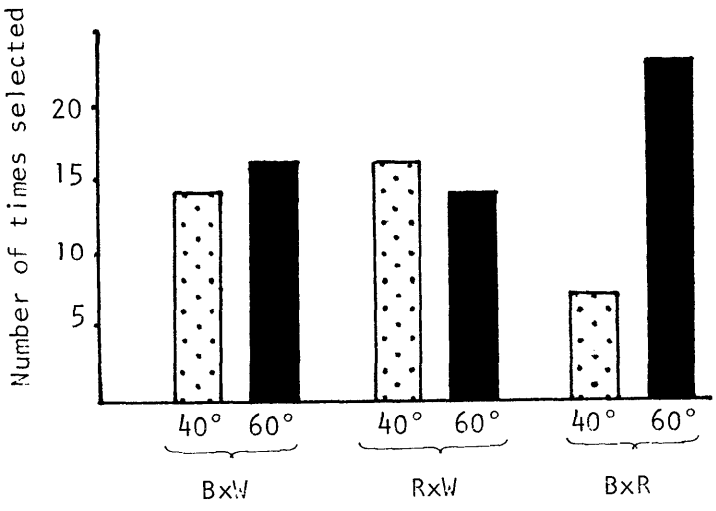


Figure 4.4.1 Number of times options of 40° (▦) and 60° (■) angles were selected by B x W, R x W and B x R hens

Some difficulties were experienced in testing several of the hens as mentioned previously. These hens, particularly those B x R hens from the pen environment, appeared to be distressed when placed in the pen for testing. They would frequently attempt to escape from the pen and sometimes, in their attempts to fly up the pen walls, they would smash light globes. These hens seemed to be capable of withholding their eggs for considerable lengths of time before finally settling in a nest option. One B x R hen, in particular, appeared to delay oviposition for up to 22 hours on several occasions in these conditions. It was decided, therefore, that to avoid similar problems when studying nest selection in the test-pen with experienced hens, that the White Leghorn cross hens would be more suitable and hens should be housed in cages rather than pens.

Study 4.4.2
Responses of Hens from Different Environments to Nest Light Intensity

The previous study indicated that hens selected dark nests to a greater extent than light nests regardless of whether they had, unintentionally, been allowed experience of laying in pen environments with nest-boxes. Experience did exert some influence on the extent to which such tendencies were exhibited however. The influence of prior rearing and laying experience on selection for light intensity was therefore investigated further.

Materials and Methods

Hens used in this study were 20 B x W strain birds purchased at 14 weeks of age. They had been reared in either cages or pens up to point of lay and

then housed in either the same environment or transferred to the alternative environment in which they remained up to and through testing. These birds were treated and allocated to environments as for those in Study 4.2.2, and were housed in adjacent cage-sets or in the same pen as those in the study already described. They were tested after they had been laying for four months on average.

Nest options available to the hens were 60° recesses fitted with either a 100, 75 or 40 watt globe, or no globe fitted to either panel forming the nest recess. Black cotton curtains were hung down at the front of all recesses so that hens could not see into the nests unless they actually went to the nest and looked under or pushed in through the side of the curtains. Only the four options were offered in the pen, each being spread with wood shavings to a depth of 3 cm. Forty watt globes were fitted to each of the panels between the nest recesses. Curtains were fitted across the nest options from the top of the pen, so there was minimal filtration of light from each nest option into the main body of the test-pen. The light intensity in each site in the three test-pens used averaged 36, 32, 26 and 5 lux for recesses with 100, 75, 40 watt or no light globes fitted respectively. Light intensity in the middle of the pen was 24 lux.

Hens were placed in the test situation when they had begun to show behaviours typical of nesting in the home cage or had entered a nest in the home pen. They were retested until they had registered five consecutive selections of the one nest option, selection being defined as where the hen laid, at which stage they were said to have made a 'final choice'. All nest selections which occurred before 'final selection' were also recorded.

The numbers of hens, from each rearing and laying environment treatment, which registered each nest option as a 'final choice' were tabulated. The total number of times each option was laid in, both before and during final selection, was analysed using Chi-square analysis.

Results and Discussion

Hens in this study seemed to experience some difficulty in finding or using the nests and a large number of eggs were laid on the floor in the middle of the pen rather than in the nest recesses. The primary difficulty appeared to be in getting into the recesses through the curtains that were hung over the entrances. Hens generally had to learn where the nests were before they started to establish nest usage habits. An example of the approach to nests used by nest-seeking hens in this test situation is shown in Plate VI.

PLATE VI

PLATE VI

Top left: Layer strain hen approaching a potential nest recess occluded, except for a small gap at the bottom, by black curtains as per Study 4.4.2. The exaggerated leg lift action and horizontal body position typical of a hen in the nest examination phase is displayed by this hen

Top right: Hen performing material gathering movements in the test-pen after leaving a nest recess before laying. In this instance, the piece of litter collected was dropped before transfer to the side of the body had occurred

Centre left: Broiler breeder hen sitting in 30 cm nest option with approach as per Study 4.5.1. The hessian 'roof' of the test-pen has been removed in order to take this photograph

Centre right: Broiler breeder hen sitting in 0 cm nest option as per Study 4.5.1. The hessian 'roof' of the test-pen has again been removed in order to take this photograph

Bottom left: Broiler breeder hen performing foot scraping activities in a 30 cm nest option with approach, as per Study 4.5.1

Bottom right: Broiler breeder hen during relaxation phase immediately after laying in 0 cm nest option as per Study 4.5.1

Results of this study, summing over all hens in each treatment, are shown in Table 4.4.2

Table 4.4.2 Number of times that hens laid in particular nest options (40,75,100 watt light globes, or no light globe) and mid-pen sites prior to 'final selection' of a particular nest type, and numbers of hens which finally selected particular nest options or mid-pen sites

Environment		Times Selected Prior to 'Final Selection'					Number of Hens Making Option the 'Final Selection'				
Rearing	Laying	Mid-Pen	0	40	75	100	Mid-Pen	0	40	75	100
Pen	Pen	3	22	0	1	1	0	5	0	0	0
Cage	Pen	19	15	0	0	2	2	3	0	0	0
Pen	Cage	4	16	2	3	0	0	3	0	2	0
Cage	Cage	13	19	7	2	0	1	3	0	1	0

More hens laid five consecutive eggs in the unilluminated nest option than in any other. Three hens, all with experience of laying in cages, laid five consecutive eggs in the 75 watt globe option, but this can not be taken as evidence of differences between hens from different environments, particularly since most hens in all groups selected the darkest option. Analysis of optio usage before and during 'final selection' shows that hens were not distributing their selection of sites evenly between the options ($\chi^2_{3df} = 59.7^{***}$). Analysis of the partitioned data indicates that the hens laid more of their eggs, in total, in the darkest (unilluminated) nest option than they laid in the next two darkest nests (40 watt and 75 watt options) which in turn were used to a greater extent than the 100 watt option ($\chi^2_{2df} = 59.0^{***}$).

Some suggestion of a possible interaction between the usage of different nest options by hens with different laing experience was obtained ($\chi^2_{3df} = 14.2$; $P<.01$). Hens with previous experience of laying in cages tended to lay a greater proportion of their total eggs in the illuminated nest options. Observation of these hens indicated that they tended to use the illuminated options mostly in their first few testings in the pen.

Comparison of the numbers of mid-pen selections and nest recess selections that took place revealed that hens from floor rearing treatments laid less of their eggs in the mid-pen area. These hens appeared to be more adept at finding the nests and appeared to be more active in exploring the pen in their nesting efforts. In the case of floor reared hens which had also spent

their previous laying life in the floor pen environment, there appeared to be greater agitation in their searching activities and attempted escapes from the pen were sometimes observed.

Study 4.4.3
Responses to Nest Recess Angle/Size

Although an earlier experiment had failed to show any overall trend in selection for nests which differed in the sense of confinement that they might afford by way of angle (see Study 4.4.1), differences with respect to strain were suggested. The present study attempts to further investigate selection for angle in two breeds of hen.

Materials and Methods

The first two experiments were conducted on 20 B x W strain hens purchased at 20 weeks of age and housed in individual laying cages.

Hens were tested in the test-pen situation for their first and 19 subsequent nestings. An attempt was made to ensure that these birds had no prior experience of nesting before testing and that they did not have the opportunity of laying in their home environment during the testing period.

Ten naive hens were tested in situations in which they had options of 30°, 40°, 50° and 60° angles creating the nesting recesses. A further ten naive hens were allowed options of 60°, 80°, 100° and 120° nest recess angles. Mid-recess panels were illuminated with 40 watt globes. The symmetry of the test-pens was somewhat affected by these pen arrangements, but all pens were set up so that each option still faced directly into the centre of the pen.

Records of overall usage of the nest options, and of numbers of hens predominantly selecting each option, were analysed by Chi-square analysis, separate analyses being carried out for both sets of nest options.

A further small study was conducted in which three mature B x W hens which had been housed in a floor pen and three similar hens from a cage environment were tested in the test-pen situation with nest options of 30°, 40°, 50° and 60° angulation. Light intensity in these options was manipulated by using light globes of differing wattage in the recesses so that all were of very similar light intensity, or the larger nest angle options were marginally 'lighter'. Each hen was tested on five occasions and the total numbers of occasions on which each option was selected by caged or penned hens were analysed. Insufficient numbers of hens were studied to allow for verification of these results by analysis of number of hens predominantly selecting each nest option.

Another trial was carried out using five broiler breeder hens (described in General Materials and Methods). At the commencement of the present study

they had been in lay for five months on average. The five particular hens used in this study had therefore had considerable nesting experience in their home pen, but had not been used in the test-pen situation previously. They were given the choice of 40°, 50°, 60° and 80° recess angle options, lighting being provided on mid-recess panels,and were tested until they had registered five consecutive selections of the one nest option which was deemed to be their 'final' selection.

The data pertaining to these broiler breeder hens were analysed separately from that of the B x W hens. Analysis was as per Study 4.2.2.

Results and Discussion

Total numbers of eggs laid in each nest option are given for both experiments with naive B x W hens in Table 4.4.3a.

Table 4.4.3a Number of times each nest option was selected by naive B x W hens and numbers of hens predominantly selecting each option

Group	Number of Times Selected / *Number of Hens Selecting*					Test	χ^2 Value	Signif.
	Mid-Pen	30°	40°	50°	60°			
1	38	9	22	43	88	Mid-Pen vs Nests	76.9	***
						Nest Options	88.8	***
		0	*1*	*1*	*8*	*Nest Options*	*16.4*	***
	Mid-Pen	60°	80°	100°	120°			
2	10	127	59	3	1	Mid-Pen vs Nests	162.0	***
						Nest Options	223.1	***
		8	*2*	*0*	*0*	*Nest Options*	*17.2*	***

The results of the first experiment indicate that the hens laid more often in the larger nest option, formed by an angle of 60°, than in the others. The smaller the angle the less often the hens laid in that option.

The second experiment, allowing naive hens the choice of larger options, again indicated that hens most often laid in the 60° nest recesses. The larger options were used to progressively lesser extents.

Most eggs were laid in the nest options, but a comparison of the relative rates of nest and mid-pen selection between the two experiments reveals that hens in the experiment using the larger options laid significantly less eggs mid-pen than hens in the first experiment ($\chi^2_{1df} = 18.6$***). This occurred despite the fact that more mid-pen area was available to hens in test-pens with larger nest angles, since enlargement of the angles in a test-pen resulted in a slight change of overall pen shape and size.

Results of nest selection by mature laying hens from pen and cage environments (Table 4.4.3b) show that the preference for the 60° option over smaller options still held if light intensity was controlled so that larger options tended to be marginally lighter.

Table 4.4.3b Number of times nest options were selected by mature laying hens from pen or cage environments

Environment	Number of Times Option Selected 30°	40°	50°	60°	Test	χ^2 Value	Signif.
Pen	0	1	5	9	Nest options	16.7	***
Cage	2	2	4	7	Nest x Environment	2.7	N.S.

Hens with prior experience of laying in either pen or cage environments reacted in the same way with respect to nest selection for these options.

The numbers of broiler breeder hens which selected the various nest options as a 'final' choice and the total numbers of occasions on which these hens selected nest options before 'final selection' are given in Table 4.4.3c.

Table 4.4.3c Number of times that broiler breeder hens laid in particular nest options prior to 'final selection' and the numbers of hens making particular nest options their 'final selection'

Times Selected Prior to 'Final Selection'					Number of Hens Making Option the 'Final Selection'				
Mid-Pen	40°	50°	60°	80°	Mid-Pen	40°	50°	60°	80°
4	3	3	6	1	0	0	0	1	4

It is apparent from these results that most of the hens eventually selected the largest option, 80 , than any other in which to lay during five consecutive testings. When total numbers of selections, both before and during 'final selection', were analysed, significant differences were found between the extents of usage of nest options (χ^2_{3df} = 23.1***). On partitioning, it was found that more hens selected the 80° option than the 60° option, which, in turn was more often selected than either of the other two options (χ^2_{2df} = 23.1**

Observations recorded for these broiler breeder hens suggested that hens in 80° nest options could remain in the site and perform complete rotations in the nest, forming large depressions in the sites. On the other hand, hens sitting in 60° options tended to be forced out of the nest recess to perform such rotations, or would perform incomplete rotations in the nest site. Hens nesting in the 40° or 50° options seemed to sit facing into the pen most of the time and performed these nest building activities to a lesser extent.

Complete rotations were often noted for the B x W hens in 60° options in the first trial, but the same hens seemed to be restricted in the performance of the same activities in nests formed by angles of 40° and, particularly, 30° in the test-pen. Hens sitting in such alternatives would sometimes be observed to commence a rotating movement and then stand for several seconds before resettling. In the second experiment, complete rotations and foot scraping were noted for hens in all options. Hens seemed to enter the 60° option more frequently than they did the other nests, even from the very beginning of the study. These studies were not designed to obtain detailed records of the actual motor patterns performed by hens in the different nest options, and tendencies noted with respect to these activities in each site could only be verified by further research.

Study 4.4.4
Responses to Nest 'Depth'

An earlier study (Study 4.3.1) had indicated a marked tendency for second generation 'feral' hens to lay in a particular type of nest-box in preference to any other. Although the particular nest type used differed from the other alternatives provided in a number of respects, the birds' habit of lying low down in a firm sitting position in these nests, which resulted in them being very difficult to detect in the nest, suggested that the 'depth' of the nest might have been of importance. The present studies were carried out in order to see if other breeds of hens would respond differentially to nest depth in their selection of a nesting site.

Materials and Methods

The first experiment was carried out on a group of 35 purchased B x W strain hens which were housed in a deep litter floor pen and from which the 20 floor housed hens of Studies 4.2.2 and 4.4.2 had been drawn. Details of the origin of these hens and the pen that they were housed in are given in the General Materials and Methods. Hens were 44 weeks of age at the commencement of these studies.

Nests were not made available to the hens in these pens until recording for Studies 4.2.2 and 4.4.2, involving a number of these hens, was about to commence. The hens had therefore laid in sites on the shed floor for about four months prior to the introduction of these nests. The nest alternatives provided in the pen were those to be offered in the experimental situation, although recording was not commenced for several weeks. During this time the position of each alternative in the set was altered daily.

The nest alternatives offered to the hens were made from corrugated cardboard and were 30 cm wide, 30 cm long, and 35 cm high. The size of the opening into the nest remained constant for all nests, but was cut either 5, 10 or 15 cm from the bottom of the nest (see Figure 4.4.4). Floor litter, to a depth of 3 cm in the nests, was used as a nesting material throughout these studies.

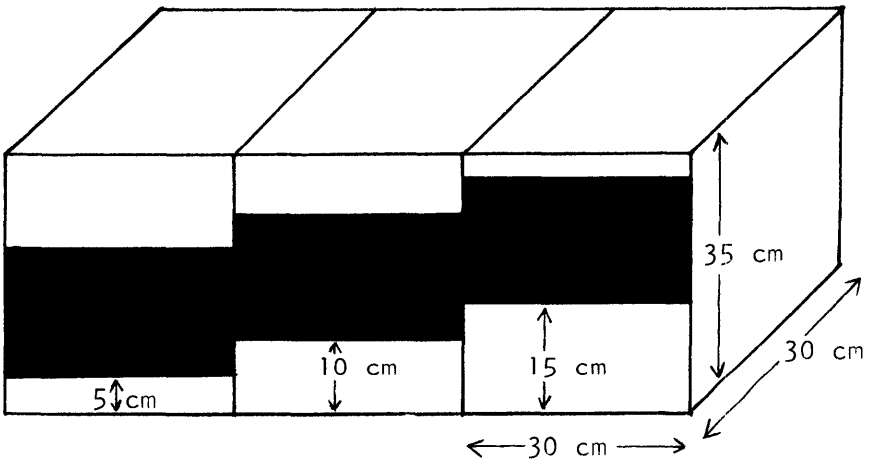


Figure 4.4.4 The three nest alternatives originally provided to B x W and broiler breeder hens

All alternatives were placed together in one corner of the shed. Eggs were collected at 10.00 am, 12.00 pm and 2.00 pm during each day, with total daily results recorded in the late afternoon, at which time the options were reallocated randomly to position in the set of three nests.

Initially, nests were simply placed on the floor of the pen at floor level (Situation a). However, it was considered that hens may be unable to use certain nests to the extent that they could use others. This could occur since the openings of each nest occurred at different elevations from the floor. To see if this was the case, the same alternatives were again offered, but the opening of each was positioned at the same level by burying the 'deepest'

(15 cm) alternative into the litter and raising the 'shallowest' (5 cm) alternative up above the litter (Situation b). All nests were positioned so that their entrances were a uniform 10 cm from the floor. The position of each in the set was again reallocated daily and recordings taken for another nine days.

Since it was possible that both height of the opening above the floor and position of the hens in relation to the level that other hens or fixtures in the pen occurred may be important factors in determining which nests were used, the nest alternatives were made available in a further way. All nests were sited at floor level, so that a hen sitting in any nest was at the same base level as hens in the pen in general. However, the litter in front of the nests was built up daily and packed down so that it formed a ramp up to each nest opening which placed the hen in front of the nest with a step of about 5 cm to get into the site (Situation c). Recording was conducted for a further nine days with the nests positioned in this way. Once again, alternatives were reallocated daily to a position in the set of three nests.

Total numbers of eggs laid in each alternative in all three situations were tabulated and subjected to Chi-square analysis.

These nest alternatives were then removed from the pen and three new nests introduced. These were larger nests, being 10 cm higher than the previous set, but the position of the opening was either 15, 20 or 25 cm above the base of the nest. Nests were placed on the pen floor in the corner and reallocated to a position in the set of three nests daily. Daily numbers of eggs laid in each alternative were recorded for 25 consecutive days. No attempt was made to make the nests easier to use as was done for the first set of nests provided. Total numbers of eggs laid in each alternative were analysed by Chi-square analysis.

Similar nest alternatives were then offered to a group of 20 broiler breeder hens housed in an adjacent pen (see General Materials and Methods). The hens were 50 weeks of age at the commencement of these studies.

The nest-set that had been available to these hens originally was excluded by closure of all the nest openings, although the nest-set was still in the pen. The nests provided in the present study were placed together along the opposite wall to that along which the previously used nests were fitted. Alternatives were simply placed on the pen floor against the wall in this study (Situation a).

Alternatives initially provided were the same 5, 10 and 15 cm 'deep' nests initially used in the B x W pen. After one full week of recording, these nests

were replaced by the larger 15, 20 and 25 cm 'deep' nests.

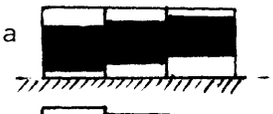
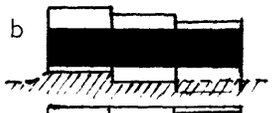
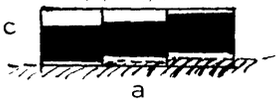
The numbers of eggs laid by these broiler breeder hens in each nest type were again recorded daily for a further seven days. Results obtained using each set of alternatives were analysed separately.

Observations of hens using nests in both layer and broiler breeder pens were taken over several days and appropriate notes were taken.

Results and Discussion

The numbers of eggs laid by B x W hens and broiler breeder hens in nests of different types are given in Table 4.4.4.

Table 4.4.4 Numbers of eggs laid in nest alternatives by B x W and broiler breeder hens

		Number of Eggs Laid in Alternatives							
Hens	Situation	5cm	10cm	15cm	χ^2	15cm	20cm	25cm	χ^2
B x W	a 	46	55	74	7.0(P .05)				
	b 	23	62	115	64.0***				
	c 	8	48	98	79.2***				
	a					270	216	22	200.9***
Broiler Breeders	a	19	20	30	3.2 N.S.				
	a					21	43	7	27.8***

B x W hens, in all situations in which 5, 10 or 15 cm 'deep' alternatives were offered, laid most eggs in the deepest nest, although this could only be regarded as a trend in the case of situation a. Comparison of results from all three situations reveals that this tendency was more pronounced in the two situations in which the different nests did not present the hens with different distances from the shed floor outside the nest to the nest opening ($\chi^2_{a \text{ vs } bc,1df} = 34.6***$).

The same hens laid most of their eggs in the 15 cm alternative when presented with 15, 20 and 25 cm 'deep' nests. The 25 cm alternative was least frequently used. It would have been interesting to have offered these same alternatives in a type (b) situation. No marked differences were observed in the behaviour of hens at different nests and most hens appeared to examine and

enter all nest types to what seemed to be equal extents.

When faced with the same alternatives, broiler breeders failed to indicate any significant preference for 5, 10 or 15 cm 'deep' nests in the first test, but laid significantly more eggs in the 20cm 'deep' nests than in the 15 cm alternative, which in turn, was laid in more often than the 'deepest' alternative when the second set of nests was offered. Observation of these hens indicated that at least some of the hens were experiencing difficulties in getting into the 25 cm alternative. When approaching these nests, the hens would often perform intention movements to enter the nest, placing one foot on the edge of the nest opening but then moving away to pace in front of the nests and then to return again to repeat the movement or enter another nest.

Study 4.4.5
Orientation of Hens in Different Nest Types

In the earlier study of selection of nests with different shaped entrances by second generation 'feral' fowl (see Study 4.3.1), it was noted that hens in the most frequently selected nest seemed to sit tight on the nest and face out towards the nest entrance or pen, whereas this did not seem to be the case for hens nesting in other nest types. To see if this was in fact the case, and if this was merely a characteristics of the hens electing to use this particular nest type, the following behavioural study was conducted.

Materials and Methods

Thirty, first generation 'feral' fowl were used in this study and were housed in a deep litter floor pen (see General Materials and Methods).

Three weeks after the completion of Study 4.3.1, during which time hens had still had access to the nest-set described in that study, all six nests were converted to what had proved to be the least popular nest type in that study, an open nest with only a 3.5 cm lip to prevent eggs rolling out of the nest. In all instances, wood shavings were spread in the nests and topped up regularly to a depth of 3 cm. After three days, the nest-set was observed from 8.00 am until 1.00 pm each day for three consecutive days. The directions that any hens actually sitting in the nests were facing, classified only as into the pen or away from the pen, were recorded every ten minutes. In addition, the direction that any hen was observed to be facing at the time of oviposition was also recorded.

A hen was classified as facing into the pen if the axis of her body was not directly across the nest or parallel to the back wall of the nest and if the

tail was nearer the back wall than was the head. Conversely, a hen was classified as facing away from the pen or nest entrance if the axis of her body was not parallel to the back wall and if the head was nearer the back wall than was the tail. Instances in which the hen was facing directly across the pen, or in which there was any uncertainty about the direction that she was facing, were not recorded.

After three days of recording were completed, the nests were altered so that all were of the 'deep' type nest found to be most popular in Study 4.3.1, consisting of a 15 cm deep nest front. Three days after installation of these nests, the orientations of hens in the nests were again recorded over three successive mornings. All observations were taken directly from a position mid-way along the wall in the pen which was opposite that to which the nest-set was fixed.

Total numbers of hens that were recorded as facing either into the pen or away from it during either sitting or laying were tabulated for both nest types. The numbers of hens facing in one or the other direction in the two types of nest were compared by Chi-square analysis. Since several recordings in sequence may have come from the same hens and some hens were observed on more than one of the days, results are not strictly independent and should be interpreted with some caution. However, serial correlation was not considered to be a great problem, particularly in the case of position during laying, because these hens laid very poorly and were recorded on only one or two occasions.

Results and Discussion

The results of this study are presented in Table 4.4.5. They suggest a trend for hens which only had access to the very open nests to lay a greater proportion of their eggs whilst facing away from the pen, or in towards the back of the nests, than they did when they only had access to the deeper type nests. Hens nesting in both nest types were recorded to face into the pen whilst sitting on the nest more than they faced towards the back of the nest. However, the extent to which this tendency was exhibited was greater in the case of nestings in 'deep' nests.

Table 4.4.5 Numbers of hens recorded as facing into the pen or away from the pen whilst sitting or laying in open (3.5 cm front) and deep (15 cm front) nests

Activity	Direction Faced	Number of Times Recorded 3.5 cm Front	15 cm Front	χ^2
Sitting	Into Pen	86	101	6.0 ($P<.05$)
	Away from Pen	60	38	
Laying	Into Pen	7	16	5.6 ($P<.05$)
	Away from Pen	11	5	

It should be noted that quite a number of hens refused to lay in either type of nest, although this was more evident on the days on which the open types of nests were offered. The numbers of floor eggs in the pen doubled when all nests in the set were converted to the more open type nest. The numbers of floor eggs declined slightly once the nests were converted to the deeper type of nest.

Study 4.4.6

Responses to Vertical and Overhead 'Confinement'

Several researchers in this field have suggested that the presence of confining barriers of some kind might enhance the attractiveness of potential sites to nesting hens (see, for example, Turpin, 1918; Murphy, 1969). It has also been noted by those involved in the poultry industry, and also in Study 3.1, that hens will often nest under fixtures for example, or in areas affording some form of overhead confinement. It was therefore decided to study the role of overhead and vertical cover in the determination of where hens will lay.

Materials and Methods

The 15 hens used in this study were B x W strain hens purchased at 12 weeks of age and housed in individual laying cages from then on.

Hens were tested in a test-pen situation, except that no recesses were formed in the pens. Instead, the pens were formed so as to be as close to circular as possible, each join between panels forming the smallest angle possible and all angles being the same. Two black cardboard squares, 900 sq.cm. in area, were placed in each pen so that one was standing vertically in the pen, supported by wires from the top of the pen and gummed to the floor of the pen (vertical confinement), and the other was suspended above the floor and parallel to it by wires from the top of the pen (overhead confinement). The height above the floor that this square was suspended varied. Three heights were used, being 35, 25 and 15 cm above the pen floor.

Several of the panels in the pen were inverted so as to provide a light source closer to the floor. The position of the two squares in the same pen was manipulated so that light intensities on either side of the vertical square and under the overhead square were the same, while ensuring that the two squares were no closer to each other, when viewed from above, or to a pen wall, than 35 cm. No nesting material was provided in the pens to eliminate any effect that might result from the solid vertical wall assisting in the making of a nest depression.

Five individual naive hens were first tested in pens in which the overhead square was suspended 35 cm above the pen floor. Once they had laid next to

and/or under squares on five occasions, they were then tested in pens with the overhead square 25 cm and then 15 cm above the floor. In addition, five naive nesters were also tested in the test-pen with overhead confinement at 25 cm, and a further five naive nesters were tested with overhead confinement at 15 cm. In all cases, hens were tested for successive nestings until they had laid five eggs next to and/or under either square. Hens were closely observed during these studies to ensure that hens were actually laying in positions directly beside or under the squares. Hens were said to have laid under a square if, when viewed from directly above the square more than half of their body was obscured. Hens were said to have laid next to a vertical square, if they nested within an area 30 x 30 cm square on either side of the square. Although hens were tested until they had registered five nestings and ovipositions either next to the vertical square and/or under the overhead square, nestings which occurred elsewhere in the pen were also recorded.

Results obtained for the initial group of hens studied, which had gained experience in the test with 35 cm overhead confinement, were compared with those of the naive hens in 25 and 15 cm overhead confinement situations by Chi-square analysis. Pooled data were then used for analyses of nesting frequency in vertical and overhead confinement in pens differing in the level of overhead confinement and also of numbers of eggs laid elsewhere in the pen when overhead confinement of varying levels was used.

Results and Discussion

Analysis indicated that the selection of both naive and experienced hens for vertical or overhead confinement, or for sites elsewhere in the pen, did not differ when both groups of hens were tested in pens with 25 and 15 cm overhead confinement. Therefore, results for both groups were pooled.

Results, including pooled data for pens with overhead confinement at 25 and 15 cm, of usage of areas next to vertical or overhead confinement and the numbers of eggs laid elsewhere in the pen are presented in Table 4.4.6.

The mean number of times each hen laid in either vertical or overhead confinement and elsewhere in the test-pen are shown in Figure 4.4.6. In pens with overhead confinement at either 35 or 15 cm above the floor, vertical confinement was selected for nesting more often than often than overhead. This result was supported by analysis of the numbers of hens which laid in each form of confinement on more occasions than the other ($\chi^2_{1df} = 8.1^{**}$). Levels of usage of overhead and vertical confinement were not significantly different for pens with 35 and 15 cm overhead confinement. On the other hand, when all results were compared, significant differences were found, both between the total numbers of times that each type of confinement was selected and between the numbers of hens which

Table 4.4.6 Numbers of nestings in and numbers of hens predominantly selecting vertical or overhead confinement in pens with 35, 25 and 15cm height of overhead confinment and the numbers of nestings which took place elsewhere in the pens

Level of Overhead Confinement (cm)	Number of Hens	Times Selected/*Hens Predominantly Selecting* Type of Confinement: Vertical	Overhead	Elsewhere
35	5	21 *5*	4 *0*	11
25	10	22 *4*	28 *6*	12
15	10	39 *3*	11 *2*	22
χ^2 35 vs 25 vs 15		17.5*** *6.6**		3.2 N.S.

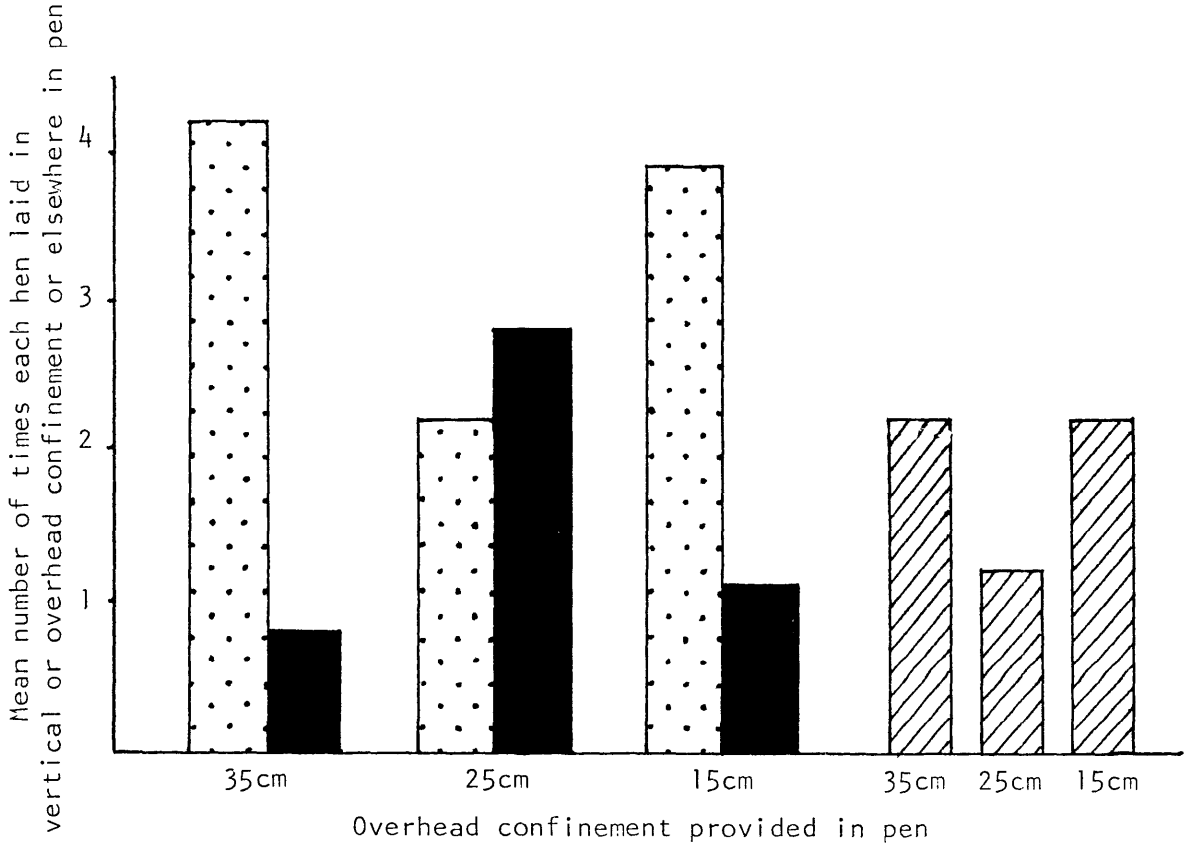


Figure 4.4.6 The mean number of times each hen laid in vertical (⚄) or overhead (■) confinement, or elsewhere (▨) in the test-pen

predominantly selected each type of confinement. On partitioning the data, it was found that the distribution of both total selections made (χ^2_{1df} = 17.2***) and numbers of hens predominantly selecting each type of confinement (χ^2_{1df} = 6.0*) was different in the case of the test situation with overhead confinement at 25 cm, than for either of the other (35 cm and 15 cm) situations. Whereas vertical confinement was used to a much greater extent as nesting cover when overhead confinement was provided at either 35 cm or 15 cm, overhead confinement was much more popular, possibly even more popular than vertical, provided at 25 cm.

Observations of the hens involved in this study indicated that hens attempting to find suitable nesting sites often nested briefly next to the shiny pen walls or near to the vertical square before trying to nest under the overhead square. Hens nesting in pens with overhead confinement at 35 cm often walked underneath the square, without hesitating, in their movements about the pen. Hens in pens with 25 and 15 cm overhead confinement seemed to be attracted to the areas under the square and would often try to crawl under it. Hens which sat beneath the square when it was only 15 cm above them appeared to experience some difficulties in performing nest building activities, particularly between rotations, when they rose from the nest, making contact with the square overhead. Instead of resettling after this occurred, the hens would often pause in a cramped position for several seconds and would sometimes leave the site rather than resettle. The possible relevance of these observations will be discussed in the General Discussion of this section.

Study 4.4.7

Responses to Visual Contact with Flock-Mates

This study was attempted in an effort to determine whether hens, in nesting, tried to avoid visual contact with their flock-mates.

Materials and Methods

Hens used in these studies were B x W strain birds purchased at 16 weeks of age. In a trial study, 12 of these birds were, upon purchase, moved directly into individual laying cages in which they remained and laid until they were 30 weeks of age. They were then placed together in a small deep litter floor pen for one week before testing. In this study, hens were placed in a 60 cm high cardboard chamber in one arm of the test enclosure (see Figure 4.4.7). One hen, the test-hen, was placed in the central chamber containing four nest-boxes, each of which faced into one of four chambers, one of which held five flock-mates.

The test-hen was selected on the basis of whether it was expected to lay an egg that day or not. It was placed into the central chamber to select a nest and five of the remaining 11 hens from the home deep litter floor pen were placed in one arm of the test enclosure. The test-hen could see these hens through glass walls between the central chamber in which they were held and the adjacent chamber holding the flock-mates. The glass walls were old windows, 45 cm wide x 110 cm long, which were simply fitted into the pen to divide the four arms of the enclosure from the test chamber. The upper part of these walls between the chambers, above 45 cm, were made of cardboard like the rest of the pen, to a height of 60 cm. The top of the test chamber was cardboard, but all other chamber arms were covered with plastic. No lighting other than that which filtered through this clear plastic was provided.

Nests provided in the test chamber were cardboard, had a low (8 cm) nest front to prevent eggs rolling out, and were spread to a depth of about 3 cm with

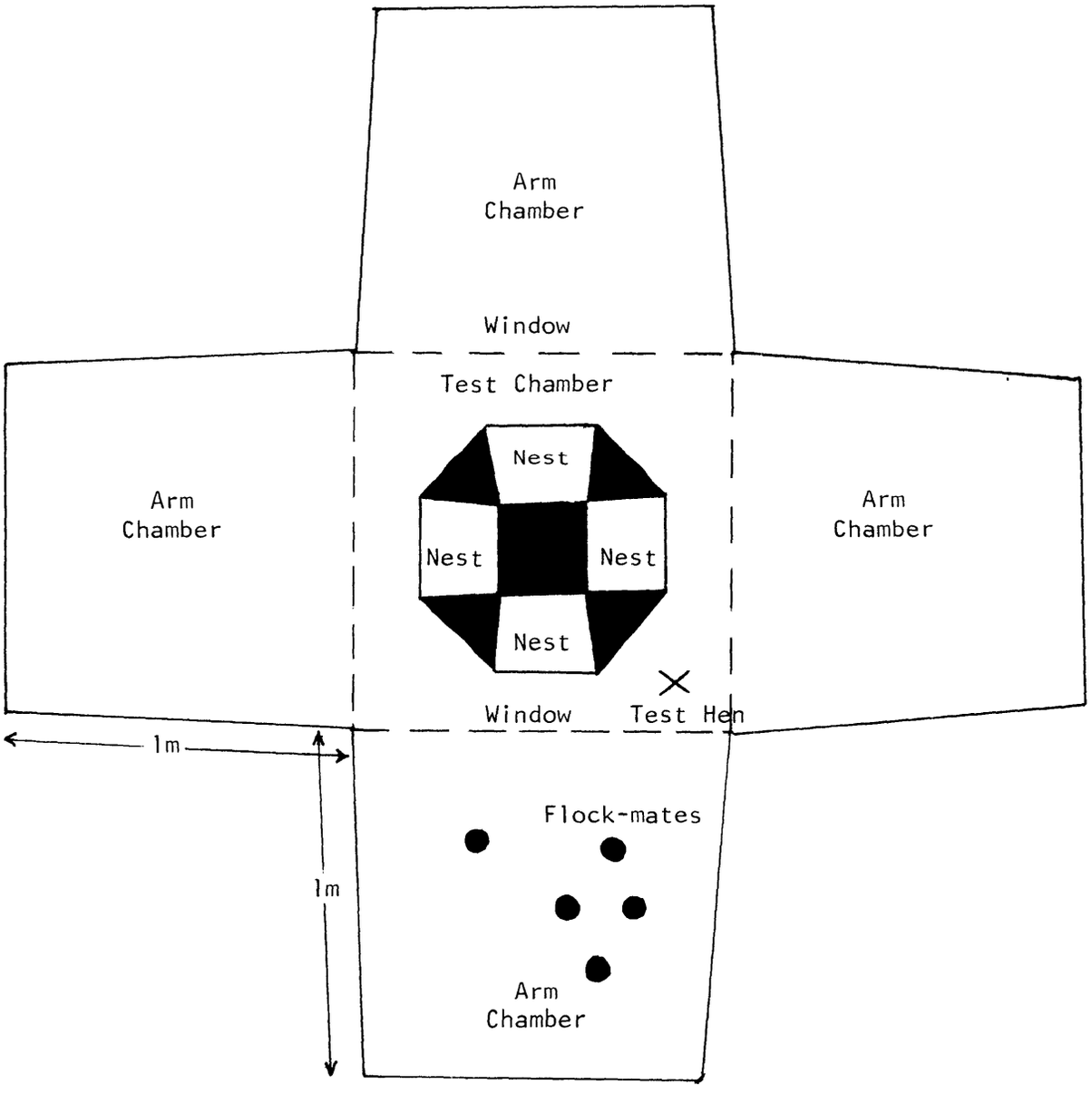


Figure 4.4.7 Test enclosure used for studies on responses to visual contact with flock-mates; showing four arm chambers, one containing five flock-mates, and one test chamber, containing four nests and the test hen

wood shavings as a nesting material. The entire test chamber sat on a cement floor which was also covered to a depth of 3 cm with wood shavings. Each nest, as previously indicated, faced out either onto the chamber containing the five flock-mates, or one of three other identical chambers which were empty. Hens were unable to squeeze into gaps between the nests because these areas were blocked off with cardboard barricades.

Hens were left to lay in the test chamber and were removed when they had laid, as seen through replaceable cardboard windows cut in the roof of the test chamber. Hens were simply removed by swinging out one wall of a chamber arm and a window wall. The entire enclosure, although made of thick cardboard, could be quickly altered or dismantled if required.

Initially, four hens were tested on each of three days in this set-up. However, it was found that most of the hens paced a great deal before laying. Many hens attempted to escape from the test-pen and all but one eventually laid on the floor near the window dividing the test-hen from her flock-mates.

It was therefore decided to try the test situation again but using hens which had not laid prior to being placed together in the test enclosure for ten days. All windows between chambers were removed so that hens could move freely through all arm and test chambers. Feed and water were provided in all arm chambers and the four nests were left in position in the test chamber. Over the ten days that all hens were allowed to move freely about the test enclosure, all of the hens began to lay. After this period had elapsed, all windows were moved into place between chambers and testing began.

The hens were in the habit of being fed in the morning, feed being removed at night, and fed eagerly when food was placed out. Hens were palpated each morning to determine if they were going to lay and one hen was selected to be tested. She was then moved into the test chamber, other hens being confined to one arm chamber. This test-hen was then allowed to lay with window dividers in place so that she was unable to leave the test chamber and other hens were not able to join her there. After one hen was tested and removed another could be tested.

Two testing situations were used. In one, all flock-mates in the arm chamber were not nesting that day, all potential nesters being removed to cages nearby. In the other situation, only hens that were going to lay that day were left in the arm chamber. These hens then had to lay on the floor of the arm chamber. No more than five hens were left in the arm chamber during testing. Four hens were tested on four occasions in the first situation and another four tested on four occasions in the second situation. On each

occasion for each test-hen, flock-mates were housed in a different arm of the test enclosure.

The numbers of occasions that hens laid, in the nest facing directly in towards the arm chamber in which her flock-mates were housed, or in the two nests to the side of this one, or in the nest furthest from her flock-mates, were tabulated. The level of usage of different nests was analysed by Chi-square analysis.

Results and Discussion

The numbers of times hens laid in the different nest types in both situations and times that they laid on the test chamber floor, are given in Table 4.4.7.

Table 4.4.7 Numbers of times that hens selected nests facing directly onto arm chambers with flock-mates, side nests and nests facing away from flock-mates and on the floor of the test chamber with nesting and non-nesting flock-mates

Situation	Number of Times Selected			
	Facing Flock-Mates	Side Nests	Farthest from Flock-Mates	Floor
Non-Nesting Flock-Mates	4	8	0	4
Nesting Flock-Mates	4	5	2	5

Although it appeared that hens were avoiding the nest from which nothing could be seen of the arm chamber containing flock-mates, no significant differences in nest selection were found. Hens penned next to nesting flock-mates did not respond differently from hens penned next to non-nesting hens, despite the fact that the nesting hens often spent a great deal of their time pacing along the window dividing the chambers. Most of the floor eggs were laid along this window area by the test-hens. Although there appeared to be some 'agitation' of the hens that did this, most of the hens settled quite readily in the selected nests but displayed some agitation afterwards when they had completed nesting and began to pace backward and forwards along the window separating them from their flock-mates.

General Discussion - The Sense of Confinement/ Lighting of the Nest

The results of Study 4.4.2 indicate that hens with experience in laying in the lighter environment occurring in a laying cage may intially select lighter nests than hens with experience of laying in the somewhat more diverse environment provided by a floor pen in which the scope for experience of nesting in a wider range of lighting conditions exists. The ability of prior experience to modify selection for light intensity is also indicated by the results of Study 4.4.1, although the relationship was by no means established. Hens in that study showed a tendency to lay in unilluminated nests, but this seemed to be modified by their previous experience of nesting in either cage or pen environments. It should be noted, however, that all options provided in this study were probably better illuminated than any of the areas that were available for nesting in the home pen and possibly the home cage environment.

The influence of experience on a hen's selection for nest site would appear, however, to be a short term effect. It is worth noting in this respect that although caged hens tended to lay more eggs in lit nests than did hens from pens, no differences were detected with regard to the number of hens that finally selected nests over a sequence of five successive nestings.

The results of these studies agree to some extent with those of Murphy (1969) who found that hens experienced in the use of low, dark trap-nests more often selected the same type of nest than any other combination of dark/lit or low/high nests. The results reported by Wood-Gush and Murphy (1970) for naive pullets suggest that hens do not respond to darkness unless they have had previous experience of it in a nesting context. However, it has already been pointed out that testing of naive pullets for their first nest selection only, particularly when using a trap-nesting system, may not actually provide a measure of responsiveness to lighting in a nesting context. Pullets unfamiliar with dark trap-nests may inially be extremely nervous about entering such a poorly lit area in the strange situation in which they find themselves. Exploratory entries into the better lit alternatives, which they may have never ended up using, may eventually result in a selection being recorded. In an open nesting situation, or where hens are practised in the use of trap-nests as opposed to experienced in nest selection, hens perhaps would not register such a 'preference'. It is interesting in this respect that all pullets were trapped in lit nests. This may indicate an effect of nervousness, since even if darkness does not act as a releaser for nest entry or sitting, it is extremely doubtful that 'lightness' should act as a releaser in nesting.

A sequential pattern of responsiveness to certain stimuli may also occur in nesting. It may well be that hens do not immediately respond to appropriate

stimuli and perhaps need to examine a number of sites before eventual selection. This may be evidenced by the observation that feral fowl seem to examine a number of sites before eventually settling in one which may or may not be the one first entered and examined (McBride *et al.*, 1969). Hens inexperienced in the use of trap-nests would not be allowed to exhibit this tendency.

It would appear from the present studies that hens may take light intensity into 'consideration' in the selection of a nest. However, it is unlikely to be the only factor used in selection of a nest site. The observation that some variability exists for selection of dark or light in nesting indicates that either the precise level of 'darkness' that will release nest entry or sitting has not been offered, or that it is not critical to nest selection. It seems unlikely that hens would respond to light intensity alone, or to one specific light intensity alone. In a natural habitat this could result in the placement of nests in all sorts of unsuitable sites, for example damp holes or extremely steep slopes beneath overhangs. It would also limit the range of nesting options available to the nesting population to a great extent. In fact, nests of gallinaceous species occur in many situations, even with respect to light intensity. However, the present studies indicate that it may be used in nest selection, all other factors being equal (or of less importance).

Discrepancies between the results of any studies of hen preference for different light intensities, or light as opposed to dark nests, may result from strain differences in responsiveness to such stimuli. This seems to be indicated by Wood-Gush's (1972) finding that one strain of hen responded to darkness in the pre-laying phase with decreased pacing and increased sitting whereas another strain did not. The three strains compared in Study 4.4.1 did not differ in terms of their selection of light or dark nest sites, but these hybrids did share some common parents and differences in light intensities did not vary a great deal between alternative sites. If light intensity differentials are important in determining selection, it may also be of importance that alternatives differ considerably from areas 'outside' the nest before a preference will be exhibited.

The point in the nesting sequence at which light intensity may exert an effect is not indicated by these studies. However, it would seem from previous reports (Wood-Gush, 1972) that light intensity can be used to manipulate the extent of sitting in the pre-laying period in cages. It would be of considerable interest to determine if light does influence nesting in the sitting or 'remaining' in the nest phase. Of particular interest would be an investigation of the requirements for lighting change. For example, absolute light intensity may not be important, but differential lighting patterns between

the nesting environment and the outside environment may be important. Where this effect is felt may also be of importance. For example, it may be that hens may respond to decreasing light as they approach the nest or they may respond by remaining on the nest if the area outside the nest, as they are sitting on the nest, is less dark. Such stimuli would provide for more adaptability to habitat and greater possibilities for distribution of nests in a given habitat than would absolute light intensity. However, from the results presented in the foregoing studies, it is impossible to tell if this is the case.

If light intensity is important in releasing sitting or 'remaining' in the nest, then it seems likely that some other factor could be involved in getting the hen to the area in which the nest is situated or in getting the hen into the nest in the first place.

One tendency noted in Study 4.4.2 was for less laying in the mid-pen area to be exhibited by hens which were reared in floor pen environments than by hens reared in cages, at least during some part of their earlier history. Possibly, hens reared in cages experienced more difficulty in getting to nests under the nest curtains, perhaps because they were not so experienced in exploring the pen or floor area as floor reared hens. However, one might expect that the same would be true of hens housed in cages through the laying phase also. It is possible that pullets are most sensitive to learning through exploration of their environment at particular ages and that such tendencies are less apparent after they have reached reproductive maturity. On the other hand, hens which had been housed in pens during their laying history sometimes responded in an agitated fashion when placed into the testing situation and may, in fact, have dropped eggs more indiscriminantly about the pen, so disguising any influence of enhanced ability or desire to explore their environment on nest recess usage.

The results of Study 4.4.1 suggested that while there was no effect of nest recess angle overall, strains may possibly differ in this respect. The results of Study 4.4.3, however, indicate that White Leghorn x Black Australorp hens exhibited a marked preference for 60° angles when allowed to select from that option and others either smaller or larger. Broiler breeder hens on the other hand, most frequently selected an 80° nest recess although a 60° recess was more popular than either 40° or 50° options. Behavioural observations on these hens suggested that the relative sizes of these two strains may have been important in determining a preference for angle size. The larger broiler breeder hens may have been inhibited in their nest building and settling activities in larger nests than those in which the smaller, layer

strain hens began to experience similar difficulties. This of course assumes hens did not use smaller angles than the most popular because they may be in some way disturbed or frustrated in their nesting activities by the limited space available in such nests, which may not necessarily be the case.

The reason for a decline in nest popularity as nest angle increased beyond a certain level could be that as nest angle increased, the sense of enclosure or confinement that was provided by the site declined and the hens were exhibiting a response to these stimuli. Alternatively, it may not have been the sense of confinement that the nest provided so much as the ability of the recess walls to hold the 'nest', or more precisely, the accumulation of litter forming the 'nest' together, that produced this effect. Certainly, the closer around the hen that the walls of the recess were, the more obvious the depression that was formed about the bird, providing that the size of nest allowed the hen to turn and nest build in the site at all. However, observations on nesting of similar hens in pens with the same options but with no nesting material present, although not reported here because they were only conducted on a casual basis, suggested that White Leghorn x Black Australorp hybrid hens would show a preference for 60° over larger angles even if no nesting material was provided. Results of tests using mature hens indicated that the previously established trends were still apparent, even if preferred options were lighter, regardless of prior experience.

The differences observed in numbers of eggs laid mid-pen by the two groups of layer hybrid hens tested in pens with either 30°, 40°, 50° and 60°, or 60°, 80°, 100° and 120° options may simply have been an effect of several individual hens. Results for individual hens indicated that this may be the case.

The response of layer strain hen groups in the two trials with either 60° and smaller, or 60° and larger angle options, seems to suggest that 'sense of confinement' or enclosure may be more important in determining preferred nesting site than provision of adequate space in which to perform nesting activities. This appears to be indicated by the more dramatic preferences for the 60° option shown when it was presented with larger as opposed to smaller angles. However, since the hens used in each trial were different individuals, it is possible that the observed differential responses may have been a result of individual variability.

These results for angle preference are inconsistent with those found for hens in Study 4.4.1 which failed to indicate a significant effect of angle overall. However, response to angle may have been obscured by the previously noted preference for light intensity in that experiment. Some indication of

the possible influence of angle was given by the non-significant trend for strains to select angles slightly differently in the same experiment.

Results of Study 4.4.4 on preferences for nest 'depth' show that the B x W (layer) strain hens laid most eggs in all situations in the nest with a 15 cm nest front, size of nests and nest openings being the same. In the initial test, this type was the deepest available. Upon retesting, it appeared that this tendency was even more marked if the nest lips were all placed at the same distance above the floor area outside the nest, suggesting that difficulty in getting into deeper alternatives may have diminished the initial response to nest depth. However, since all subsequent tests were performed on the same group of hens, it is possible that the more dramatic response to nest depth exhibited in later trials may have been a result of tendencies for hens to form attachments to the deeper nest in previous trials. Similarly, when tested with 15 cm and deeper nests, the apparent preference for the 15 cm alternative may have resulted from their previous experience and established preference for it. On the other hand, behavioural observations seemed to suggest that avoidance of the deepest, 25 cm, alternative may have resulted from difficulties encountered in getting into or using such nests.

Unlike the layer strain hens, broiler breeders indicated no particular preferences for the 5, 10 or 15 cm alternatives, but did show a marked tendency to select a 20 cm nest over 15 and 25 cm alternatives. Taken together, the results of these studies seem to suggest that hens may respond to nest depth favourably up to a certain point. Behavioural observations of hens using different nest types gave the impression that the deeper than optimum nest types presented some difficulties in terms of getting into or using the nest. Also, hens seemed to attempt to sink down into the nest and in some nest types were very difficult to see when in such positions. The most preferred alternatives seemed to correspond to those nests in which a hen sitting low inside one of them was difficult to see from the pen because she would usually be just at or below the level of the top of the nest. This particularly appeared to be the case with the second generation 'feral' hens whose colouring made them even more difficult to notice. The fact that the most preferred nest depth differed for each breed and tended to be deeper in the case of the larger breed would seem to support the idea that nest depth provided concealment or confinement to a hen sitting close on the nest. Concealment from other nesting hens was apparently unimportant since all nests tended to be examined to the same extent by nest-seeking hens regardless of depth or whether they were occupied. The finding that broiler breeder hens showed no significant preference for nest type when presented with 5, 10 or 15 cm alternatives may therefore have been because none of the alternatives provided the necessary

degree of confinement or concealment to these larger hens.

It would also appear that hens assessed the various nest alternatives during the examination phase or after nest entry, since all nests seemed to be examined to about the same extent. It was more difficult to say whether this was the point at which selection of nest for nest depth occurred since hens often only made intention movements to enter certain deeper nest types and may have been inhibited by difficulties inherent in actually getting into these nests. However, it did appear that entry into nests less deep than the most preferred type occurred as often as entry into preferred types, but that hens tended to remain or sit in nests of the preferred depth whereas they tended to leave the less deep alternatives. If this were the case, then sitting or remaining in the nest is likely to have been the behaviour influenced by nest depth. It should be noted that these were only impressions gained by the observer from incomplete and, therefore, not quantified observations, so further observational studies would be required to verify these suggestions.

Studies of second generation 'feral' hens nesting in either deep or open nests (see Study 4.4.5) suggested that hens sitting and, particularly, laying in deeper nests tended to face into the pen to a greater extent than hens in the open type nest. This trend is probably more reliable in the case of orientation at laying where results could be considered as independent, since few hens, if any, were believed to have been observed while laying on more than one day. Since it would seem advantageous for hens in the wild to look out from their nests towards the direction that danger is likely to come from, it would seem inconsistent that hens nesting in nests with closed backs should face away from the opening as did occur, particularly in the less preferred open nests with only a low front lip. The tendency for hens to nest near to an open area or at the edge of a block of cover has been noted for many gallinaceous species nesting in the wild (see Chapter 2). This could perhaps relate to a tendency to nest in sites from which the hens could watch over the direction from which potential enemies might approach. The fact that hens in some nest types in provided housing face towards the closed back of the nest may indicate either that they are not concerned about the existence of potential danger during nesting or that they are in some way inhibited in looking out from the nest. If the latter is the case, then it may be that nests in which this occurs are in some way inadequate, even if more acceptable than other areas of the environment and that the 'facing away from the flock' tendency might be a response to insufficient concealment or visual isolation value provided by the nest.

If the normal nesting sequence is indeed disrupted in the above way, it may be possible to determine the acceptability of certain nest sites, at least in terms of whether they provide adequate stimulus value for some aspects of nesting, by determining the preferred direction of orientation of hens using them. Unfortunately, neither time nor the availability of hens allowed for this

to be followed up. However, it should be remembered that there may be other explanations for the differences in orientation of hens nesting in deep as opposed to open nest types in Study 4.4.5. Perhaps, for example, hens in the open nests are as aware of or concerned about potential sources of danger as hens in deep nests but do not need to face into the pen to detect them because the nests are so open, whereas hens sitting in deeper nests have to face out directly into the pen because they cannot see so well if anything is approaching. Whether this is the case or not could only be determined by further experimentation comparing orientation of hens in nests varying in respect to nest depth or other factors known to influence nest preference, but in which field of vision from the nest is unaffected.

Unfortunately, it is not possible to determine from the results of Study 4.4.5 whether the orientation of hens using either deep or open nest types is a function of the particular type of hen that selects such nest types, or whether it is the nest type itself which stimulates hens using them to respond by facing in some particular direction. Many hens, particularly in the situation in which only open nests were available, chose to lay on the floor and so a complete record of the responsesof hens nesting in either nest type could not be obtained. However, those hens which did lay in both nest types tended to demonstrate the tendencies established for the whole group, suggesting that it may be the nest environment rather than the type of hen that may determine the orientation response. This is only a suggestion based on limited observations however.

Results of Study 4.4.7 indicate that hens will not necessarily seek visual isolation from either their nesting or non-nesting flock-mates when physically separated from them during nesting. In fact, hens seemed to avoid nesting in provided nests from which their flock-mates could not be seen, although this trend was not found to be significant. Regrettably, these results may be confused by the possibility that the hens were not indicating a preference for nesting conditions, but were disturbed by the testing procedure and were reacting to familiarity and perhaps 'security' provided by the flock group in such unfamiliar circumstances. It is interesting in this respect that selection of environment in other, non-nesting, situations often favours a social environment (Dawkins, 1976). It is also worth noting that in the pilot study preceding the reported trial, most hens which had no previous experience of the test situation laid their eggs almost exclusively next to the window separating them from their flock-mates. Most hens eventually used the provided nests after a ten day period of experience with the nest enclosure prior to testing.

Despite these criticisms of the testing procedure, it would appear that the desire to achieve visual isolation from the rest of the flock is either

completely unimportant or not so strong as to deter hens from seeking the security of familiar flock-mates in unfamiliar surroundings. Perhaps hens may attempt to achieve isolation from the flock area rather than from flock members themselves. Since all parts of the test chamber were part of the general flock area prior to testing, no matter where hens laid in the test situation they would always be in contact with the flock area, so the present test does not clarify this possibility. On the other hand, hens may actually prefer to face towards and be able to see into the areas of greatest activity if necessary. For hens nesting in a natural habitat this could be the direction from which danger might usually come. As previously noted, gallinaceous hens nesting in such situations tend to lay near openings or near the edges of cover, but usually on the outskirts of the flock territory.

It is also possible that domestication has lowered the fowl's reaction to other hens during the nesting phase. Generally, wild gallinaceous birds tend to avoid laying in the nests of other hens or sharing nests, although instances of dump nesting do sometimes occur. The existence of at least some individuals which prefer to nest with other hens has been recorded in Study 3.1 and noted throughout this research. However, it should also be noted that pheasants nesting at free range in wildlife areas (see Chapter 2) often lay more eggs in dump or community nests in seasons in which population density is highest or availability of appropriate nesting sites lowest. Therefore,tolerance of other hens during nesting in studies conducted in the more limited conditions of a deep litter floor pen or test enclosure may only be a response to population density or lack of space or potential nest sites rather than a genetically determined tolerance of nest sharing or proximity to other hens in nesting resulting from domestication.

The importance of some confining barrier or cover to nesting hens is indicated by Study 4.4.6. In these experiments, overhead cover was found to be popular only if it was provided at certain levels. Behavioural observation suggested that if overhead cover was provided at the lowest test height, 15 cm above the pen floor, some aspects of nesting behaviour may have been inhibited and this may have discouraged hens from remaining in the nest or may have even frustrated the hens in their nesting activities under such cover. On the other hand, if the overhead cover was placed so that hens could easily walk beneath it, hens appeared not to respond to it. Perhaps the way in which a hen must enter or leave a nest may be important in determining whether it will enter or remain in the nest. Perhaps, however, the overhead barrier did not provide adequate cover or confinement when positioned too far over the pen floor and so hens failed to respond to it in most instances, or at least they responded

more to the vertical barrier. In all cases, it would be anticipated that the size of the hen, and therefore its breed, would affect the height at which overhead confinement would become popular as nesting cover, as it would influence the height at which overhead cover would interfere with nest building and its height above the head of the bird which may, in turn, affect the hen's responsiveness to it. This could only be determined by further research using larger and smaller breeds of hens than those used in the present study, a suggestion which time did not allow to be followed up.

Many hens laid next to vertical confinement, despite the fact that such areas were not necessarily darker than other areas in the test-pen. Taken alongside the results of usage of overhead cover, this tends to suggest that hens may re-pond to proximity to some sort of a barrier in their selection of nest site, as also suggested by the results of Study 3.1.

Results of all these studies seem to suggest that hens are capable of selecting nests on the basis of light intensity, size or sense of confinement or enclosure provided by walls or other barriers, perhaps also concealment as possibly indicated by preferences for nest depth, but not necessarily visual isolation from other hens. It is interesting that hens appeared to be able to respond to light intensity and confinement of the site independently, and it is possible that hens may use the stimulus change in light intensity as an indicator of proximity to confining walls or barriers or other areas of concealment.

II. Factors Related to Approach to Potential Nesting Areas

4.5 Where the Nest is - Height Above the Floor

Introduction

As indicated in Chapter 2, the domestic fowl belongs to a family of birds which are predominantly ground nesting. Junglefowl usually nest at ground level, although exceptions have been reported. It is interesting, therefore, to note that most nesting facilities provided in commercial deep litter floor sheds tend to be elevated above the shed floor. This procedure has mainly been adopted for the convenience of egg collectors. Despite the fact that domestic fowl should be ground nesters, these elevated nests are surprisingly well accepted by hens in such situations. It seems possible that this acceptance may have resulted from the inability of hens to find sufficiently isolated, confined or concealed nest sites elsewhere in the pen and that attainment of elevation may to some extent compensate for this.

To investigate this possibility, individual hens at point of lay were tested in test-pen conditions and allowed to select nest options differing in elevation above the floor in several situations, with or without approaches to the options being available.

Study 4.5.1
Selection for Nest Elevation

The object of this study was to determine whether hens would select nests of different elevations in an otherwise barren test-pen environment. The effect of provision of approaches to elevated nests was also investigated.

Materials and Methods

The 20 hens used in this study were B x W strain hens purchased at 16 weeks of age and housed in individual laying cages.

Hens were allowed to select nest recesses in which a nesting platform was provided at 0, 15, 30 or 50 cm above the pen floor. Nest platforms were simply fitted into the four nest recesses in each pen, being suspended from sheet metal 'arms' from the top of the pen. Two photographs taken whilst hens were actually sitting or nest building in one such option, a 30 cm nest in fact, are shown in Plate IV. In this first study no roofs were provided to the nest platforms.

Recesses were fixed at 60° angles and 40 watt globes were inserted into the four mid-recess panels to light the test-pen. The area below the nest platform was blocked off by means of cardboard, and wood shavings were spread on the pen and nest floors to a depth of 2 cm. The nest platforms had a 2 cm lip to hold the shavings and eggs laid in the site.

Ten hens were tested in pens in which the three elevated nests were accessible via step-up platform approaches. These were constructed of brick supports with fibro tops. The approach to the 15 cm option was a platform of fibro 10 cm above floor level. The approach to the 30 cm option consisted of two platform levels, one at 10 cm and the next at 20 cm. Two photographs taken whilst hens were sitting or nest building in 30 cm nests with such approaches are shown in Plate VI. The approach to the 50 cm nest option was similar, except that it was constructed of three levels, the bottom two being wider than those used for 30 cm approaches to allow for adequate space to move about on each level. The three levels of the approach were 13, 25 and 27 cm above floor level.

A further ten hens were tested in pens in which no approaches were provided to allow hens access to elevated nests. In such pens the only way that hens could get up to nests was to step or hop up to 15 cm options, jump or fly to 30 cm options or jump/fly to 50 cm nest options directly from the floor. Whenever possible, hens were observed during their stay in the test-pen. In

all cases, records of where hens laid in the pen and any other behaviours of interest were taken

Each hen was tested from its first nesting and oviposition for 15 nestings in succession. Hens which were allocated to pens with approaches were only ever tested in such pens. Similarly, hens allotted to the 'no approach' treatment were only ever tested in pens without approaches provided.

The numbers of occasions on which hens selected each nest option, or a site in the middle of the pen rather than in 0, 15, 30 or 50 cm nest options, were tabulated. Total numbers of selections of each nest option were compared for approach and no approach situations using Chi-square analysis. Similar analysis was performed on the numbers of selections of all nest options as opposed to mid-pen sites. The reasons for applying these tests are discussed in the General Materials and Methods. The numbers of hens which predominantly selected each nest option during the final five selections (testings 11 to 15) were also tabulated. Unfortunately, the availability of hens and facilities did not permit sufficient numbers of hens to be studied to provide large enough expected values for adequate analysis of these results. Due to lack of independence of these data related to total numbers of selections, analyses performed on them are considered significant only if the probability level reached is less than .001 (ie. $P<.001$).

Results and Discussion

Hens usually accepted the test-pen situations very well and immediately upon being placed into the pen would often begin to give the high frequency 'glicking' call described in Study 3.5. They would often begin to examine potential nest sites immediately, even if they had not been exhibiting typical nesting behaviours in their home cage prior to being moved to the pen. The exceptions tended to be naive birds when placed in the test-pen for their first one or two nestings, in which case nest examination was often not observed and the hens eventually squatted and laid their eggs anywhere in the pen after a period of apparently aimless movement about the pen. One activity often recorded shortly after hens were placed into the pen was vigorous and prolonged dust-bathing.

In most cases, hens were apparently undisturbed by their transfer to the testing situation. Two interesting cases were noted. The first involved one particular hen who, from the fifth testing onwards, would get out of her cage when she had entered the nesting phase and sit on top of the cage. As the observer moved about the pen and past the set of cages on which she was perched, this hen would follow her along the top of the set until she was finally selected for testing and placed in the test-pen, at which point she would very quickly examine and sit in a particular nest option and lay. She did not attempt to get out of her home cage again until shortly before her next oviposition was due. If left on top of the set of cages until the time of oviposi-

tion drew very near, and on occasions after the fifteenth observation had been completed on that individual, the hen would appear to become extremely anxious and would follow the movements of the observer closely, making intention movements to fly towards her and, indeed, often fulfilling these.

Another hen did not appear to be disturbed on transfer to the test-pen, but was always very difficult to remove from it after laying. Eventually, a system was developed whereby one panel of the test-pen would be opened and the lights turned off in the pen after she had laid and the hen was allowed to leave the pen at will. Usually within 15 minutes after laying, this hen would leave the test-pen, find her way out of the light-proof enclosure and into the cage and move directly down the rows of laying cages until she reached the set from which she had come, at which point she would fly to the set and enter her home-cage. This hen always returned specifically to her own cage, which happened to be at the end of a set, even though many other cages were usually vacant.

Usually, hens would lay their first one or several eggs on the test-pen floor (mid-pen) in none of the provided nesting recesses. They would then lay in the ground level recess (0 cm) for a variable interval before beginning to use any of the elevated nest options, although several hens laid all 15 eggs in the 0 cm option. The total numbers of times hens selected mid-pen, 0 cm and elevated (15, 30, 50 cm) nest sites on their first, second, third and so on to fifteenth testing are shown in Figure 4.5b. These are total figures for hens in pens with or without approaches to elevated nest options. Additional recordings taken after the fifteenth testing indicated that the observed trend, in which the frequency of elevated nestings increased with the number of testings, continued, so that eventually most hens were laying in elevated nests regularly.

The original data indicated that hens were no more likely to change to a different nest option between sequences (clutches) of eggs than in the middle of a sequence (clutch).

Hens using elevated nest options in pens with approaches always did so via the approaches, at least on occasions on which the hens were being observed.

The total number of times that each nest option was selected and that mid-pen oviposition took place, in both pens with or without approaches to elevated nests, are given in Figure 4.5a (i. Study 4.5.1). Analysis indicated that hens distributed their selections between the four different nest options in a different way in pens with, as opposed to without, approaches ($\chi^2_{3df} = 38.9^{***}$). Hens in pens with approaches selected 0 cm options less and 15 and 30 cm options more often than did hens in pens without approaches. Analysis also showed that the number of ovipositions which took place mid-pen, as opposed to occurring in any of the nest options, did not differ significantly for pens with or without

approaches to elevated nests. In other, words, hens in pens without approaches laid about the same proportion of their eggs on the pen floor, rather than in nest recesses as did hens with access to approaches.

The numbers of hens predominantly selecting each nest option during the final five selections are shown in Table 4.5. Of the elevated nest options, the 30 cm option appeared to be the one most frequently settled upon by hens. Of the 20 hens, 14 selected the same nest option on all five of the testing occasions. Nine of these 14 were from 'no approach' treatments. This probably reflects the fact that many of these hens had not graduated to the use of elevated nests and so had only one nest option to select from, since all were fully responsive to the nest recesses and so did not lay in mid-pen areas. Only half of the hens tested in pens with approaches selected the same nests on all five approaches selected the same nests on all five testings.

Table 4.5 Numbers of hens predominantly selecting each nest option or mid-pen site during the final five selections

Study	Number of Hens Selecting									
	Approach					No Approach				
	Mid-pen	0	15	30	50	Mid-pen	0	15	30	50
3.5.1	0	4	1	4	1	0	7	0	2	1
3.5.2	5	2	3	0	0	5	1	1	1	2
3.5.3	0	1	0	2	2	0	3	0	2	0
3.5.4	0	0	3	2	0	0	0	3	2	0
3.5.5	0	4	0	1	0					
3.5.6 (experience with test-pens)						0	8	0	1	1
" (experience with laying)						0	6	0	2	2
3.5.7	0	1	0	1	3	0	2	0	1	2
3.5.8	0	0	0	4	1	0	1	0	3	1
3.5.9 (caged/mature)	0	2	0	2	1	0	3	0	2	0
" (floor/mature)	0	1	0	3	1	0	1	0	3	1
Total (not 5.5,5.6)	5	11	7	18	9	5	18	4	16	7

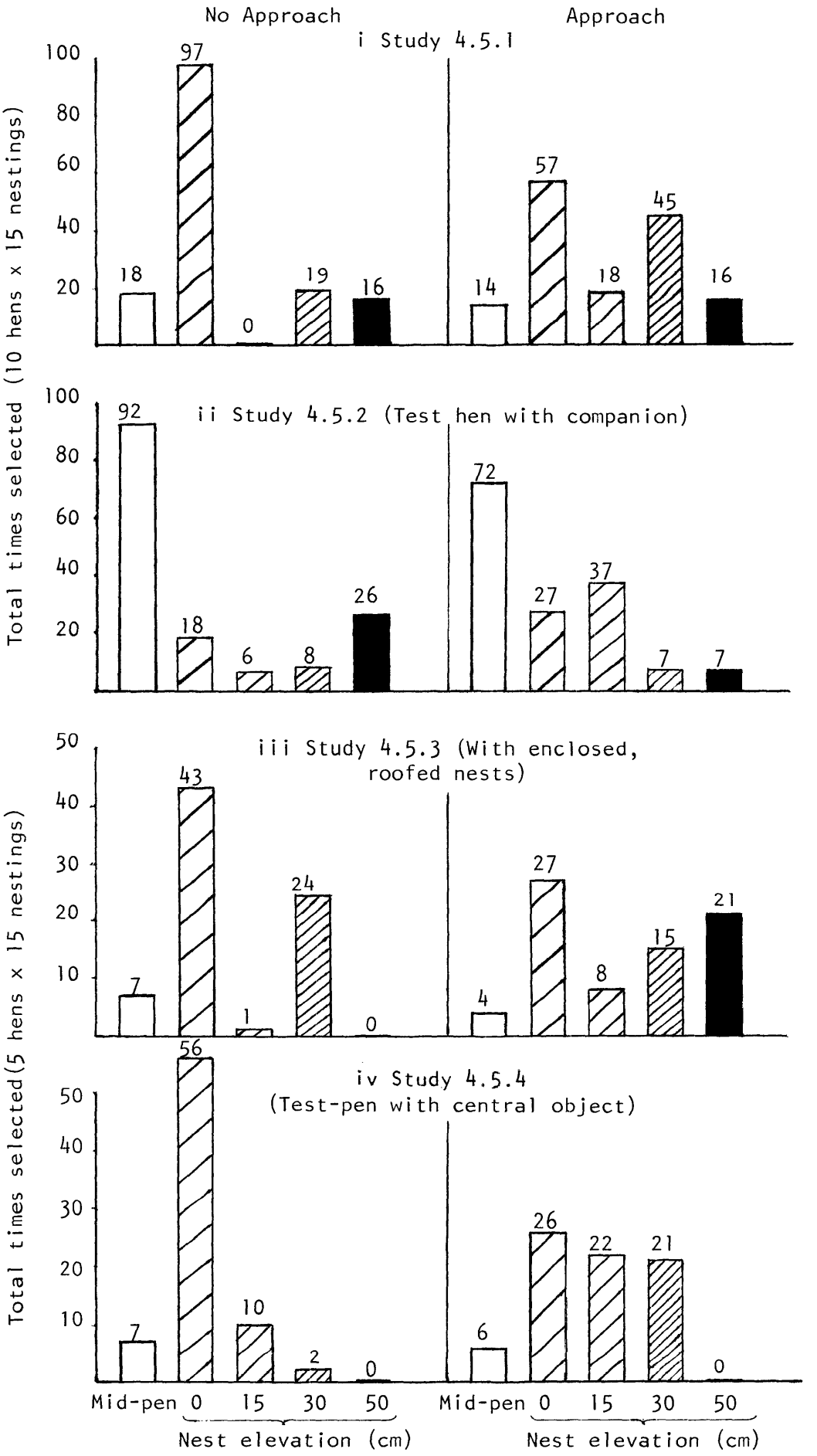


Figure 4.5a. Total numbers of times hens selected mid-pen or 0, 15, 30 and 50 cm nest options in pens without or with approaches to the nest in i.Study 4.5.1; ii.Study 4.5.2; iii.Study 4.5.3 and iv.Study 4.5.4

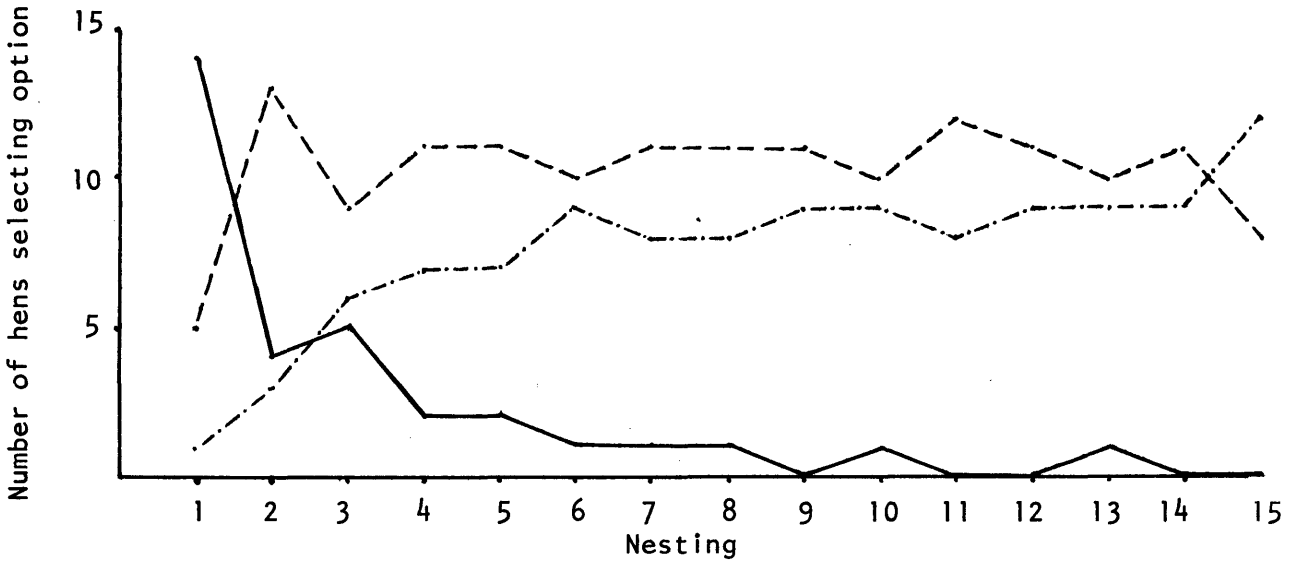


Figure 4.5b. Total numbers of hens that selected mid-pen sites (——), 0 cm (---) or elevated (15, 30, 50 cm) (-·-·-·) nest options on their 1st, 2nd ... to 15th nesting

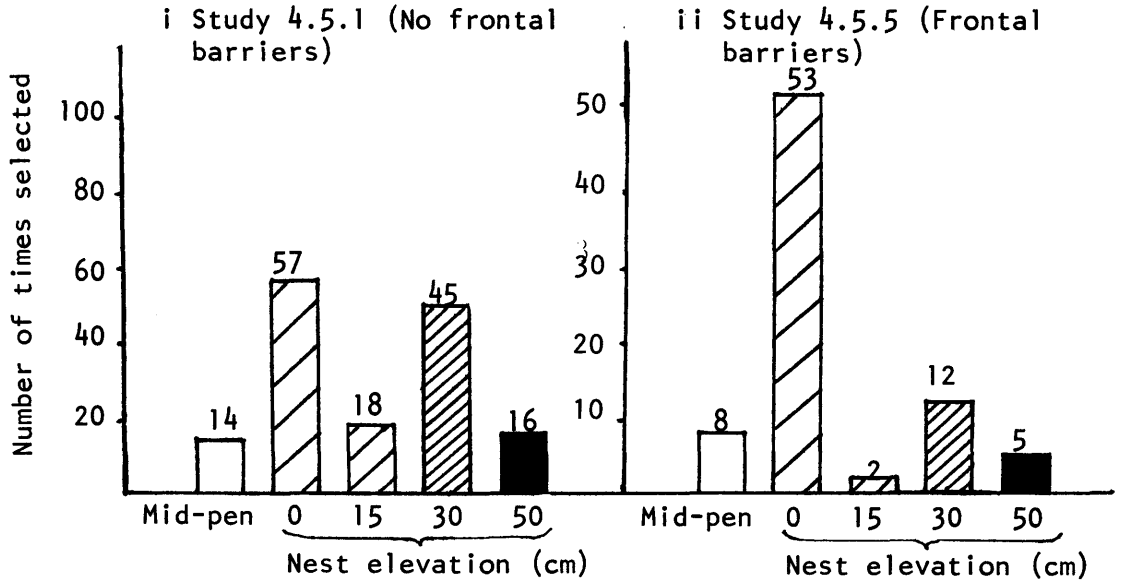


Figure 4.5c. Total numbers of times hens selected mid-pen or 0, 15, 30 and 50 cm nest options in pens with approaches and with frontal barriers or without frontal barriers to nests

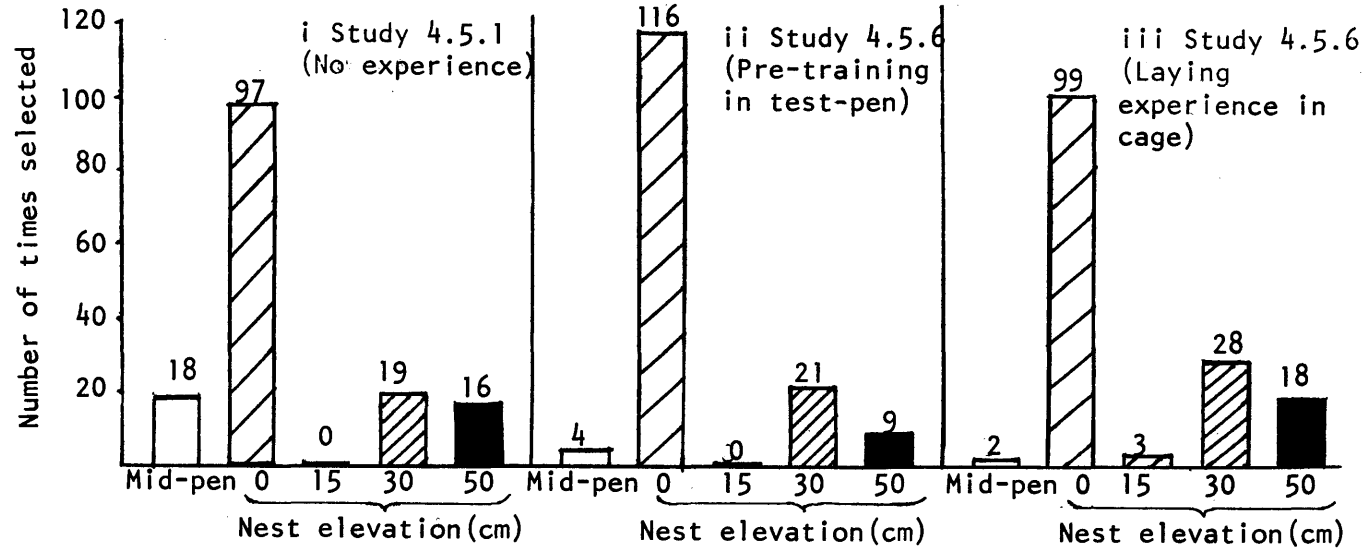


Figure 4.5d. Total numbers of times hens selected mid-pen or 0, 15, 30 and 50 cm nest options in pens without approaches after no experience (i. Study 4.5.1)or after experience with the test-pen (ii) or with laying (iii) in Study 4.5.6

Study 4.5.2
The Effect of Another Hen on Selection of Elevated Nests

The object of this study was to determine whether the presence of another hen, which was unable to actually physically interfere with the selection of nest options, could nevertheless influence the eventual choice of nest elevation by test-hens.

Materials and Methods

In this study 20 naive Bx W hens of identical breeding and rearing experience as those used in Study 4.5.1 were tested under similar conditions to those in that study, except that a caged companion hen was placed centrally in the test-pen during testing.

A companion hen was selected from among those hens of the group being tested which had already laid that day or were not going to, as indicated by palpation of hens early each morning. The companion hen was caged centrally in the pen so that the hens could not actually come into physical contact and the companion could not get into the nest options and so interfere with the test-hen's selection of a nest site. Initially, an attempt was made to tether the companion hen in the centre of the pen but this only resulted in the test-hen spending most of its time in the pen attacking its companion.

Hens were tested in the test-pens from their first to their fifteenth nesting. Ten hens were studied in pens with approaches to the elevated nests as described in Study 4.5.1 and the remaining ten hens were studied in pens without approaches. The means of testing these hens was as described in that study. No hen which was to be used for testing was used as a companion hen prior to study. No hen which was to be used for testing was used as a companion hen prior to its first testing and so none of the hens had previously been in the test-pen situation before their first testing. As a result, two additional hens had to be used as companion hens for the first few days of testing and were hens which had previously been subjects of Study 4.5.1.

The total numbers of times a mid-pen site or nest option was selected for nesting by all hens in pens either with or without approaches to elevated nest options were tabulated. These data were then compared with those obtained for hens tested without companion hens from Study 4.5.1 by Chi-square analysis, as per Study 4.5.1. Total numbers of hens predominantly selecting each nest option during the final five selections were also tabulated, but again could not be analysed due to insufficiently large expected values.

Wherever possible, the hens were kept under observation during testing. Notes were made of where hens sat and nest built whilst in the pens.

Results and Discussion

Total numbers of times that hens selected each nest option or a mid-pen site in which to lay are given for both 'with' or 'without approach' situations in Figure 4.5a (ii. Study 4.5.2). Results of the analyses of these data and those from the preceding study are shown in Table 4.5.2.

Table 4.5.2 Results of Chi-square analyses (values/significances) on data from hens in pens either with (A) or without (Ā) approaches to elevated nests and tested with (C) or without (C̄) a companion

Nesting Sites	Approaches (AvsĀ) × Nesting Site	Companion (CvsC̄) × Nesting Site	Approaches x Companion × Nesting Site
Nest Options 0vs15vs30vs50cm	56.4***	64.1***	35.4***
Mid-pen vs Nest Options	4.4(.01<P<.05)	132.0***	N.S.

Hens in pens with companions distributed their selection of nest options differently than did hens in pens without a companion. In the presence of a companion, hens selected 0 cm nest options less often than did hens nesting alone. They also selected the 30 cm option, which had been the most popular elevated option for hens nesting alone, to a lesser extent. The effect of presence or absence of approaches on selection of the nest options was altered by the inclusion of a companion hen also. Hens did not necessarily select 0 cm options less and elevated nests more in pens with approaches as they had previously done when tested alone in the pen.

The most significant finding, however, was that when the numbers of mid-pen as opposed to nest option selections were compared, hens in pens with a companion hen elected to lay in mid-pen sites to a much greater extent than did hens tested alone. This was particularly true of hens tested in pens without approaches. The interesting feature of this was that the majority of these ovipositions took place right next to the cage holding the companion hen. Hens appeared to be trying to get as near as possible to the caged companion during nesting. However, overall there was some evidence to suggest that approaches reduced the proportion of mid-pen eggs laid. Numbers of hens predominantly selecting each nest option or mid-pen site are shown in Table 4.5. It is apparent from these figures that many more hens opted to settle in mid-pen sites (50% of all hens) in the final five days of testing than had been the case when no companion hen had been present in the pen. It is also interesting to note that half of the hens selected the same nest on all five occasions, but ofhese ten birds, seven were mid-pen nesters. Apparently, the presence of the companion hen in the pen disrupted the establishment of nest attachments somewhat.

Behavioural observations revealed that in all test situations hens were capable of getting into even the most elevated nest option. In fact, many hens which for the duration of the testing period laid all of their eggs in mid-pen or 0 cm sites, were found to fly or step up to all elevated options quite regularly but not to nest there. There were several hens, on the other hand, that did not ever visit these elevated nests for nesting or any other purpose.

Study 4.5.3
Selection of Elevated Nests with Nest Roofs

To investigate the possibility that hens may have been moving to elevated nests in an attempt to achieve overhead confinement by gaining proximity to the hessian roof of the test-pen, a group of hens was tested in the test-pen situation with the same nest options as described in the previous two studies except that the nests had roofs over them. In this way, a completely enclosed nest area was provided in each recess, the size of each nest being identical.

Materials and Methods

A further 10 naive B x W hens of the same background as those hens used in Study 4.5.1 were used in this study.

Test-pens used in the previous two studies were modified by fitting cardboard 'ceilings' to each nest in the four recesses provided in all pens. These ceilings were fitted 30 cm above the nesting platform at each nest level. Cardboard barricades were also fitted from the front of these ceilings and reaching to the top of the test-pens, to prevent hens from jumping up onto the top of each nest and to prevent them from nesting on top of nests.

Five hens were tested for their first 15 nestings in test-pens in which approaches were provided to elevated nests and another five hens were tested for the same number of nestings in pens without approaches. Approaches and nest elevations used were the same as for Study 4.5.1.

Total numbers of times hens selected each nest option or a mid-pen site were tabulated for hens in either 'approach' or 'no approach' situations. These data were then compared with those of hens from pens with open nests (Study 4.5.1) by Chi-square analysis. Numbers of hens predominantly selecting each option were also tabulated for the final five testings.

Results and Discussion

Total numbers of times hens selected each nest option or a mid-pen site for nesting in pens with or without approaches to elevated nests are given in Figure 4.5a (iii. Study 4.5.3).

Analysis revealed that enclosing the nests with a nest ceiling did not affect the proportion of nestings that took place in mid-pen sites rather than in any of the nest options. The proportion of nestings in nest options that took place in the 0 cm option was not much affected by the provision of nest ceilings. Approximately half (50.4%) of all ovipositions in nest options occurred in the 0 cm recess in pens with enclosed nests, while a similar proportion of nest option selections (57.5%) occurred in the same recess in pens with open nest options. There were no significant differences found in the selection of different nest options in pens with enclosed as opposed to open nests.

Overall, a significant effect of provision of approaches was detected (χ^2_{3df} = 48.2***). Hens in pens with approaches to elevated nests used 0 cm options less and elevated nest options more than did hens in pens without approaches. This tendency was influenced by nest enclosure treatment, however, as significant differences were found for nest option usage in pens with or without approaches in either open or enclosed nest situations (χ^2_{3df} = 26.1***). From Figure 4.5a it can be seen that this reflects a complete lack of usage of the highest (50 cm) option in pens without approaches but with enclosed nests and a concomitant increase in the number of selections of the 30 cm option. Usage of the 50 cm option in enclosed nests accessible via approaches was, on the other hand, quite high.

The numbers of hens which predominantly selected each option over the five final days of testing are given in Table 4.5 (page 380a). Since so few hens were studied these results reveal very little about the response of hens in this situation, although the dissimilar proportions of 0 cm and elevated nestings between 'approach' and 'no approach' groups are apparent. Seven of the ten hens studied selected the same nest on all five occasions during these final five testings.

Study 4.5.4

Selection for Nest Elevation with a Central Object in the Pen

Since neither presence of another hen nor proximity to overhead confinement seemed to have been important in encouraging hens to use elevated nests, a study was conducted in which an attempt was made to provide a somewhat less

barren or open test-pen environment by inclusion of a centrally placed object in the pen.

Materials and Methods

Hens used in this study were naive B x W hens of the same background as those used in Study 4.5.1.

The object used in each pen was a cylinder of green cardboard which extended from the floor to about 10 cm from the top of the pen and which was about 45 cm in diameter. It was placed centrally in the test-pen so that a hen sitting in any of the nest options could see nothing of the option opposite less of the general pen area than could hens in open pens. Apart from the inclusion of the central object, the pen and nest options were as in Study 4.5.1.

Ten hens were used in this study, five in pens with approaches and five in pens without approaches. One replacement hen had to be used after one of the original hens managed to get in and lay behind the cardboard barricade under one of the elevated nests and repeated this on all subsequent testings.

Hens were tested in the test-pen for their first 15 nestings. Total numbers of times hens selected each nest option or a mid-pen site were tabulated for hens in either 'approach' or 'no approach' situations. These data were then compared with those obtained from hens in pens without a central object in the pen (Study 4.5.1).

Results and Discussion

Total numbers of times hens selected each nest option or a mid-pen site for nesting in pens with or without approaches to elevated nests are given in Figure 4.5a (iv. Study 4.5.4).

Hens in pens with central objects laid approximately the same proportion of their eggs in mid-pen sites as hens tested in pens without a centrally placed object. Hens in pens with or without approaches also laid about the same proportion of their eggs in mid-pen sites.

Overall, most nestings in nest options occurred in the 0 cm recess. Hens in pens with approaches laid less of their eggs in this option and more in elevated nests than did hens in pens without approaches. A significant (χ^2_{3df} = 62.0***) effect of approaches on the distribution of selection of each nest option was detected. Hens nesting in pens with a centrally placed object selected nest options somewhat differently from hens in pens without such an object (χ^2_{3df} = 38.9***). Such hens laid more of their eggs in lower nest options (0 and 15 cm) and less in higher options (30 and 50 cm) than was the case for hens nesting in open pens without a central object.

The numbers of hens which predominantly selected each nest option during the last five testings suggest that the above trend may have been transient, since fewer of the hens actually 'settled' in the 0 cm option than when no central oject was present. However, the shift seemed to have been to 15 cm nests which became the most frequently settled in. It should also be noted that only three of the ten hens selected the same nest during all five final testings, and these three were all hens which had not yet learned to find, respond to or use any of the elevated nests. The selection of nests and establishment of an attachment to particular options may somehow have been interfered with by the introduction of a central object into the pen.

Study 4.5.5
Selection of Elevated Nests with Frontal Barriers

Since the previous study seemed to suggest that hens might be less inclined to move to elevated nests if the test environment was made less barren or open, at least initially, a further study was designed to see whether hens would remain and lay in ground level options if the sites were isolated behind frontal barriers.

Materials and Methods

Five naive B x W hens were used in these studies. They were of the same background as those hens used in Study 4.5.1.

Cardboard barriers, extending from the pen floor to 30 cm above the top of each nest option and 45 cm in width, were erected in front of each nest option in pens in which elevated nests were accessible via approaches. These barriers were placed at a distance of 15 cm out from the front of the nest, in the case of 0 cm options, or 15 cm from the front edge of the nest approach, in the case of elevated nests. Only test-pens with approaches were used in this study because of the probability that the nest barriers would interfere with the hens' ability to fly up to elevated nest options, since they were so close to the front of the nests.

Apart from the addition of these frontal barriers, pens, nest options and approaches were as described in Study 4.5.1. Five hens were tested in the present study on each of their first 15 nestings.

Total numbers of times that hens selected each nest option or a mid-pen site were tabulated and compared withsimilar results obtained for hens in pens with approaches but without frontal barrires. The number of hens predominantly selecting each option over the last five testings were also tabulated.

Results and Discussion

Total numbers of times that hens selected each nest option or a mid-pen site in which to lay are given in Figure 4.5c, along with the corresponding data from hens tested in pens without frontal barriers to the nests as determined in Study 4.5.1.

Analysis showed that there was no significant difference between the numbers of nestings that took place in mid-pen sites as compared with nest options in the two test-pen situations, one with and the other without frontal barriers to nests. When usage of the different nest options were compared, however, significant differences were observed between pens with or without barriers ($\chi^2_{3df} = 20.0^{***}$). Hens in pens with barriers laid the majority of their eggs in 0 cm options (73.6 %) whereas hens in pens without barriers in front of nests laid less of their eggs in this option (41.9 %) and more in elevated nests.

The numbers of hens which predominantly selected each nest option during the final five testings are shown in Table 4.5 (page 280a). These results support the described finding for hens to use 0 cm options more when frontal barriers were provided in in pens. Hens must also have formed attachments to nests in this situation, four of the five hens laying all their final five eggs in the same nest.

Observations of these hens indicated that hens using elevated nests in pens with frontal barriers to the nests did so without any apparent difficulty created by the barriers. One hen laid only in the 0 cm option, but was observed on several occasions to visit and leave even the most elevated option, apparently without difficulty.

Study 4.5.6
Effect of Prior Experience of the Test-Pen or With Laying on Subsequent Selection for Nest Elevation

In previous studies, naive hens often exhibited a tendency to lay their first one or two eggs mid-pen and thereafter to commence nesting in one or other of the provided nest recesses. In an effort to determine whether prior experience with the test-pen environment or with nesting in the home environment would influence this tendency, hens used in this study were allowed to gain experience in two situations. Hens were either given prior experience of the test-pen environment or experience of laying in their home cages.

Materials and Methods

Twenty B x W strain hens of the same background as those described in Study 4.5.1 were used in this study. They were housed, upon purchase and thereafter, in individual laying cages.

Results and Discussion

Total numbers of times that hens selected each nest option or a mid-pen site in which to lay are given in Figure 4.5c, along with the corresponding data from hens tested in pens without frontal barriers to the nests as determined in Study 4.5.1.

Analysis showed that there was no significant difference between the numbers of nestings that took place in mid-pen sites as compared with nest options in the two test-pen situations, one with and the other without frontal barriers to nests. When usage of the different nest options were compared, however, significant differences were observed between pens with or without barriers ($\chi^2_{3df} = 20.0^{***}$). Hens in pens with barriers laid the majority of their eggs in 0 cm options (73.6 %) whereas hens in pens without barriers in front of nests laid less of their eggs in this option (41.9 %) and more in elevated nests.

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Materials and Methods

Twenty B x W strain hens of the same background as those described in Study 4.5.1 were used in this study. They were housed, upon purchase and thereafter, in individual laying cages.

Ten of the hens received pre-training in the test-pen before being tested for their first 15 nestings. Pre-training involved the hen being placed in the test-pen for periods of about 12 hours on each of ten days immediately prior to the first oviposition. The onset of production was manipulated to a certain extent by the feeding programme of the birds so as to ensure that they did not come into production before pre-training was completed.

The remaining ten hens were similarly restricted in their feeding leading up to the onset of lay but were then allowed to lay in their home cages for ten consecutive ovipositions before being tested in the test-pen situation for 15 consecutive nestings.

The test-pens were as described for test-pens without approaches in Study 4.5.1 and all nest options were available during pre-training of the first group of hens.

The total numbers of times hens selected each nest option or a mid-pen site, after either form of prior treatment, were tabulated. These data were then compared for each treatment, and with that obtained for hens given neither type of experience ('no approach' situation) from Study 4.5.1, by Chi-square analysis.

Results and Discussion

The numbers of times hens selected each nest option or a mid-pen site in which to lay following prior experience with either the test-pen or with laying are given in Figure 4.5d. Results for hens in pens without approaches and neither type of experience are also given in this Figure for comparison.

The numbers of hens predominantly selecting each of the nset options or mid-pen sites over the final five days of testing are given in Table 4.5 (page 280a).

Hens from different experiential treatments did not distribute their selection of nest options differently, although it had seemed that hens with experience of test-pens had used the 0 cm option more than hens with laying experience.

Analysis of the numbers of eggs laid in mid-pen sites as opposed to nest options by hens of different experiential backgound indicated that treatments differed significantly in this respect ($\chi^2_{2df} = 20.1^{***}$). The proportion of mid-pen selections that took place did not differ significantly for groups of hens which had either been given prior experience of the test-pen or of nesting and laying in home cages. However, the proportion of mid-pen selections was significantly lower for both these groups than it was for hens which had been allowed neither familiarity with the test-pen environment nor experience of the

process of nesting and egg laying (χ^2_{1df} = 19.8***). Hence, prior experience of, or familiarity with, the test environment or with egg laying was associated with a reduction in the number of times hens would fail to respond to nest recesses for nesting purposes.

Study 4.5.7
Selection for Nest Elevation by Broiler Breeder Hens

Earlier studies (see Study 4.5.1) indicated that naive B x W (layer) strain hens tended to lay in 0 cm nest options before beginning to lay in elevated nests. A further study was designed to investigate the selection of the same nest options by heavier, broiler breeder hens.

Materials and Methods

Ten broiler breeder hens of a commercial strain were used in this study (see General Materials and Methods). All hens used were at the point of lay, although in some cases it was suspected that the individual may have laid one or two eggs in the home pen provided with nest-boxes prior to their first testing. All hens were placed in the test-pens with four nest options available as for Study 4.5.1, 0, 15, 30 and 50 cm options being provided. They were tested for 15 nestings and the nest option or mid-pen site selected for egg laying recorded on each testing. Five hens were tested in pens in which approaches were provided to elevated nest options as per Study 4.5.1 and a further five hens were tested in pens in which no approaches were provided.

The results obtained for nest option and mid-pen selection by broiler breeder hens were compared with those obtained for the lighter B x W hens used in Study 4.5.1 by Chi-square analysis.

Results and Discussion

Hens were not always tested for consecutive nestings since testing of these hens was a rather slow process. Several of the hens would delay oviposition for periods of up to a day when placed in the test environment and this resulted in unavailability of test-pens at times. Hens would therefore occasionally lay in the home pen because all test-pens were already occupied.

The numbers of times that hens selected each nest option or a mid-pen site in which to lay are given in Figure 4.5e (ii. Study 4.5.7). Results for the B x W hens are again given in the same Figure (i. Study 4.5.1). The numbers of hens which predominantly selected each of the nest options or mid-pen sites over the final five days of testing are given in Table 4.5 (page 280a).

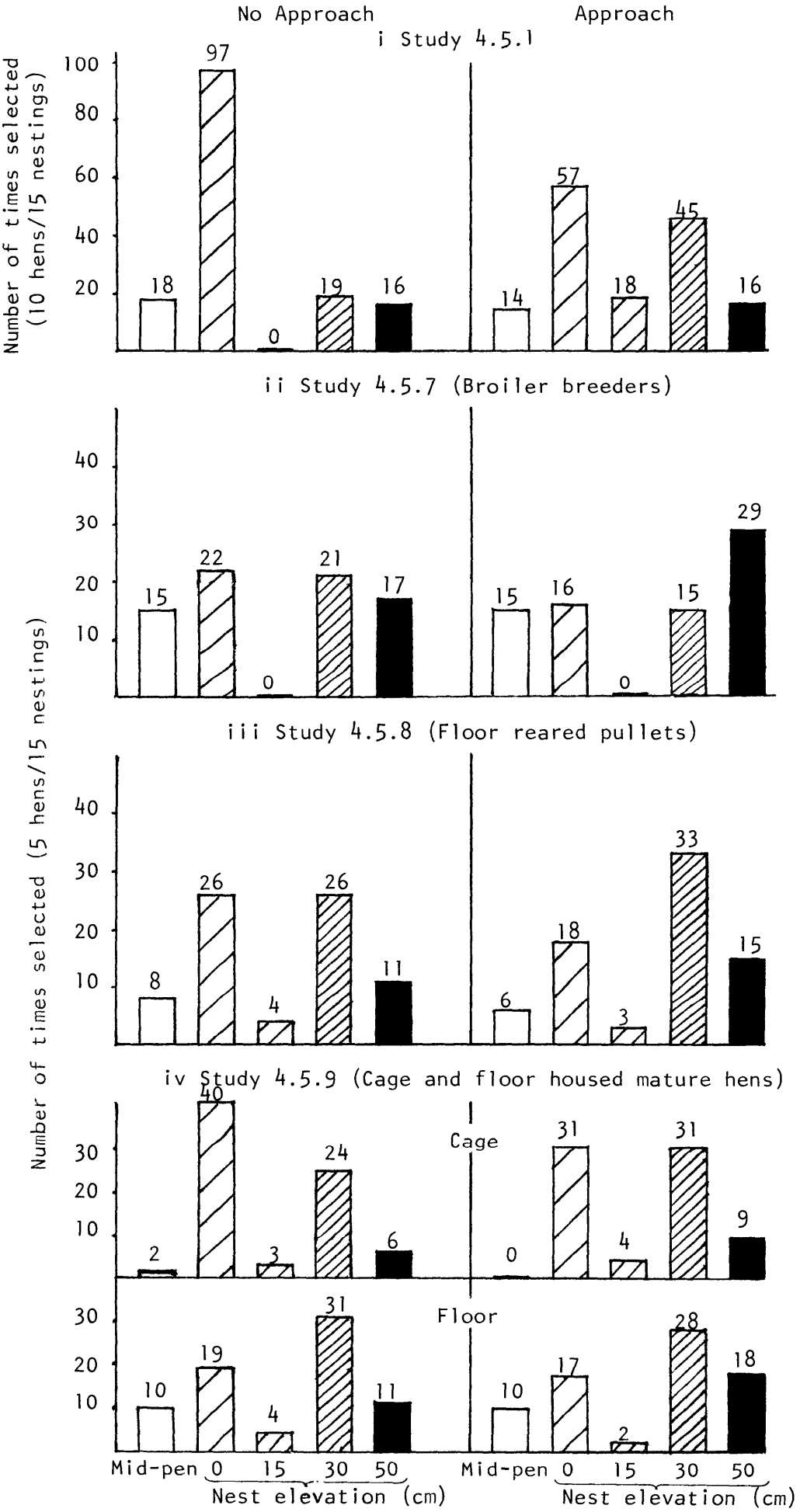

Figure 4.5e. Total numbers of times hens selected mid-pen or 0, 15, 30 and 50 cm nest options in pens without or with approaches to the nest in i.Study 4.5.6; ii.Study 4.5.7; iii. Study 4.5.8 and iv.Study 4.5.9

The overall trend was for hens to select the 0 cm option to a greater extent than any other option. However, as was the case in most other studies, this was less apparent in the case of hens nesting in pens with approaches to elevated nests (χ^2_{3df} = 36.4***). Elevated nestings were proportionally more common in such situations

Levels of usage of different nest options differed for broiler breeders as compared with B x W hens (χ^2_{3df}=49.2***). Broiler breeder hens selected 50 cm options more frequently than any other. The proportion of nestings in either of the most elevated nest options, 30 and 50 cm, far exceeded the proportion of nestings in 0 cm options in the case of these hens, whereas the reverse was true in the case of the B x W hens. The influence of approaches on nest option selection also tended to differ for the two strains (χ^2_{3df} = 18.9***). The stage of acceptance of elevated nests was less affected by the provision of approaches in the case of broiler breeder hens and as a result these hens laid proportionally fewer eggs in the 0 cm nest option in pens without approaches than did B x W hens.

There was also a trend (χ^2_{1df} = 7.3; .001<P<.01), for broiler hens to lay more eggs in mid-pen sites than the B x W hens of Study 4.5.1.

Numbers of hens which predominantly selected each nest option during the final five days of testing are shown in Table 4.5 (page 280a). Although limited, these results lend further weight to the suggestion that the broiler hens used the highest alternative, 50 cm, to a greated extent and the 0 cm option to a lesser extent than did hens of Study 4.5.1. In fact, half of these hens 'settled' in 50 cm options during this final period of testing, and six of the hens selected the same nest option on all five final testings.

Observations conducted on these broiler hens suggested that they did not experience much difficulty in getting to the highest options and in fact seemed to be highly motivated to do so. It also appeared that these hens sought elevated nest options in an attempt to get out of the test-pen, although not necessarily in the nesting context.

Study 4.5.8
Selection for Nest Elevation by Floor Reared Hens

The previous study suggested that broiler breeder hens used elevated nests to a greater extent that did B x W (layer) strain hens. However, the broiler breeder hens had been reared on the floor while the B x W hens had been reared, at least for the two months prior to testing, in laying cages. It was decided

therefore, that the studies on nest elevation would be repeated using naive hens of the B x W strain which had been reared throughout their lives on the floor, as had been the case for the broiler breeder hens.

Materials and Methods

Ten naive B x W strain hens of the same background as those used in Study 4.5.1 were used in this study. They were placed in a deep litter floor pen when purchased at 16 weeks of age (see General Materials and Methods).

Five hens were tested in a test-pen with approaches and five in test-pens without approaches to elevated nests. Nest options and approaches were as described in Study 4.5.1. Each hen was tested from its first nesting and oviposition for 15 consecutive nestings.

Results obtained for nest option and mid-pen selections by these hens were compared with those for cage reared hens (Study 4.5.1) and floor reared broiler breeder hens (Study 4.5.7) by Chi-square analysis.

Numbers of hens prodominantly selecting each nest option over the final five days of testing were also tabulated.

Results and Discussion

The numbers of times that hens selected each nest option or a mid-pen site in which to lay are given in Figure 4.5e (iii. Study 4.5.8). Results pertaining to cage reared B x W strain hens and floor reared broiler breeder hens are also presented in this Figure.

The numbers of hens which predominantly selected each nest option over the final five days of testing are shown in Table 4.5 (page 280a).

These results reaffirm the effect of approaches on usage of elevated nests observed in the previous studies (χ^2_{3df} = 30.2***). The three groups of hens differed in their usage of the four nest options (χ^2_{6df} = 64.1***). Floor reared B x W strain hens differed in their selection from both the cage reared B x W strain hens (χ^2_{3df} = 47.6***) and the floor reared broiler breeder hens (χ^2_{3df} = 16.6***). They selected 0 cm nest options less often than did the caged reared layers (32.6% as compared to 57.5% of all nestings in nest options) but with approximately the same frequency as did broiler breeder hens (32.6% as compared with 31.7% of all nestings in nest options). The floor reared B x W hens tended to distribute their selections of elevated nests differently from the broiler breeder hens. They laid proportionally more times in 30 cm options (43.7% as opposed to 30.0%) and less in 50 cm options (19.3% as opposed to 38.2%) than did the broiler breeder hens.

The effect of approaches on the selection of nest option tended to vary for each group of hens (χ^2_{6df} = 19.3; .001<P<.05). Approaches were most effective in increasing the level of usage of elevated options in the case of the cage reared B x W hens and least effective in the case of the broiler breeder hens

A trend, which however did not reach significance (χ^2_{2df} = 9.1; .01<P<.05), for the type of hen to influence the effect of rearing on the proportion of mid-pen selections was suggested by the results. This may merely have reflected the strain differences as noted in the previous study, since cage and floor reared B x W hens did not differ in this respect. The trend was more apparent if these two groups were compared with the broiler breeders (χ^2_{1df} = 9.3; .001<P<.01), the broiler breeders tending to lay a higher proportion of their eggs in the mid-pen sites as already noted in the previous study.

Numbers of hens which predominantly selected each nest option during the final five days of testing also suggest that the floor reared hens had eventually settled in elevated nests more readily than had their cage reared counterparts. These results also seem to suggest that the main difference between these floor reared B x W hens was that they tended to settle in 30 cm options whereas the broiler breeders more frequently settled in the 50 cm options. Seven of the ten floor reared hens selected the same nest on all five final testings.

Study 4.5.9

Selection for Nest Elevation by Mature Floor and Cage Housed Hens

The previous study indicated that differences noted between B x W and broiler breeder hens in Study 4.5.7 could only partly be attributed to the previous rearing experience of the hens. It was considered possible that the experience gained by the broiler breeder hens whilst laying in their home environment between testings may have influenced their selection of nest site in the test-pen situation. A study was therefore conducted to investigate the selection of nest options by both floor and cage reared hens which had been allowed to lay

in their respective home environments for some time prior to testing.

Materials and Methods

Twenty B x W hens of the same background as those used in Study 4.5.1 were used in this study. Half had been reared and housed in individual laying cages and the other half reared and housed in a deep litter floor pen (see General Materials and Methods). Hens were allowed to lay in their home environments up until 31 weeks of age, at which point they were approximately four weeks into production. They were then tested for 15 consecutive nestings in the test-pen situation with the same 0, 15, 30 and 50 cm nest options, either with or without approaches to elevated nests, as per Study 4.5.1. Five hens of each rearing treatment were tested in pens with approaches and the remaining five hens of each treatment were tested in pens without approaches.

Total numbers of selections of each nest option or of mid-pen as opposed to nest site selection were compared for caged and penned hens by Chi-square analysis. Results for mature floor reared hens were also compared with those of the naive floor reared hens of Study 4.5.8 and results for the caged hens were compared with those of the naive cage reared hens of Study 4.5.1.

Results and Discussion

Total numbers of times that hens selected each nest option or a mid-pen site in which to lay are given for cage and floor hosued hens in test-pen with or without approaches in Figure 4.5e (iv. Study 4.5.9). The numbers of hens which predominantly selected each nest option over the final five days of testing were tabulated and are shown in Table 4.5 (page 280a).

The results suggested that cage housed mature hens selected nest options differently than did their pen housed equivalents, although this was only shown as a trend in the total selections data ($\chi^2_{3df} = 14.8; .001<P<.01$). These hens, which had been allowed to lay in their cage for a month prior to testing, laid the majority of their eggs in the 0 cm nest option (48.0%), whereas hens from the floor pen environment laid less eggs in the 0 cm option (27.7%) and more in the elevated options. This is supported by the finding that half (five) of the mature, cage housed hens laid most of their final five eggs in 0 cm options, whereas only two of the mature, floor housed hens did the same, the eight remaining selecting elevated nests.

When the numbers of mid-pen as opposed to nest option selections were compared for hens from either cage or pen environments, mature hens from pens were found to lay significantly more eggs in mid-pen sites than their equivalents from cages (13.5% as compared with 1.3% of all selections made) ($\chi^2_{1df} = 16.3^{***}$). Overall, no effect of approaches was found.

Unlike the case in most of the foregoing studies, mature hens tested in pens with approaches did not use nest options significantly differently from their counterparts tested in pens without approaches.

Mature caged hens did, however, lay a significantly lower proportion of their eggs in mid-pen sites (1.3%) than did their naive counterparts (10.7%) ($\chi'^{2}_{1df} = 13.7^{***}$).

Comparisons made between mature and naive birds from floor pen environments failed to indicate any significant differences which could be attributed to the age or relative experience of the birds tested.

These findings were also suggested by the results of typical selections made.

A further point that should be noted was that only one of the mature hens from floor pens laid all five eggs in the final five testings in the one option, compared with six out of ten mature hens which had been housed in cages to the point of testing. This tends to suggest that these mature hens from the floor had not established attachments to any particular nest type or were using available nest options somewhat more at random than were their equivalents which had been housed in cages or naive hens.

Study 4.5.10
Selection for Nest Elevation in the Presence of Another Hen

In a previous study (see Study 4.5.2) a tendency for hens to lay near to a caged companion hen rather than in any of the provided nest options had been noted. The object of the present study was to investigate the response of nesting hens to a companion hen which was not nesting and which was not restrained in the pen and to study the influence of relative dominance/subordinance of the test and companion hens on eventual nest selection.

Materials and Methods

Ten naive B x W strain hens of the same background as those used in Study 4.5.1 were studied.

Hens were tested for their selection of nest options differing in nest elevation as in Study 4.5.1, with 0, 15, 30 and 50 cm options offered. All tests were carried out in test-pens in which no approaches were provided to elevated nests. All birds were tested in the test-pen situation with another non-laying companion hen present.

On the first day that each hen was to nest, as determined by palpation and previous records, it was placed in the test-pen with an unfamiliar hen which had previous experience of the test-pen. These companion hens were either birds used in earlier studies or hens from among the ten used in this study which had already been studied in the test-pen on at least two occasions. Only hens which were not going to lay that day were selected as companion hens.

On the second occasion that the hens were tested, they were placed in the test-pen with the same non-laying companion hen. Half of the hens were tested, for their first two nestings, with a companion hen which proved to be dominant to them and half with a companion which was subordinant to them. This was easily arranged since companion hens were selected from hens in the shed which were known to be very lowly ranked as evidenced by their status in relation to hens in adjacent cages, or from broiler breeder hens, which were known to be invariably dominant to the lighter B x W strain hens in paired encounters. During the first two occasions that each hen was tested, the pair of birds was observed in order to establish the relative status of the test and companion hens.

Hens were tested for a further ten nestings but were placed in the test-pen on alternate testings with either dominant or subordinant hens. Therefore, five of the hens had gained their first two days nesting experience in pens with a dominant companion hen and were tested thereafter on five occasions with a

dominant and five occasions with a subordinant companion. The other five pullets gained their first two days nesting experience in pens with a subordinant companion hen and thereafter on five occasions with a dominant and five occasions with a subordinant companion.

The numbers of times that the test hens selected each of the nest options or a mid-pen site when placed with either a dominant or subordinant companion were tabulated for individuals which had nested on their first two occasions with companion hens which were either dominant or subordinant. These results were then analysed using Chi-square analysis. The 'typical' response of each hen in each situation was also determined.

Results

The numbers of times that test hens selected particular nests or a mid-pen site in which to lay, and the numbers of hens typically selecting each of these, when tested with either dominant or subordinant hens are given in Table 4.5.10.

Table 4.5.10 Numbers of times that test hens selected each nest option/mid-pen aite, and the numbers of hens typically selecting each of these, when tested with with either dominant or subordinant companion hens

Nested on First Two Occasions With a:	Numbers of Times Option Selected With: *Numbers of Hens Typically Selecting Option With:* Dominant Companion					Subordinant Companion				
	Mid-pen	0	15	30	50	Mid-pen	0	15	30	50
Dominant Companion	1	8	1	3	12	2	9	0	4	10
	0	*2*	*0*	*½*	*2½*	*0*	*2*	*0*	*1*	*2*
Subordinant Companion	4	10	1	1	9	7	10	1	0	7
	0	*3*	*0*	*0*	*2*	*2*	*2*	*0*	*0*	*1*

The status of the test bird in relation to the companion hen with which it was placed for its first two nestings did not have a significant effect on its subsequent selection of nest options. Similarly, the relative status of the test hen, in terms of the companion hen, in subsequent nestings did not affect the birds' selection of nest option. If the numbers of mid-pen selections, as compared with nest nest option selections, are compared, a trend seems to exist which suggests that hens which had initially been tested with subordinant companions for their first two nestings thereafter laid more of their eggs in mid-pen sites (22% of all selections) than did the same birds tested on occasions with dominant companions (6% of all selections) ($\chi^2_{1df} = 4.9; .01 < P < .05$). The results of typical selections made may also indicate a similar trend, although these data are limited. Status of the test hen in relation to the companion hen during subsequent testings did not affact the day by day selection of nest site.

General Discussion - Height Above the Floor

Contrary to expectations, solitary nesting hens exhibited a tendency to seek nests elevated above the pen floor after laying first in mid-pen sites or in 0 cm options for a number of days (Study 4.5.1). Since gallinaceous birds are predominantly ground-nesting, this tendency would appear unusual. Introduction of a caged, non-nesting companion hen into the test-pen (Study 4.5.2) was ineffective in terms of encouraging hens to seek more elevated nests and, in fact, resulted in a larger proportion of nestings occurring in mid-pen areas outside nest options. It is possible that birds unfamiliar with the process of nesting and with the test-pen situation may have sought proximity to the caged companion because of the sense of 'security' another hen provided in the otherwise unfamiliar situation. It is also possible that the sight of another sitting hen acts as a stimulus for approach to potential nesting areas for the naive nesting pullet. It is certainly true that incidences of dump nesting in wild gallinaceous birds tend to mainly occur early in the season (e.g. Baskett, 1947) and this may be associated with selection of occupied or previously occupied nest sites by naive birds nesting for the first time. Caged hens spent a large amount of their time sitting and this may, to the nest-seeking hen, have resembled a hen sitting in the nesting context.

Results of a later study (Study 4.5.10) indicated that hens were largely unaffected by the relative status of a companion hen with which they were penned, in their selection of nest elevation. However, if they had initially had experience of laying their first two eggs in the presence of a subordinant companion, hens tended to lay more of their eggs, thereafter, in mid-pen sites. Relative status of the hens put together for subsequent testings had no effect on the proportion of mid-pen selections. It may be that, during the initial two testings, hens were drawn towards the companion hen in searching for a nest but were repulsed if the companion was dominant to them and so went to the outskirts of the test-pen and into nest options to lay. On the other hand, dominant test hens may have remained in the centre of the pen while their subordinant companion moved to the sides of the pen, or into elevated nests, to get away from them. Observations taken on the birds during their initial encounters suggested that both these situations did occur between dominant/subordinant pairs, although insufficient data were collected to support this. These laying tendencies established during each test hen's first two nesting experiences may have determined her subsequent nest site preferences and hence the overall trend in the frequency of mid-pen selections thereafter.

Provision of roofs to the nest options offered (Study 4.5.3) did not prevent hens from eventually moving from 0 cm to elevated nest options in their nesting preferences. Hens were therefore not moving into elevated nests to achieve overhead confinement provided by the cover of the test-pen. Hens

in pens with roofed nests did tend to avoid 50 cm nest options in situations without approaches, probably because the more limited opening available for the hens to jump directly into in these situations made the 50 cm option more difficult to use.

Provision of a central object in the test-pen had the effect of increasing the proportion of nestings that occurred in lower nest options (Study 4.5.4). The proportion of selections of the 0 cm option was further increased by provision of frontal barriers to each nest option. Since behavioural observations suggested that these barriers were not affecting the ability of hens to use the elevated options, it is suggested that hens may have been using elevated nests in the bare pen/open nest situation in an attempt to gain isolation or confinement in an otherwise barren or exposed nesting environment. This explanation may also account for the observation that hens in commercial deep litter sheds usually accept elevated nests quite readily. Potential floor level sites in such situations may not supply adequate confinement or isolation for nesting purposes for most hens and so birds may be encouraged to attain elevation to achieve some form of isolation.

The results obtained for the broiler breeder hens (Study 4.5.7) were surprising since these hens were expected to be less agile or less capable of using elevated nests because of their heavy build. However, these hens laid a higher proportion of their eggs in the test situation in the 50 cm nest option and also laid fewer eggs in the 0 cm options in pens without approaches than had the naive caged B x W hens. However, naive floor reared B x W hens laid about the same proportion of their eggs in 0 cm options as did the broiler breeder hens (Study 4.5.8), although they used 30 cm options more and 50 cm options less than the broiler breeders. Mature, floor housed B x W hens seemed to lay more eggs in elevated options than did their cage housed counterparts. These results suggest that the greater use of elevated as opposed to 0 cm nest options by broiler breeder hens may have partly been an effect of their housing rather than their breed. Possibly, hens which have been reared in pen environments may have had greater opportunity to examine more elevated sites in the home pen or were more practised in flying or jumping. Even though no perches were provided in the home pens, feeders, waterers, nest-boxes and even the walls of the pen were frequently mounted by the birds. Cages offered no such opportunity for hens to exercise their capacity to fly or jump to elevated sites and perhaps even suppressed the motivation or drive to do so. This could explain why cage reared hens were comparatively slow to seek elevated sites in the barren test-pen environment.

Mature floor reared B x W hens also tended to lay more of their eggs in mid-pen sites than did their cage reared counterparts which tended to use elevated nests to a greater extent than the naive cage reared hens (Study 4.5.9). The mature floor reared hens may have been disturbed or frustrated when removed to the test-pen for testing and so reacted with a higher propensity to lay indiscriminately on the floor of the pen or to lay in elevated nests which they had gone to in an attempt to get out of the pen. Naive hens, on the other hand, may not have reacted this way because they had no previous opportunity to establish a nest in the home environment. Similarly, cage reared hens, which may have been frustrated in their nest-seeking activities in their home cages and which may not have previously established a 'nest' in that limited environment, may have been less distressed in the testing situation and so have actively selected nest options within it. The apparent increase in mid-pen and 50 cm selections by broiler breeder hens may also have resulted from their previous experience with nesting in the home pen and subsequent establishment of nest preferences.

It is therefore possible that the trends noted in selection of nest elevation by broiler breeder hens were not determined by their breed, but by their previous nesting experiences and their rearing and laying environment.

Both prior experience with the test-pen and experience of laying in the home cage substantially reduced the numbers of eggs that were laid in mid-pen areas (Study 4.5.6). These hens apparently did not learn to use elevated nests any earlier than hens without pre-training, particularly in the case of hens with pre-training in the test-pen.

The results of Study 4.5.6 suggest that failure to respond to the appropriate stimuli from the nest, or in this test situation, the nest recess, may be a result of lack of familiarity with both the test situation and/or the process of nesting and laying. Prior experience of the process of laying an egg was found to be particularly and consistently effective in reducing the number of eggs laid outside nest options. This could possibly result from nervousness, by the unfamiliarity of the internal motivation or the nesting environment associated with the first few nesting experiences of each hen.

Another possibility is that some maturation of the physiological processes involved in nest selection may occur over the first day or two that hens lay. It could be speculated that oestrogen and progesterone, which are believed to have important roles in the control of nesting behaviour (see Chapter 2), may be involved in this effect. Plasma concentrations of oestrogen have been

found to reach a peak two to three weeks before the first egg is laid (Senior, 1974; Petersen and Webster, 1974). This is believed to be associated with the rapid growth of ovarian follicles and maturation of the uterus which occurs around that time. Similarly, serum progesterone in pullets has been found to increase after 18 weeks of age and reach a peak at 20 weeks of age, dropping slightly thereafter to 24 weeks of age (Tojo and Huston, 1980). Progesterone concentration in the sera of turkeys has been found to peak about seven weeks before sexual maturity and then decrease as the growing females approach sexual maturity, after which it starts to increase again to reach a peak at peak production (Mashaly and Wentworth, 1974). Similarly, progesterone concentrations in the sera of pheasant hens increase through sexual maturity, peaking at peak egg production (Mashaly *et al.*, 1982).

In the light of these reports it seems reasonable to speculate upon the possible influence of the low levels of circulating progesterone, and possibly oestrogen, present at the onset of lay. If one or both of these hormones is important in maintaining the attentional mechanisms of the hen to the stimuli from the nest, as suggested by Wood-Gush and Gentle (1978), then it is possible that levels of these hormones in the hen laying its first few eggs may be insufficiently high to produce a response to stimuli relevant to nest selection via action on neurones in the appropriate part of the brain controlling the response. The apparent lack of response of some individuals to the nest recesses in the test-pen during their first one or two nestings could be explained by this hypothesis. Some hens did, however, respond to nest options during their first testing. This could be explained by individual differences either in the amount of circulating hormone at this stage or in the concentration of hormone required to have an effect on that part of the brain controlling the response. Large variations in the concentration of progesterone in the blood of individual turkey hens (Mashaly and Wentworth, 1974) and individual laying fowl (Peterson and Common, 1971) have been reported and lend credence to this suggestion.

If the apparent lack of response to stimuli from the nest exhibited by some hens during their first few nestings is hormonally induced, then it would seem that a certain proportion of the initial floor eggs, or eggs laid outside conventional nesting facilities, in a commercial floor pen situation, could not be eliminated by manipulations of the design of the nests provided. However, the role of hormone levels in producing this effect could only be validated by further research. One fact which seems to discredit the suggested role of progesterone and/or oestrogen in the observed lack of response to stimuli from the nest during initial nestings is that levels of these hormones may drop significantly after peak production (Mashaly and Wentworth, 1974; Mashaly *et al.*,

1982). The decline may be to levels equivalent to, or perhaps lower than, those found at the onset of lay and yet nest responsiveness continues. Hens at this stage would generally have established nest preferences, however, and may not actively go through the process of nest selection as such.

The possible hormonal cause of failure to lay in provided nest options in early stages of lay is therefore considered worthy of investigation. Perhaps one means of approaching this problem would be to investigate the level of responsiveness of naive pullets to provided nesting facilities during their first nesting; pullets being tested having either no hormonal treatment, or having exogenous progesterone and/or oestrogen administered, so as to increase circulating levels of these hormones during the nest selection phase.

4.6 What the Nest is 'Behind'

Study 4.6

The Effect of Different Types of Barrier or Cover to the Nest

This study was undertaken in an effort to determine whether the nature of any visual or physical barriers used to conceal potential nests would influence the selection of otherwise identical nest sites. Types of barriers compared were either solid, transparent, or could be partially seen through.

Materials and Methods

Eight B x W hens purchased at 16 weeks of age and housed in individual laying cages were used in this study, being tested one month into production.

The hens were tested in a test-pen with four 60° nest options provided. All nest options were identical, being at floor level and containing wood shavings as a nesting material. In front of each option was a 45 cm by 45 cm vertical barrier which was erected 18 cm from the front of the nest recess. To get into each nest option, therefore, hens had to go around either side of the barrier or fly over the top of it.

The test-pen used was illuminated by 40 watt globes in mid-recess panels.

A different type of barrier was placed in front of each nest recess. All were constructed of 3 cm wide corrugated cardboard frames and were fixed in position with wire at the top and bottom. One barrier was made of clear plastic (transparent) so that hens could see through the barrier, another was made completely of cardboard ('solid') so that hens could see nothing at all through it and the remaining two barriers were made of hessian ('hessian') or of interwoven green leafy twigs ('natural'). Both of the latter two barriers could be partially seen through. It was much easier to see from the nest area

into the mid-pen area than vice versa through these two barriers in general, because the light in the pen was provided in the mid-pen area and more could be seen of the other side of the barrier the closer to the barrier that the observation was taken.

Hens were placed in the test-pen and allowed to select a nest recess for a number of consecutive nestings until each bird had selected one particular nest on five consecutive testings. It was then deemed to have made a 'final selection'. The number of hens making each nest recess their 'final' choice was then tabulated and the data analysed by Chi-square analysis. The total number of times each nest recess was selected before and during 'final selection' by all hens was also tabulated, and the results analysed.

Results and Discussion

The number of times that hens selected each nest option prior to making a 'final selection' and the number of hens making each nest option their 'final selection' are given in Table 4.6.

Table 4.6 Number of times that hens selected nest recesses behind transparent, solid, hessian and natural barriers prior to 'final selection' and the number of hens making each of these nests their 'final selection'

Times Selected Prior to 'Final Selection'				Number of Hens Making the Option Their 'Final Selection'			
Transparent	Solid	Hessian	Natural	Transparent	Solid	Hessian	Natural
1	4	0	0	0	2	0	6

All but two hens made the nest recess behind the natural barrier their 'final selection'. When all selections up to and including those involved in the 'final selection' were compared, recesses behind the natural barrier were most popular, recesses behind the solid barrier occasionally used and recesses behind transparent or hessian barriers rarely used ($\chi^2_{3df} = 52.5^{***}$).

Observations on the hens using nest recesses revealed that hens always entered the nest recesses around the sides of the barriers and rarely examined or entered any recess other than those behind solid or natural barriers. On several occasions hens were removed from pens while they were still in the nest recess after having laid. This particular group of hens was, for some reason, very flighty and nervous, particularly when removed from the test-pen.

On all six occasions on which hens were removed directly from the recess behind the 'natural' barrier, the hens involved dashed immediately towards the barrier and broke through it. On no occasion did a hen which was being removed from any other recess run towards the barrier itself or try to push through it. Instead, hens would attempt to escape at the side openings between the nest and the barrier.

General Discussion - What the Nest is 'Behind'

Wild gallinaceous hens nesting in a natural habitat tend to select nest sites in the shelter, or cover, of some sort of partial or complete physical barrier (see Chapter 2). Hens may be attracted to such barriers in the search for a potential nest site. Results of Study 4.6 suggest that hens may form preferences for nests on the basis of the type of cover that is provided to the site, all other factors being equal. Solid barriers would afford the greatest visual isolation for the hen sitting on a nest site and would also provide the darkest nests but in the present study were not the most effective in encouraging hens to nest behind them. Nests behind transparent barriers, which would provide a physical but not a visual barrier, were rarely used. It is therefore probable that the visual properties of the barrier are important to the nest-seeking hen.

The 'natural' barrier used in Study 4.6 proved to be most acceptable as a form of nesting cover. Perhaps hens seek sites which provide partial visual cover so that they are concealed from potential enemies but can also see out of the nest so as to know if an enemy is approaching. Hens rarely nested behind hessian barriers, which also provided partial visual cover. An irregular, broken form of visual cover may provide the best type of cover for camouflage of the sitting hen. Certainly, other gallinaceous species nesting in a natural habitat tend to select areas in a diverse and broken plant community for nesting purposes, whereas the actual species used as cover is relatively unimportant (e.g. Trautman, 1960; Dumke and Pils, 1979).

Although solid barriers provide a high degree of concealment of the nesting hen and any eggs laid behind them, they do not allow hens sitting within the nest to look out for the approach of potential enemies. Many species of wild gallinaceous birds have been shown to prefer to nest on the periphery of a block of cover or near an opening in the cover pattern (see Chapter 2). This may relate, not only to the view of the likely direction of approach of potential enemies that it may afford, but also to ease of gaining access to the site, of being able to find and identify the site on subsequent visits and of being able to leave the site in a hurry if its occupant is threatened by the approach of

an enemy. It is interesting in this respect that hens nesting behind the 'natural' barrier in Study 4.6 dashed from the nest through the barrier when frightened although they had never entered the nest that way.

It is impossible to say at what point hens respond to stimuli from the cover type. In Study 4.6 it appeared that hens responded to the cover type from outside the nest, approaching, examining and then entering only particular types. However, this was not quantified and it is possible that hens may have responded to stimuli from the barriers whilst inside the site. It may be that the suitability of a cover type, in terms of its concealment value, may be determined from outside the nest. Once inside the site however, the hen may then respond to other stimuli from the barrier or cover type which are relevant to its suitability in terms of the extent to which it allows the hen to look out towards the direction of approach of potential danger. Hens may therefore respond to stimuli from the cover type in which the nest is sited both from outside the nest, as the hen approaches the site, and from within the site, as the hen sits in the nest and looks out from it.

Conclusions - Characteristics of Nest Selection and Nest Preference

The results of these studies indicate that a number of factors will influence the selection of nests by hens. One major factor which all, or almost all, hens were found to respond to was the presence of nesting material in the nest. Bare nests were shunned by both bantam and White Leghorn hens and the response to nesting material was stronger than to either the presence of another egg in the nest or the provision of a frontal curtain to the nest. Hens selected nest options containing wood shavings in preference to carpet, cement or wire alternatives, regardless of their previous nesting experience in either pen or cage environments. It is suggested that the nesting material may provide a substrate for the hen to build in and that the characteristic upon which hens may base their selection of nests containing nesting material may be the material's ability to be manipulated or 'moulded' by the hen.

Hens also preferentially selected nests which contained eggs laid by other hens, or nest-eggs, although hens may also have responded to the presence of other hens in the nest. Stronger responses were found for nests containing two rather than one nest-egg or large as opposed to small nest-eggs. Preliminary studies indicated that hens may not respond fully with appropriate egg-related behaviours as young, naive nesters and that these responses may develop as the hen matures and/or has more experience of laying.

Some groups of hens responded to shape of the nest entrance, and feral fowl showed a marked preference for the shape of the nest, although this may have been a response to the floor type rather than the nest itself. Feral hens were found to change their patterns of nest usage over time, however, and this may result from a tendency to avoid previously used sites in establishing new nests. Shape of the nest/nest entrance was considered to be a minor factor influencing nest selection and responses to such factors may merely indicate a means by which hens identify previously used nests, to which they will then tend to return. In a number of studies, preferences for 'end nests' in a set were found, and these too may provide means of identification of established nests.

Although initially influenced by prior nesting experience or housing environment, hens exhibited a marked tendency to eventually select darker nest types. It is suggested that actual level of light intensity may not be as important as the change in light intensity that may occur as hens approach potential nesting sites, or the difference in light intensity detected as hens sit on the nest and look out beyond the nest.

Confinement or the extent of enclosure provided by a nest site seemed to be of some importance to the nest-seeking hen. Hens tended to select smaller, more confined nests, but only if the sites allowed the nesting bird sufficient space to rotate and perform nest building activities. Hens do not apparently seek visual isolation from other flock-mates in nesting but isolation from the flock area may be important. The orientation of hens in nests may provide a useful means of determining whether the nests used allowed the hen to feel sufficiently isolated or concealed. Hens in preferred, deep nest types faced into the pen, while sitting and laying, to a greater extent than they did when laying in less popular, open nest types.

Nest concealment may be particularly important to nesting hens and the depth of the nest and type of external cover afforded the nest site proved to be very influential in the establishment of nest preferences. A broken, irregular cover type may be preferable in this respect because, not only will it afford concealment of the sitting hen and the eggs, but perhaps because it allows the hen to watch for the approach of potential enemies and to leave the site readily if threatened by the approach of such.

Hens were found to seek elevated nests, in preference to ground nests, in very barren or open testing environments. This response is suggested to result from the hens' inability to find isolation in any other form in such situations, as indicated by the tendency of hens to nest at ground level if frontal barriers were provided to nests. The rearing environment of the hens was found

to have an effect on subsequent patterns of usage of elevated nests. The results suggest that hens which have been reared in the more confined conditions of a laying cage may not seek elevated nests as readily as floor reared hens.

The number of times that hens failed to respond to the nest recesses in nesting was found to be largely an effect of the age or level of nesting experience of the bird. Many naive pullets nesting for the first few times apparently fail to respond to appropriate stimuli from the nest. A possible hormonal mechanism, which may account for this, is suggested.