Use of Space by Laying Hens: Social and Environmental Implications for Free-Range Systems

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To my parents

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Declaration

I declare that this thesis is my own composition. The work presented in it is entirely my own, and has not been presented in any other thesis.

Philip Grigor, April 1993.

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Abstract

The use of space by laying hens in free-range systems is often very uneven, with birds displaying an apparent reluctance to leave (and move away from) the house. Using mainly small groups as models for the larger flocks normally housed in commercial free-range systems, the role of various social and environmental factors concerning hens' movement and use of space were investigated in this thesis.

Hens displayed a greater readiness to emerge from a familiar covered box into an unfamiliar outdoor area when the outdoor area contained familiar feeders, even though the birds had free access to food in their home pens. Emergence latencies decreased with repeated testing. Birds also spent more time in the outdoor area when feeders were present, though they tended not to move past the feeder which was nearest the box. Birds which had been exposed to an enriching stimulus (traffic cones) in their home pens tended to leave the box earlier than those which had not, though this was not dependent on the actual presence of cones in the outdoor area. This suggests that a more complex home environment can influence birds' responses to novel environments. Furthermore, the order of emergence into the paddock was not significantly influenced by social rank. Birds which had been regularly exposed to the outside environment during the rearing process displayed little or no fear of the outdoor area as adults. In contrast, regular handling had little effect on birds' readiness to enter the outdoor area. Regular exposure to the outside environment also reduced birds' underlying fearfulness (measured by tonic immobility), both in small experimental groups and in a larger free-range flock. Individual birds from small groups or from single cages took longer to move past unfamiliar birds than they did to move past familiar birds (even those of higher rank), and took longer to move past an increasing number of unfamiliar birds. However, birds in a free-range house displayed a wide range of movements, and very little aggression, suggesting that any inhibition of movement within the house was not due to "pecking pressure" from other birds. Birds displayed greater readiness to enter into and disperse in the outdoor area when other birds were already present in the area. This was not dependent on the familiarity of birds in the outdoor area. A larger number of birds in the outdoor area increased the attractiveness of the outdoor area to other birds. The introduction of cover into an outside area had a limited effect on increasing the attractiveness of the outdoor area to domestic fowl, though this was not reflected in the birds' vigilance behaviour. It was concluded that birds find the outside environment aversive due to its fear-evoking properties (such as the fear of predation), and to the large discrepancy between the inside and outside environments. Possible implications of the present findings for free-range systems are discussed.

CHAPTER 1: General Introduction

In this thesis, the effects of various social and environmental factors on the use of space by laying hens are examined, with possible implications for free-range systems. The following section (1.1.) presents a brief outline of the topic of animal dispersion. This is followed by a review of previous studies which have examined the influence of social and environmental factors on the use of space by domestic animals, including laying hens (1.2. and 1.3.). The use of space by laying hens in various husbandry systems (including free range) is also discussed (1.4.). Section 1.5. summarises some of the advantages and disadvantages of various poultry husbandry systems, many of which have implications for the welfare of hens. The free-range system is described in section 1.6., which is followed by an outline of the thesis (1.7.).

1.1. Animal dispersion

The subject of animal dispersion, or the way in which animals distribute themselves in relation to the available area, has been widely investigated. In his book, *Animal Dispersion in Relation to Social Behaviour*, Wynne-Edwards (1962) provided a possible definition of animal dispersion as "comprising the placement of individuals and groups of individuals within the habitats they occupy, and the processes by which this is brought about". Animals may be expected to occupy habitats which provide resources such as food, nesting sites, mates, shelter, protection from predators, etc. In animal communities, dispersion may serve to control population density, thereby providing a safeguard against over-population and avoiding over-exploitation of the food-supply (Wynne-Edwards, 1965). Wynne-Edwards (1962) proposed that dispersion may be brought about by group selection (which is concerned with the viability and survival of a group of individuals). However, as selection acts primarily at the level of the individual, or, more precisely, at the level of the gene (Davies and Krebs, 1978), it was later proposed that dispersion is brought about by natural selection, which is concerned with the survival and reproductive success of the individual (Lack, 1966; Pulliam, 1987). Within a habitat, animals may be more evenly dispersed than they would be at random ("over-dispersed"), or less dispersed than at random ("congregated") (Crook, 1965). Furthermore, there may be temporal variations in dispersion, ranging from seasonal variations (such as colonial breeding among some bird species) to diurnal variations (such as birds returning to communal roosts at night). The use of space by free-ranging domestic animals (or the way in which they occupy the available area) will be governed in part by their genetic inheritance; it has implications for management and welfare, and may be influenced by both social and environmental factors.

1.2. Use of space by free-ranging domestic animals: social and environmental factors

1.2.1. Social factors

The effects of social factors on the use of space have been investigated in a variety of species. Such factors include social status, activity, and familiarity of conspecifics. In pigs, for example, no relationship between rank and preferred location was found. However, high-ranking pigs had less tendency to face away from their nearest neighbours, and individuals tended to avoid close association with high-ranking animals (McCort and Graves, 1982). The use of shade by sheep was shown to be influenced by social factors, as high-ranking animals remained in shade for longer periods, especially at higher temperatures (Sherwin and Johnson, 1987). Winfield *et al.* (1981) found that sheep displayed a strong preference for familiar rather than unfamiliar individuals, and sheep which were unfamiliar with each other did not readily form a single homogeneous group.

1.2.2. Environmental factors

The heterogeneity of the environment and the location of resources can also affect the way in which animals distribute themselves. Environmental factors which might influence the use of space include weather, the presence of cover, and the location of feeding sites and water sources. At low grazing pressures, variation in the use of the environment by sheep was influenced by the distribution of water sources and the heterogeneity of vegetation (Arnold and Dudzinski, 1978). Dudzinski *et al.* (1969) found that drought conditions led to an increase in the average distance between sub-groups of sheep, as well as an increase in the average nearest-neighbour distance. These distances decreased when range conditions improved. Sheep may seek out shade and shelter as protection from hail, sun and wind, and choose lambing sites which are progressively more sheltered as windspeed increases (Winfield *et al.*, 1969). Similarly, Lynch and Alexander (1976) found that sheep (especially shorn individuals) stayed close to shelter strips during inclement weather, and mortality (attributable to cold exposure) was lower in sheltered groups than in unsheltered groups. Unshorn sheep tended to use shelter for shade on warm sunny days. Furthermore, both shorn and unshorn sheep chose lambing sites close to the shelter strips. The availability of shade in hot, humid climates may affect productivity in cattle (McDaniel and Roark, 1956), and, where no natural shade exists, artificial shade can be used to manipulate cattle dispersion (McIlvain and Shoop, 1971).

1.3. Use of space by laying hens: social and environmental factors

Social and environmental factors have been shown to influence the use of space by laying hens (*Gallus gallus domesticus*); for example, Keeling and Duncan (1989) found that spacing among groups of three individuals in pens was influenced by their relative social ranks, with the greatest inter-individual distances occurring between ranks 1 (alpha) and 3 (omega), and the smallest between ranks 2 and 3. In flocks of domestic fowl, the possibility of territorial behaviour (in which individuals defend specific areas) was investigated by Craig and Guhl (1969). Randomly-selected hens spent disproportionate amounts of time in specific areas of the pen (suggestive of home-range behaviour), and there was a correlation between residence time and relative dominance. Site attachment was also found in groups of male domestic fowl in floor pens, with high-ranking birds defending fixed sites against lower-ranking individuals (Pamment *et al.*, 1983). Lill (1968) found that spacing was activity-dependent, as birds formed aggregations for activities such as resting and dustbathing, but tended to be more solitary (and aggressive towards potential competitors) when feeding.

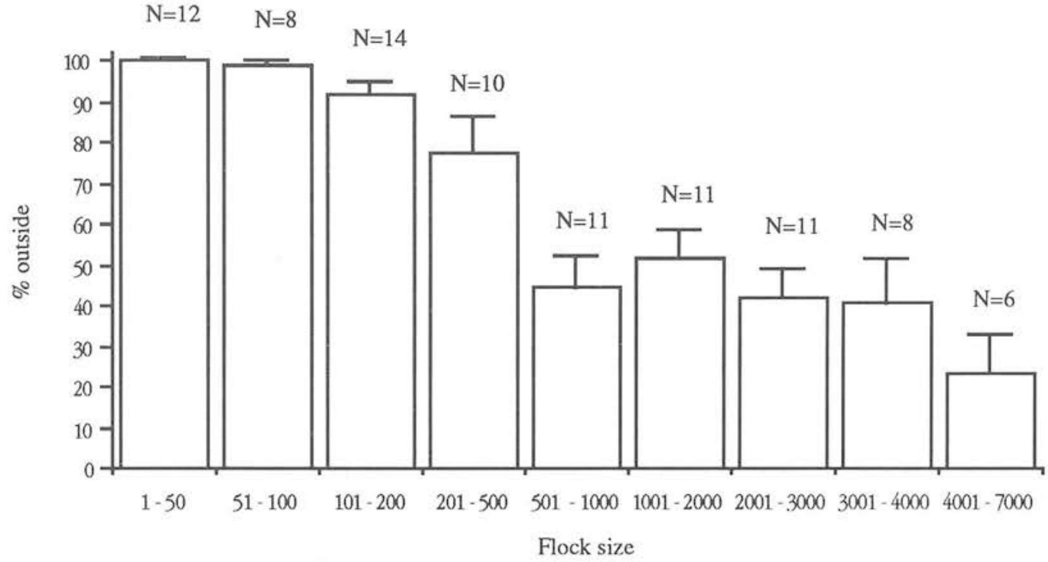
Home-range behaviour, in which birds may restrict themselves to a certain part of the available area, may be influenced by the location of roosting locations. When separate groups of birds were allowed to intermingle, a higher proportion than expected tended to roost in their home pens, or in the immediate vicinity (Crawford, 1966). McLean *et al.* (1986) found that hens in a perchery system made differential use of various resources, and certain resources were used in a diurnal pattern, with disproportionate use of nestboxes in the morning, and dustbathing areas used more often in the afternoon.

1.4. Use of space by laying hens in various husbandry systems

The use of space by domestic fowl and its wild progenitor, Red jungle fowl (*Gallus gallus spadiceus*), has been investigated in a wide variety of housing systems, ranging from an unconfined population of zoo-kept jungle fowl to conventional battery cages. These studies have indicated that laying hens display non-random dispersion in a wide variety of husbandry systems. Collias *et al.* (1966), for example, found that groups of free-ranging zoo-kept Red jungle fowl showed locality fixation, with small home ranges and territories centring about the flock roosting sites. Inter-individual distances among domestic fowl (and other species) may be the result of a balance between forces of attraction and forces of repulsion. In the aforementioned study on spacing among penned birds, Keeling and Duncan (1989) found that, in a large pen, forces of attraction were stronger than those of repulsion (leading to a more clustered spacing than would have been expected by chance), whereas the opposite was true for a small pen (leading to a greater dispersion than expected by chance). McLean *et al.* (1986), in a comparative study of battery cages and a perchery, found that birds did not appear equally in all areas of the perchery. Similarly, in a study on a covered strawyard system, Gibson *et al.* (1986a) reported a non-random use of space by the birds, largely due to the heterogeneity of the strawyard environment in terms of microclimate and resources. In two studies on spacing patterns in battery cages, Doyen and Zayan (1984) and Zayan and Doyen (1985) found that hens did not make use of all the space that was available to them. The former study varied the cage size for pairs of hens, and found that birds did not use all the available cage space at any density. In the latter study, using two group sizes (2 or 4 birds) at each of two stocking densities (545 or 850 cm^2 per bird), it was found that, in all cases, mean inter-individual distances were much smaller than the highest mean distances that could have been recorded.

In free-range systems, hens have daytime access to an outdoor area. However, the few systematic studies which have been carried out on the behaviour of laying hens in free-range systems have reported that birds tend to show a non-random distribution, with only a small proportion of the flock outside at any one time (Hughes and Dun, 1982; Davison, 1986; Keeling *et al.*, 1988). There is a negative relationship with flock size, with the proportion of a flock going outside decreasing as the flock size increases. The graph below (Figure 1) shows the combined results of two recent surveys of free-range egg producers (Chickens' Lib, 1992; Grigor, pers. survey). Analysis of these results showed that, despite much variation, there was a significant negative correlation between flock size and the average proportion of the flock outside (Spearman Rank correlation coefficient (r_s) = -0.756; $p < 0.001$).

Figure 1: Average percentage of a flock outside versus flock size.



In addition, the distribution of land usage is often very uneven, with most of the outside birds occupying the area directly in front of the house (Davison, 1986; Keeling *et al.*, 1988). This may result in the land around the house becoming "fowl-sick," as parasite-infested mud builds up over time, presenting a disease risk to the birds.

1.5. Comparison between poultry husbandry systems

The following section presents a brief background to the current debate regarding the housing of laying hens. This is followed by a review of the various advantages and disadvantages of alternative husbandry systems (including free range), compared to conventional cages, many of which have implications for the welfare of hens. Section 1.5.4. reviews studies which have directly compared cages and alternative systems for various welfare indicators (mortality, production, physiology, behaviour), and evaluates the suitability of any one system according to the "five freedoms" outlined by the U.K. Farm Animal Welfare Council.

1.5.1. Background

One of the most controversial issues in the animal welfare debate is that of laying hens kept in battery cages. The battery cage has been in commercial use for over forty years, and, at the time of its introduction, it was seen by producers to have certain advantages over the traditional free-range and deep-litter systems: it required little manpower to operate (thus reducing labour costs), it eliminated some diseases, it allowed control of the photoperiod and other environmental variables, and hens were protected from predators and extreme weather conditions. In addition, birds were originally housed in single cages, which allowed the identification and removal of unproductive birds (Hewson, 1986).

Since the publication (in 1964) of Ruth Harrison's book "Animal Machines," however, which led to the Government appointing the Brambell Committee to investigate intensive husbandry systems, there has been much public concern over the welfare of intensely-kept farm animals, including caged hens. In a report on various egg production systems, the U.K. Farm Animal Welfare Council (formed in 1979 as an independent advisory body to monitor the welfare of farm animals) stated: "We do not approve of the cage system on welfare grounds.......The birds may be subject to chronic discomfort" (F.A.W.C., 1986). In 1983, a National Opinion Poll found that only 13% of the public considered the battery cage to be acceptable, and a pilot study assessing public opinion on various egg production systems revealed conventional battery cages to be the least acceptable system (Rogers *et al.*, 1989), with modified cages (containing perches, nest boxes and dustbaths) perceived as being only slightly more acceptable. This concern over the well-being of laying hens in cages has not been confined to the United Kingdom. Following a referendum, conventional cages were abolished in Switzerland at the end of 1991, and Sweden plans to abolish cages from 1998.

1.5.2. Advantages of alternative husbandry systems

The Brambell report (HMSO, 1965) identified the need for a more welfare-acceptable egg production system than the battery cage. Public concern surrounding the welfare of laying hens in battery cages has provided the impetus for research into alternative husbandry systems, examples of which include the traditional free-range and deep-litter systems (the most commonly used systems prior to cages), aviaries, percheries, strawyards, "tiered wire floor" systems, and modified cages. Hens in alternative systems (including free range) may enjoy a higher standard of welfare than caged birds. These systems provide hens with a greater freedom of movement than conventional cages, which, together with a more complex environment, enable the birds to carry out a wider variety of natural behaviour patterns. These include perching, ground-pecking and scratching, dustbathing, and comfort behaviours such as stretching, wing-flapping and body-shaking. Non-caged hens are also provided with nest boxes, which allow them to perform pre-laying behaviour, and to lay their eggs in seclusion. Hens are strongly motivated to seek out suitable nest sites during the pre-laying process. The lack of such a nest site in cages often leads to vacuum nest-building, restlessness and frustration (Meijsser and Hughes, 1989). Free-range hens also have the opportunity to graze on vegetation, thus allowing a more varied diet. They also have access to natural light, to which they may be attracted (Hüber and Fölsch, 1985). Due to restriction of space and lack of facilities, all the above activities are either impossible or severely curtailed in conventional battery cages. Behaviours such as turning, wing-stretching, wing-flapping, feather ruffling, preening and ground-scratching, for example, all require more space than the E.C. minimum space allowance of 450 cm^2 per bird (Dawkins and Hardie, 1989).

Hens transferred to single cages showed a gradual decline in comfort activities over a 4-week period (Nicol, 1987). However, the fact that certain behaviours are not performed in some circumstances may just be because the appropriate external causal factors are absent. As a result, the motivation to perform these activities will decrease. It has been argued, however, that if certain regularly-occurring activities (such as comfort behaviours) are not performed (due to environmental restriction), there may be a rise in the strength of the appropriate internal causal factors. Prolonged non-performance of such activities may lead to a subsequent instantaneous "rebound" (in which previously prevented behaviours are performed at a high intensity) when the opportunity to perform such activities arises (Nicol, 1987, 1989). Thus, it appears that hens are highly motivated to perform comfort activities which are prevented by spatial restriction. Furthermore, when given the choice between a large cage and a small cage, hens showed a significant preference for the large cage (Hughes, 1975), and when given the choice between different floor types, hens chose a grass floor over a wire floor, even when this meant entering a smaller cage (Dawkins, 1978). Thus, when birds were allowed to choose their environment, they consistently selected against restricted spaces and wire floors. Operant tests have also shown that birds are willing to work for access to more space (Faure, 1986; Lagadic and Faure, 1987).

The physical restraint imposed by cages can lead to physical damage as well as frustration (Hughes, 1973; Black and Hughes, 1974). Laying hens have a strong tendency to peck at inedible objects. In a study on free-ranging (zoo-kept) Red jungle fowl, from which domestic fowl are descended, Dawkins (1989) found that birds spent 60% of their time ground-pecking, and 34% of their time ground-scratching. In barren cages, which lack a suitable pecking substrate (such as litter or grass), hens often resort to pecking at each others' feathers (Hughes and Duncan, 1972; Blokhuis, 1986). The effects of floor type and stocking density on integumental damage were investigated by Simonsen *et al.* (1980). Birds housed on wire floors suffered significantly higher skin damage than those on deep litter, especially at a higher stocking density. Some damage was directly attributable to the physical environment; for example, denudation of the belly among birds on wire floors was due to the lack of suitable material for dustbathing. However, most lesions were caused by the pecking activities of other birds, possibly due to a lack of appropriate stimulation from the physical environment. In addition to skin and feather damage, caged birds also tend to suffer from weaker bones than birds from alternative systems. In a comparison between floor-kept birds and caged birds (of the same age and strain, and using the same diet), it was found that the bone breaking strength of floor-kept birds was significantly greater than that of caged birds (Rowland *et al.*, 1968). A subsequent study indicated that the reduced bone strength observed among caged birds was more likely to be caused by a lack of exercise (due to spatial restriction) rather than floor type (Rowland and Harms, 1970). Furthermore, Meyer and Sunde (1974) reported that exercising caged birds in a treadmill or transferring them to litter for several weeks reduced bone breakage compared to control (non-exercised) caged birds, though bone strength was still less than that of floor birds.

1.5.3. Disadvantages of alternative husbandry systems

Although alternative husbandry systems can overcome many of the welfare problems associated with conventional cages, non-cage systems also have potential drawbacks, some of which have detrimental effects on bird welfare. Food costs account for about 70% of the cost of production, and there is often a higher food consumption in alternative systems (due to increased bird movement and lower ambient temperature), which, together with higher labour costs, leads to increased production costs. Compared to cages (stocked at 450 cm^2 per hen), the costs of production in various alternative systems were estimated to be as follows: aviaries and percheries - 10-15% higher, deep litter - 20% higher, strawyards - 30% higher, free-range (at least) 50%

higher (Elson, 1985). Alternative systems also tend to require a higher standard of stockmanship. Average egg production tends to be lower than in cages, and floor-laying may lead to a problem with broken or dirty eggs (Appleby *et al.*, 1988a). Furthermore, production is less predictable in alternative systems than in cages (Tauson, 1989). There tend to be more problems with air quality in floor systems than in cages, especially where low ventilation rates are used to maintain temperature. There is an increased risk of enteric disease (especially coccidiosis), due to hens remaining in close contact with their droppings. Harmful social effects, such as cannibalism, are less easy to control in colony systems. This is influenced (in part) by the large group sizes found in floor systems, where birds have more chance to imitate each others' behaviour. In cages, however, such problems may be contained within the small groups, thus limiting their subsequent spread. Cannibalism often leads to birds having to be beak-trimmed. This process involves the top third of the beak being removed with a hot blade, and may cause long-term or even permanent pain (Gentle, 1986). The large flock sizes often found in alternative systems may lead to social strife, and control of environmental variables (such as temperature, dust level, and ammonia concentration) is more difficult. Inspection of individual birds may also be more difficult in alternative housing systems. Although, as previously indicated, caged hens tend to have weaker bones (due to lack of exercise), birds in non-cage systems may suffer more broken bones during the laying period. Gregory *et al.* (1990) found that old breaks were most common among perchery birds, and least common among caged birds. Furthermore, the pain and discomfort of old breaks was endured over a longer period than breaks which occurred at depopulation, thereby posing a serious welfare problem to hens in alternative systems. Free-range systems present additional potential problems, such as the risk of predation, and possible disease contamination by wild birds, especially in systems using fixed housing (Laing, 1988). Löliger *et al.* (1981), for example, reported that the incidence of worm infestation and coccidiosis was at least 10 times higher in a well-run free-range system than in battery cages.

1.5.4. Comparative studies between cages and alternative systems

Measures commonly used to assess welfare include mortality, production, physiology and behaviour. Using these indicators, studies have been conducted to compare the welfare of hens in cages with that of hens in alternative systems. Tanaka and Hurnik (1992), for example, in a comparative study between cages and an aviary, found that mortality rates were comparable. However, high mortalities were reported in a free-range system (Keeling *et al.*, 1988) and in a strawyard (Gibson *et al.*, 1985). In both cases, high mortality rates were largely due to cannibalism.

In the above study, Tanaka and Hurnik (1992) found no significant differences between the two systems in feed consumption, egg weight, or egg output, though caged birds had a significantly higher egg production ratio after 31 weeks. Hogarth *et al.* (1985) found that caged birds laid more eggs than deep-litter birds (including a higher proportion of larger eggs), and had a more efficient feed conversion. Overall, however, deep-litter birds performed as well as those in cages. The competitiveness of the deep-litter system could be improved by increasing stocking density, but Hill (1985) found that higher stocking densities led to reduced rates of lay, and to reduced bird welfare. In a comparison between cages and free range, Hughes and Dun (1982) found that free-range birds had a high egg output, improved plumage and a higher egg weight than their caged counterparts, but had an increased food intake and a higher proportion of dirty eggs. Keeling *et al.* (1988) also reported high food consumption and egg production in free-range hens. The aforementioned study on a strawyard system indicated that, compared to cages, hens had a satisfactory egg output (though there was a higher incidence of floor and dirty eggs) and a higher feed intake (Gibson *et al.*, 1985). Thus, the rates of lay of birds in alternative housing systems may be as high as those of caged birds. However, more eggs may be lost in the former, largely due to floor-laying. There may also be qualitative differences between between eggs from different systems; for example, Hughes *et al.* (1985) reported that, compared to eggs from caged hens, eggs from free-range hens had stronger shells. However, this difference was comparatively small, and environmental factors, such as eggs being laid on the wire cage floor rather than in a nest box, were more important in determining the incidence of cracked eggs.

Behavioural studies have indicated that the close confinement and lack of facilities associated with cages may restrict birds' freedom to express many of their natural behaviour patterns, whereas alternative housing systems allow the expression of a wider variety of behaviour patterns. Hogarth *et al.* (1985), for example, reported few behavioural problems among deep-litter hens, while Tanaka and Hurnik (1992) found significantly more stereotyped behaviour (a possible indicator of frustration), and significantly less frequent comfort behaviours in cages than in an aviary. In addition, aviary birds had greater freedom of movement. Similarly, McLean *et al.* (1986) found that perchery birds moved (on average) seven times as far as those in cages. In a comparative study between a deep-litter system and a wire-floor system (in which the only difference was floor-type), there was significantly more dustbathing on deep litter, but aggressive behaviour was more frequent in the wire-floor system (Fölsch and Vestergaard, 1981).

In a physiological study (Gibson *et al.*, 1986b), plasma concentrations of thyroxine (T4), corticosterone and triiodothyronine (T3) were compared in birds from cages, a strawyard and free range. Although results showed that there were no differences between the systems in T4 concentration, corticosterone was lowest in strawyard birds, and T3 was lowest in free-range birds, it was concluded that plasma corticosterone and thyroid hormones are not useful measures of long-term stress or welfare. Based on evidence from the aforementioned welfare indicators, including physiological measures, Koelkebeck and Cain (1984) reported that caged hens did not suffer a higher level of stress than those in deep-litter pens or in a free-range system. Jones and Faure (1981a), however, stated that caged birds had significantly higher fear levels than those from floor pens. In addition, Fölsch and Vestergaard (1981) found a significantly higher level of serum corticosterone in birds in a wire-floor system than those on deep litter.

From the available evidence, it is clear that there are problems associated with all husbandry systems. The suitability of any one system may be evaluated according to the U.K. Farm Animal Welfare Council's recommendations that a husbandry system should provide animals with five "freedoms":

1. Freedom from hunger and thirst - by ready access to fresh water and a diet to maintain full health and vigour;
2. Freedom from discomfort - by providing an appropriate environment, including shelter and a comfortable resting area;
3. Freedom from pain, injury or disease - by prevention or rapid diagnosis and treatment;
4. Freedom to express normal behaviour - by providing sufficient space, proper facilities and company of the animal's own kind;
5. Freedom from fear and distress - by ensuring conditions and treatment which avoid mental suffering.

All systems are likely to satisfy the first need for food and water. There are problems with both cages and alternative systems with regard to both the third and fifth freedoms; for example, feather pecking and integumental damage tend to be higher in cages, whereas disease and cannibalism are more difficult to control in extensive systems. As stated previously, caged birds tend to be more fearful than those in pens, though the welfare of low-ranking birds in colony systems may be very poor. In addition, beak-trimming (which may cause permanent pain) is often necessary in non-cage systems. Nevertheless, it is likely that freedom from discomfort, and freedom to exercise most normal behaviour patterns will be more compromised in conventional cages than in other, less intensive systems. In a review paper on the advantages and disadvantages of cages and alternative systems, Appleby and Hughes (1991) concluded that "overall, welfare is compromised more in conventional cages than in well-run alternative systems, though welfare is more sensitive to poor management and to market forces in the latter". In theory, the ideal husbandry system should combine the small group sizes found in cages with the freedom of movement and complex environment of alternative systems. In conclusion, it is clear that although any one system has its advantages and drawbacks, no current commercial housing system provides the ideal environment for laying hens. To quote Nicol and Dawkins (1990): "At present, no system can be unhesitatingly recommended as good for the hens' welfare".

1.6. The free-range system

The free-range system is currently the most important alternative to battery cages in the U.K. At present, it accounts for around 10% of the U.K. egg market (MAFF, 1993), a figure which has doubled in recent years and which, according to an A.D.A.S. seminar in 1990, could account for 30% of the market by 1994 (Poultry World, 1990a). According to a recent report on colony systems by the Farm Animal Welfare Council, many cages installed in the 1960's and 1970's are now due for replacement, and producers are facing a decision of whether to invest in new cages. To quote the report: "The trend is currently towards colony systems" (F.A.W.C., 1991).

For eggs to be sold as "free-range," producers must conform to the following E.C. marketing regulations:
(1) Hens must have continuous daytime access to open air runs, the ground being mainly covered with vegetation.
(2) There must be no more than 1000 hens per hectare of run. This equates to 400 hens per acre, or one hen per 10 square metres.

(3) The maximum stocking density inside the house depends on the system. Deep litter systems allow 7 hens per square metre, and at least one third of the floor area must be covered with litter. Perchery systems allow up to 25 hens per square metre, and at least 15 cm of perch per bird.

There are various possible reasons why, despite the extra cost involved, a proportion of consumers continue to buy free-range eggs. One possibility is that free-range hens are perceived to enjoy an improved standard of welfare compared to caged birds; for example, only free range satisfies Freedom No. 4 of the "five freedoms" proposed by the Farm Animal Welfare Council, permitting hens to forage under near-natural conditions. In the aforementioned attitude survey (Rogers *et al.*, 1989), free range was consistently rated the best system for various welfare criteria. (This survey also revealed some misconceptions surrounding the various systems, such as the view that free range posed the lowest disease risk). A second possible reason is that free-range eggs are often perceived to be nutritionally superior to eggs from cages. However, although they may taste different (due to hens supplementing their diet on range), there is no evidence that eggs from free-range systems are nutritionally superior or are of a higher quality than cage eggs; in fact they may contain more pesticide residues (MacIndoe, 1987). (There is much conflicting evidence regarding differences between eggs from different husbandry systems; for example, Cirilli and Papaghoerghiu (1972) found that free-range eggs compared favourably with cage eggs with regard to the mean contents of water, proteins, lipids, minerals and colour grade, whereas Torges *et al.* (1976) found no difference in taste between eggs from the two systems, though free-range eggs had dirtier shells, and the contents of free-range eggs had a higher degree of bacterial contamination, particularly by *Escherichia coli*). In a recent report on the expanding free-range egg market in France, it was reported that "consumers are buying for different reasons: freshness, concept of liberty, and a natural product which carries quality and a different taste" (Poultry World, 1993).

The apparent reluctance of hens in large free-range systems to leave and move away from the house (as outlined in section 1.4.) has been the subject of several recent press reports and articles on poultry husbandry systems (Dawn, 1991; Nicol and Dawkins, 1990). Such reports have suggested that there is a divergence between the reality of the free-range system (in which the majority of birds are inside the house at any one time) and its public perception "that "free-range" eggs come from hens which actually spend their days ranging freely over pasture" (Harrison, 1991), thereby contravening the "spirit" (if not the E.C. marketing regulations) of free range.

1.7. Thesis outline

This thesis examines the effects of various social and environmental factors on the use of space and movement of laying hens, with implications for free-range systems. As indicated in section 1.4., the use of space by free-range hens is often very uneven: a small proportion of the flock is outside at any one time, there is an apparent inverse relationship between flock size and the proportion of the flock outside, and bird density decreases with increasing distance from the house. Although much is known about spatial organisation in large indoor flocks, and there is a little information on spacing and movement on pasture, almost nothing is known about what causes hens to move between the two environments. The objective of the present study was to investigate various social factors (rank, familiarity of conspecifics, the attractiveness of large flocks) and environmental factors (feeder position, environmental enrichment, provision of cover) on the movement and dispersal of domestic hens at the interface between the house and the outside environment.

Several hypotheses were tested, using mainly small experimental groups as models for larger commercial flocks. The use of small groups allowed a degree of experimental control and replication which would have been difficult or even impossible using larger flocks.

- Chapter 2 examines the effects of both social rank and the relative novelty of an outside area on birds' emergence (from a familiar box into the outdoor area) and subsequent dispersal in the area.
- Chapter 3 investigates the possibility that early exposure to the outside environment and/or regular handling would reduce birds' underlying fearfulness and subsequent dispersal in an outdoor area.
- Chapter 4 examines the hypothesis that an individual bird is able to recognise familiar birds (of higher or lower rank), shows differential reactions to familiar and unfamiliar birds, and may limit its movements within the free-range house in order to minimise the number of unfamiliar birds encountered.
- Chapter 5 examines the gregarious habit of domestic fowl by studying the effects on birds' emergence and dispersal behaviour of varying the number and familiarity of birds already present in the outdoor area.

- Chapter 6 investigates the effects on birds' vigilance levels and dispersal behaviour of introducing cover into the outside area.
- Chapter 7 (the General Discussion) briefly reviews the experimental findings, and discusses possible implications for free-range systems, based on the experimental findings. In addition, several hypotheses are presented which might explain why birds move on to the range. These hypotheses include a fulfilment of hens' (possible) "needs" for light and locomotion, an increase in available space, the detrimental effects of maintaining close contact with a large number of other birds, and the opportunity to forage on pasture. The penultimate section examines various theories of exploration (and its relationship with novelty and fear), and offers possible explanations for the hens' behaviour in relation to these theories. Conclusions derived from the present study are discussed in the final section.

CHAPTER 2: Effects of Social Rank and Novelty of an Outdoor Area on Emergence and Dispersal Behaviour in Domestic Hens

2.1. Introduction

The degree of discrepancy between an animal's home environment and a novel area might influence the animal's response to the novel area. Unfamiliar environments are known to evoke both fear (defined by Jones (1984a) as "an adaptive psychophysiological response to perceived danger") and exploration in animals, as both responses are likely to enhance an animal's survival in that area (Murphy, 1976). Extreme or intense novelty evokes fear responses (such as avoidance or withdrawal), whereas moderate novelty often evokes exploration (Murphy and Wood-Gush, 1978). The presence of familiar cues in an otherwise unfamiliar environment may serve to reduce the novelty of that environment, and, as a result, may affect animals' subsequent behaviour in it (Jones, 1977a). Conversely, the presence of an unfamiliar object in a familiar environment often evokes initial avoidance of that object (Murphy, 1977).

Previous studies have shown that chicks are able to imprint on (or form attachments to) familiar objects, and the longer the exposure to an object, the greater the attachment (Zajonc *et al.*, 1973). (Imprinting is discussed in greater detail in Chapter 3). There may be a sensitive period for precocial birds to form attachments to objects. Rubel (1970), for example, showed that early exposure of *Coturnix* quail to a stimulus led to a reduction of fear behaviour when the stimulus was present at a later time, and an increase in distress behaviour when the stimulus was absent. Later exposure was ineffectual. Chicks imprinted onto an object showed distress behaviour when the object was withdrawn (identified by an increase in distress calls), which was reduced when the object was reintroduced. When placed in an empty (and novel) cage, chicks showed the greatest reduction in distress behaviour in the presence of the most familiar objects (Zajonc *et al.*, 1974). The presence of unfamiliar objects was nevertheless more effective than an empty cage in reducing stress among experimental chicks, but control chicks (which had not been previously been exposed to any such object) showed no reduction of stress in the presence of an unfamiliar object. Furthermore, when two groups of chicks were reared with two different cues, there was a marked preference for remaining close to familiar cues, as chicks entered first the area containing familiar cues, and also spent more time there than in the area containing unfamiliar cues (Jones, 1977b). Chicks showed attenuated tonic immobility responses (indicating reduced underlying fearfulness) in the presence of familiar cues relative to unfamiliar cues (Rovee *et al.*, 1973). The presence of familiar objects in an otherwise novel environment has also been shown to enhance exploration of that environment; for example, broiler chicks imprinted onto coloured boxes in a small pen showed an even distribution in a larger (novel) pen when these boxes were spread throughout the larger pen. Non-imprinted chicks displayed an uneven distribution by crowding around one end of the large pen (Gvaryahu *et al.*, 1987, 1989). Imprinted chicks were also significantly less fearful of a novel object than non-imprinted chicks, had a higher feed intake, and a more efficient feed conversion. One aim of the experiments described in this chapter was to investigate the reactions of laying hens towards an open, unfamiliar environment, while varying the novelty of the environment by the introduction of familiar objects.

In addition to the presence of familiar cues, responses of grouped individuals to a novel area may be related to the social structure within the group. The relationship between dominance and leadership, in which one animal sets the pace of group activity or initiates changes in it, has been investigated in various species. Greenberg (1947), for example, reported a simple form of leadership in Green Sunfish (*Leponius cyanellus*), in which the alpha individual within a group tended to be the leader. In farm animals, the relationship varies between species. Squires and Daws (1975), for example, in a study on sheep, found that certain individuals were consistently among the leaders, while others were consistently among the tail-enders. There was a high correlation between overall movement order score and dominance score. Meese and Ewbank (1973), on the other hand, found no correlation between social rank and incidence of leadership among pigs in an outdoor enclosure. Similarly, no consistent leader was found in a herd of dairy cows, and overall herd movement was influenced by all herd members (Leyhausen and Heinemann, 1975). Katzir (1982), in a study on jackdaws (*Corvus monedula* L.), found that early exploration of a novel space was carried out predominantly by socially mid or low-ranking birds. High-ranking birds were neither the first nor the last to enter the new area. Willingness to explore may be correlated with rank only when high-ranking individuals could benefit from such exploration. Otherwise, high-ranking birds may be reluctant to explore, as they have more to lose by being exploratory. Conversely, lower-ranking birds may benefit by being exploratory, and might therefore be more willing to leave a familiar home area for a novel area. A relationship between dominance and neophobia has also been reported in rats (Robertson, 1982). Pairs of rats competed at a drinking nozzle for water or a (novel) vinegar solution. The rat which was dominant when competing for access to the nozzle (and for water) was likely to give way to (and was more neophobic than) its partner when competing for the vinegar solution.

In domestic fowl, it might be predicted that low-ranking birds will show the greatest willingness to leave a familiar environment for a novel area, as a number of studies have indicated that low-ranking hens might be at a disadvantage compared to higher-ranking birds. The peck-order (or social hierarchy) in groups of domestic fowl has been well documented. There is often a lower level of overt aggression among members of established (and stable) peck-orders. Initial status may depend on the age at which birds first show aggression, and linear hierarchies appear to result from birds developing at different rates (Rushen, 1982). In small groups of penned birds, there may be dominance-subordinance relationships among all flock members. In cages, however, there tends to be one dominant hen (a despot), with little aggression among the other birds (O'Keefe *et al.*, 1988). This leads to a higher level of overt aggression in pens than in cages. In cages, close proximity to a dominant hen inhibits aggression among the other birds (Ylander and Craig, 1980). In addition, approaching or entering another bird's "personal space" often leads to aggression, but constant presence within another's personal space (as is the case among caged birds) leads to habituation, and a reduction in overt aggression (Hughes and Wood-Gush, 1977). High-ranking birds may receive priority of access to resources, which may enhance their productivity. Eskeland (1977) found that, in floor pens, high-ranking individuals spent up to one third of the time feeding, whereas low-ranking birds were constantly disturbed while trying to eat, and only spent 5% of the time feeding. In addition, ground-scratching and dustbathing decreased with diminishing rank, while standing, resting, pacing and running were all more frequently observed among low-ranking birds. High-ranking birds were able to remain in preferred areas, whereas low-ranking individuals had irregular movements and were frequently chased around. McBride (1960) reported that, below a certain level in the peck-order, hens became progressively less productive. Similarly, low-ranking hens in deep cages had significantly reduced egg production (Cunningham and van Tienhoven, 1984), and, in high-density cages, had increased heart weights (a symptom of increased stress) and longer durations of tonic immobility, indicating higher underlying fearfulness (Cunningham *et al.*, 1988). Hughes (1977a), however, found no relationship between social status and egg production in caged birds, and no correlation was found between social rank and competitive feeding ability (Craig and Ramos, 1986). High-ranking birds may also enjoy greater freedom of movement. Mankovich and Banks (1982) reported differential use of areas by individuals, with high-ranking birds frequently beside the food dispenser, and the lowest-ranking individual spending most time on the perch (which served as a refuge). Based on the above findings (which indicate that low-ranking birds are possibly disadvantaged in their home environment), it is hypothesised that low-ranking hens will show the greatest readiness to enter a novel area, as they have more to gain by being exploratory.

This chapter investigates the effects of both social rank and varying the novelty of an outside area on the dispersal of laying hens in the novel area. The novelty of the outdoor area was varied by altering the presence and/or positions of familiar objects within the area. Hens in free-range systems often show an apparent reluctance to leave the house and enter the outside area. Furthermore, outside birds display a non-random distribution, with bird density decreasing as distance from the house increases (Davison, 1986; Keeling *et al.*, 1988). A possible explanation for this is that most, if not all, of the birds' basic requirements (such as food and water) are available inside the house. (Restricting food provision to inside the house prevents attracting wild birds and mammals (which may contaminate the food), and reduces wastage (Sloan, 1985)). An alternative explanation is that birds may be inhibited from leaving the house because the degree of discrepancy between the inside and outside environments is too great. Introducing familiar objects, such as feeders, into the outside area might reduce this discrepancy, thus increasing birds' willingness to leave (and move away from) the house. In the present study, Experiments 1, 2 and 3 examined the effects of providing feeders in the outdoor area (and altering the positions of the feeders) on birds' dispersal in an unfamiliar outdoor area. Experiment 1 also investigated the effect of social rank on readiness to emerge. Experiment 4 examined birds' emergence and dispersal behaviour using familiar but biologically neutral stimuli (traffic cones) to vary the novelty of the outside area.

2.2. Experiment 1

2.2.1. Materials and methods

This experiment examined the effects of social rank and feeder position on the readiness of laying hens to emerge from a familiar area (a covered box) into an unfamiliar outdoor (test) area, measured by the times taken to enter the test area and to move one metre from the box door. This method was analogous to the "hole-in-the-wall" test (Jones, 1979), a fear measure which assumes that more fearful or timid animals will take longer to emerge from a small box into a strange, relatively exposed area. Similarly, Dawkins (1976, 1983), when testing hens' environmental preferences, used the time taken to move from the starting area into a test area as a measure of preference.

Twenty-two 125-week-old medium hybrid (ISA Brown) laying hens were housed in 2 indoor floor pens (11 birds per pen). Each pen measured 2.4 m x 2.4 m. Each pen contained a covered box (0.9 m x 0.9 m x 0.9 m), with an open side, so that all birds could enter it and became familiarised to the box in their pen. Each pen also contained a "tower" feeder, which was situated inside the box. The birds were leg-ringed to aid identification. Observations on agonistic interactions began one week after the birds were moved into the pens. Around 80 hours of observation were made over a 4-week period. An aggressive interaction was counted when one bird pecked, chased, threatened or displaced another. The winner and loser of each interaction were noted. A total of 1841 aggressive interactions were observed during this time. Dominance-subordinance hierarchies were determined for each pen, and each bird was assigned a social rank.

Once hierarchies had been established for both pens, birds were randomly assigned to test groups of three or four pen-mates each (i.e. 3 groups per pen). Each group contained one high-ranking bird (selected from ranks 1-3 in the pen hierarchies), one or two middle-ranking birds (from ranks 4-8), and one low-ranking bird (from ranks 9-11). In the groups containing four birds, the two middle-ranking birds were of adjacent ranks, so that they were of similar social status.

Food-deprivation has been shown to increase animals' exploratory tendencies (Fehrer, 1956); therefore to minimise the likelihood that birds' emergence responses were influenced by hunger, birds had free access to food in their home pens prior to testing. Birds' emergence responses were tested in an outdoor (grass-covered) paddock, measuring 11 m x 5.5 m. A covered box, similar to those in the indoor pens, was placed in one corner of the paddock. During testing, each group was transported to the outside paddock in a holding crate and placed in the covered box (with the door closed), where they were left to acclimatise for two minutes. Tower feeders (similar to those in the indoor pens) were used to alter the novelty of the outside area. There were three treatments:

Treatment 1: one feeder inside the box;
Treatment 2: one feeder in the outside area, 1 metre from the box door;
Treatment 3: one feeder in both positions (one inside and one outside).

Following the two-minute acclimatisation period, the box door was raised (and secured), and the times taken for each bird to emerge from the box and to reach one metre from the box door were recorded. Each group was given 3 replications of each treatment in a Randomised Block Design. All testing took place in the afternoon to reduce the possibility of the birds' responses being influenced by egg-laying behaviour.

If a bird had not emerged (or reached one metre from the box) within 60 minutes of the box door being raised, the test was terminated and that bird given the maximum score of 3600 seconds. Some hens exceeded this 60-minute test criterion, which produced a skewed distribution of data. Analysis was therefore carried out on log-transformed data, as this produced a more normal distribution and homogeneity of variance. To simplify the analysis, the emergence times for the two middle-ranking birds in the groups containing four birds were averaged.

2.2.2. Results

Table 2.1.1. shows the mean times to emerge from the box for each pen, treatment, day and rank, with log-transformed data in brackets. The results of the analysis of variance (on log-transformed data) showed that birds' latencies to emerge were not influenced by which pen they came from (though there was a pen x day interaction), nor by their social rank (Table 2.1.2.). The significant day effect showed that emergence times decreased with habituation, and there was also a significant treatment effect. To clarify which treatment(s) had an effect, t-tests were carried out on the (log-transformed) means for each pair of treatments. These results, shown in Table 2.1.3., indicate that, compared to T1 and T3, birds emerged earlier when there was a feeder outside (T2). There was no significant difference between T1 and T3. (Figures 2.1.a. and 2.1.b. show the treatment and day effects on the latencies to emerge from the box).

Table 2.1.4. shows the mean times taken to reach one metre from the box for each pen, treatment, day and rank, with log-transformed data in brackets. As with the emergence latencies, birds' latencies to reach one metre from the box were not significantly influenced by which pen they came from (though, again, there was a pen x day interaction), nor by their social ranks (Table 2.1.5.). As before, there was a significant day effect, and the treatment used was again shown to have a significant effect. T-tests were carried out on the (log-transformed) means of T1, T2 and T3. The

results, shown in Table 2.1.6., reveal that birds reached one metre significantly earlier in T2 than in the other two treatments, and reached one metre significantly earlier in T3 than in T1. (Figures 2.1.c. and 2.1.d. show the treatment effect and day effect on the times taken to reach one metre from the box door).

Table 2.1.1. Mean emergence times (secs) for each pen, treatment, day and rank (log-transformed data in brackets)

Pen	1	2
Mean Time (secs)	780	711
	(5.14)	(4.81)

Treatment	1	2	3
Mean Time (secs)	782	749	706
	(5.40)	(4.46)	(5.06)

Day	1	2	3	4	5	6	7	8	9
Mean (secs)	2557	1313	852	139	300	375	407	489	281
	(7.63)	(6.16)	(5.32)	(4.16)	(4.17)	(4.71)	(4.12)	(4.31)	(4.19)

Rank	1	2	3
Mean time (secs)	870	941	426
	(5.31)	(5.18)	(4.44)

Table 2.1.2. Analysis of Variance (log transformation on raw data).

Source	d.f.	s.s.	m.s.	F	P
Pen	1	4.29	4.29	0.70	NS
Residual	4	24.45	6.11	0.59	
Rank	2	23.85	11.93	1.15	NS
Pen x Rank	2	15.37	7.69	0.74	NS
Residual	8	82.93	10.37	4.73	
Day	8	211.20	26.40	12.04	$p < 0.001$
Treatment	2	24.58	12.29	5.60	$p < 0.01$
Pen x Day	8	37.95	4.74	2.16	$p < 0.05$
Pen x Treatment	2	6.78	3.39	1.55	NS
Day x Rank	16	19.60	1.26	0.56	NS
Treatment x Rank	4	7.54	1.89	0.86	NS
Pen x Day x Rank	16	7.41	0.46	0.21	NS
Pen x Treatment x Rank	4	7.50	1.87	0.85	NS
Residual	84	184.10	2.19		

Table 2.1.3. t-tests on means of (log) emergence times in each in each treatment

Treatments	t	d.f.	P	
T1 vs. T2	3.30	84	$p<0.01$	(T2 < T1)
T1 vs. T3	1.19	84	NS	
T2 vs. T3	2.11	84	$p<0.05$	(T2 < T3)

Fig. 2.1.a. Treatment effect on emergence time (mean + s.e.)

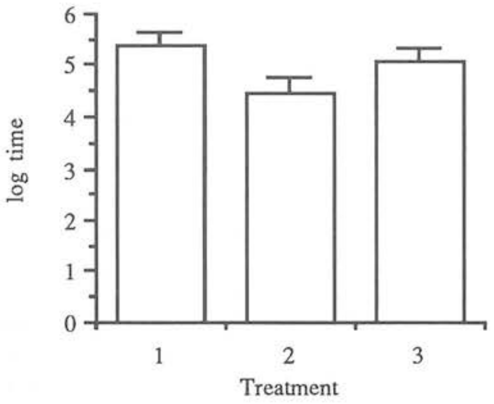


Fig. 2.1.b. Day effect on emergence time (mean + s.e.)

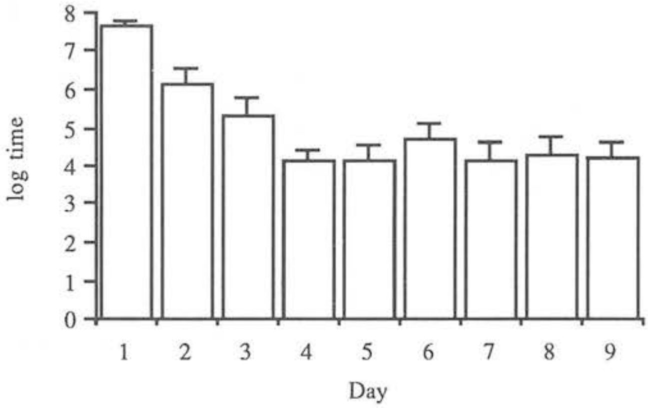


Table 2.1.4. Mean times (secs) to reach one metre for each pen, day treatment and rank (log-transformed data in brackets)

Pen	1	2
Mean Time (secs)	1125	908
	(6.02)	(5.68)

Treatment	1	2	3
Mean Time (secs)	1289	833	927
	(6.41)	(5.30)	(5.88)

Day	1	2	3	4	5	6	7	8	9
Mean (secs)	2589	1474	1242	215	500	858	738	808	730
	(7.66)	(6.71)	(6.20)	(4.86)	(5.00)	(5.57)	(5.17)	(5.76)	(5.80)

Rank	1	2	3
Mean time (secs)	1174	1273	927
	(6.09)	(6.10)	(5.39)

Table 2.1.5. Analysis of variance (log transformation on raw data).

Source	d.f.	s.s.	m.s.	F	P
Pen	1	5.38	5.38	0.95	NS
Residual	4	22.71	5.68	1.06	
Rank	2	18.12	9.06	1.69	NS
Pen x Rank	2	7.78	3.89	0.73	NS
Residual	8	42.91	5.36	3.14	
Day	8	114.86	14.36	8.40	$p < 0.001$
Treatment	2	33.10	16.55	9.68	$p < 0.01$
Pen x Day	8	30.42	3.80	2.22	$p < 0.05$
Pen x Treatment	2	0.87	0.43	0.25	NS
Day x Rank	16	15.20	0.95	0.56	NS
Treatment x Rank	4	4.26	1.07	0.62	NS
Pen x Day x Rank	16	10.49	0.66	0.38	NS
Pen x Treatment x Rank	4	2.63	0.66	0.38	NS
Residual	84	143.62	1.71		

Table 2.1.6. t-tests on means of (log) times to reach one metre from the box in each treatment

Treatments	t	d.f.	P	
T1 vs. T2	4.37	84	$p<0.01$	(T2 < T1)
T1 vs. T3	2.06	84	$p<0.05$	(T3 < T1)
T2 vs. T3	2.30	84	$p<0.05$	(T2 < T3)

Fig. 2.1.c. Treatment effect on time to reach one metre (mean + s.e.)

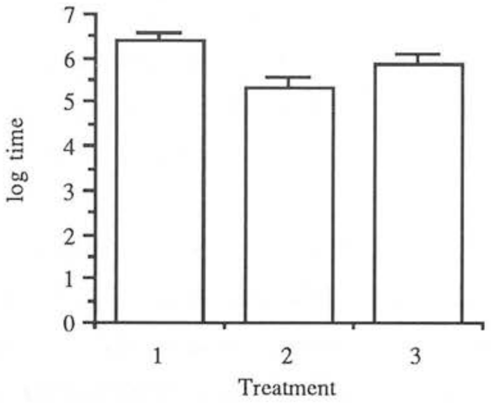
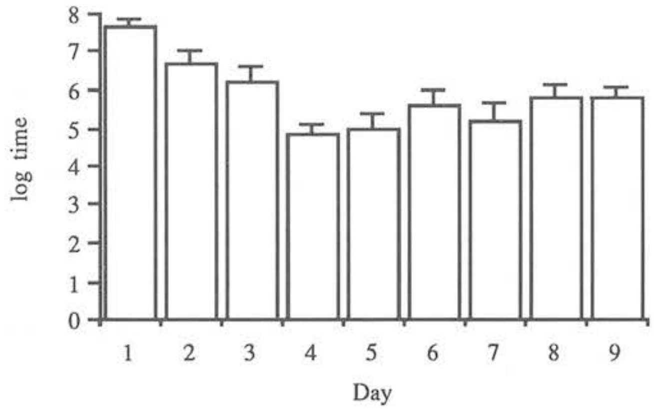


Fig. 2.1.d. Day effect on time to reach one metre (mean + s.e.)



2.3. Experiment 2

2.3.1. Materials and methods

Experiment 1 used latencies to emerge from the box and to reach one metre from the box door as measures of birds' willingness to enter the outside area. However, this method did not give any indication as to how birds made use of different areas of the paddock; for example, one bird might emerge from the box within several seconds of the box door being raised, but only spend a brief period outside before returning to the box. A second bird, on the other hand, might take several minutes to emerge from the box, but spend the remainder of the (60-minute) test period in the outside area. In Experiment 2, the amount of time which birds spent in different areas of the paddock was used as an alternative measure of their readiness to disperse in the outside area. (This method was analogous to that used by Nicol (1986) in a study on non-exclusive use of different areas in preference tests).

Twenty-four 32-week-old medium hybrid (HISex) laying hens were housed in two indoor floor pens (12 birds per pen). The birds were leg-ringed to aid identification, and were randomly assigned to test groups of four pen-mates each (i.e. 3 groups per pen). As before, both indoor pens contained a covered box, so that all birds became familiarised to the boxes in the pens. Each pen also contained a "tower" feeder. Birds' dispersal behaviour was tested in the same paddock as before. During testing, each group was transported to the outside paddock in a holding crate and placed in the covered box (with the door closed), where they were left to acclimatise for two minutes. The treatments used were the same as in Experiment 1: T1 = feeder inside the box; T2 = feeder 1 metre from the box door; T3 = 2 feeders, one in each position. Following the two-minute acclimatisation period, the box door was raised and secured. The paddock was divided into four areas (Fig. 2.2.):

Areas: 1 = inside the box;
    2 = outside the box, within 1 metre of the box door;
    3 = within 30 cm of the outside feeder;
    4 = outwith 1 metre of the box door.

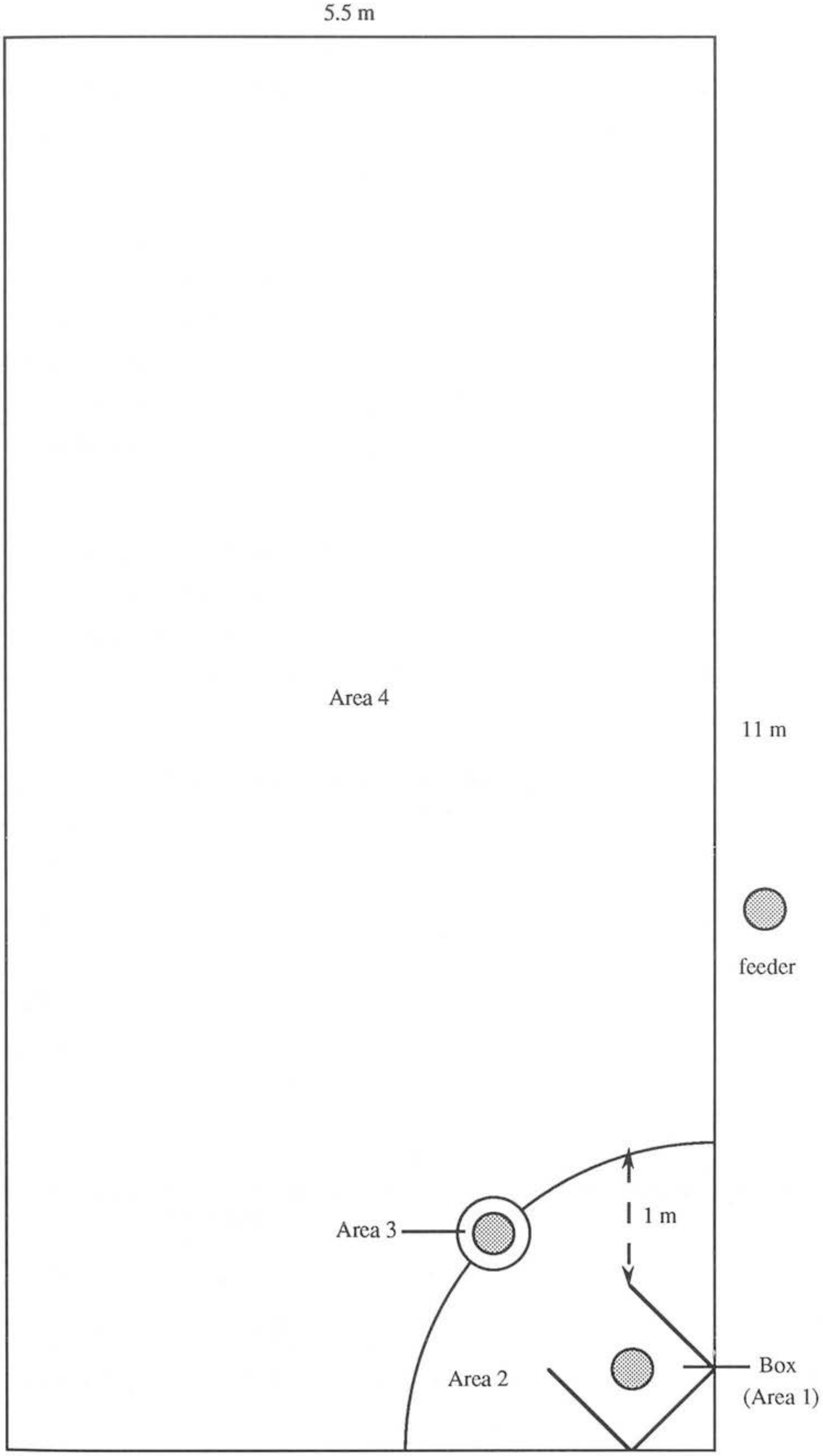
In each trial, the test group was scanned every 30 seconds over a 60-minute period. In each scan, the position of each test bird was noted. This gave an indication of the proportion of time each individual spent in each area. Each group was given three replications of each treatment in a Randomised Block Design. All testing again took place in the afternoon to reduce the possibility of the birds' responses being influenced by egg-laying behaviour.

To permit log-transformations to be carried out, 1 was added to the score for each area to allow for zero-scores. Thus, in each trial, the total number of scans per bird was 124. To determine whether the number of scans in which birds were observed in each area varied with treatment, each area was analysed separately. (Given that an increase in the use of one area will automatically result in a decrease in the use of the other three areas, it is recognised that the data are not independent. The same applies for Experiments 3 and 4). The area 1 results produced normally distributed data, so the analysis was carried out on untransformed data. The raw data for the other three areas had skewed distributions; log-transformation produced a more normal distribution and homogeneity of variance.

2.3.2. Results

Table 2.2.1. shows the mean number of scans in which birds were seen in the 4 areas in each treatment, with log-transformed data in brackets. The results of the analysis of variance showed that there was a significant treatment effect on the number of scans in which birds were seen in area 1 (F=36.60; 2, 172 d.f.; $p < 0.001$). To clarify which treatment(s) had an effect, t-tests were carried out on the means for each pair of treatments. The results are shown in Table 2.2.2., and indicate that, compared to Treatments 2 and 3, birds spent significantly more time in area 1 (inside the box) in Treatment 1. Birds also spent significantly more time in area 1 in T3 than in T2.

Figure 2.2. : Experiment 2 - Plan view of paddock



The ANOVA result revealed that there was a significant treatment effect on the number of scans in which birds were seen in area 2 (F=4.39; 2, 172 d.f.; $p < 0.05$). As before, to clarify which treatment(s) had an effect, t-tests were carried out on the (log-transformed) means for each pair of treatments. The results, shown in Table 2.2.3., indicate that birds spent significantly more time in area 2 in T2 than in either of the other two treatments. There was no significant difference between Treatments 1 and 3.

Analysis of variance on log-transformed data indicated that there was a significant treatment effect on the number of scans in which birds were seen in area 3 (F=138.58; 2, 172 d.f.; $p < 0.001$). As before, t-tests were carried out on the (log-transformed) means for each pair of treatments, the results of which are shown in Table 2.2.4. These show that birds spent significantly more time in area 3 in T2 than in either of the other two treatments. Birds also spent significantly more time in area 3 in T3 than in T1.

The non-significant ANOVA treatment effect (F=0.32; 2, 172 d.f.; $p > 0.05$) indicated that birds spent equivalent amounts of time in area 4 (outwith 1 metre of the box door) in all three treatments. (Figures 2.2.a., 2.2.b. and 2.2.c. show the treatment effect on the number of scans in which birds were observed in areas 1, 2 and 3, respectively).

Table 2.2.1. Mean number of scans in which birds were seen in each area in each treatment (log-transformed data in brackets)

Treatment	1	2	3	ANOVA
Area 1	89.9	55.6	78.6	$p < 0.001$
Area 2	20.3	28.2	18.5	
	(2.43)	(2.84)	(2.45)	$p < 0.05$
Area 3	1.9	28.9	16.0	
	(0.43)	(2.97)	(2.17)	$p < 0.001$
Area 4	11.8	11.3	11.0	
	(1.56)	(1.62)	(1.50)	NS

Table 2.2.2. t-tests on means of number of scans birds were seen in area 1 in each treatment

Treatments	t	d.f.	P	
T1 vs. T2	8.407	172	$p < 0.001$	(T2 < T1)
T1 vs. T3	2.770	172	$p < 0.01$	(T3 < T1)
T2 vs. T3	5.637	172	$p < 0.001$	(T2 < T3)

Table 2.2.3. t-tests on (log) means of number of scans birds were seen in area 2 in each treatment

Treatments	t	d.f.	P	
T1 vs. T2	2.615	172	$p < 0.01$	(T1 < T2)
T1 vs. T3	0.102	172	NS	
T2 vs. T3	2.513	172	$p < 0.05$	(T3 < T2)

Table 2.2.4. t-tests on (log) means of number of scans birds were seen in area 3 in each treatment.

Treatments	t	d.f.	P	
T1 vs. T2	16.278	172	$p < 0.001$	(T1 < T2)
T1 vs. T3	11.172	172	$p < 0.001$	(T1 < T3)
T2 vs. T3	5.106	172	$p < 0.001$	(T3 < T2)

Fig. 2.2.a. Mean number of scans in which birds were seen in area 1 in each treatment (mean + s.e.).

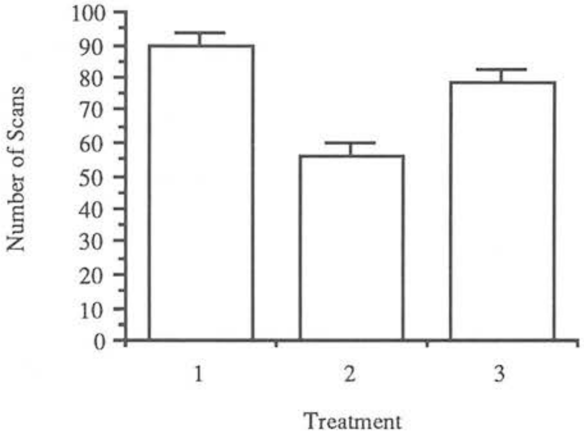


Fig. 2.2.b. Mean number of scans (logs) in which birds were seen in area 2 in each treatment (mean + s.e.).

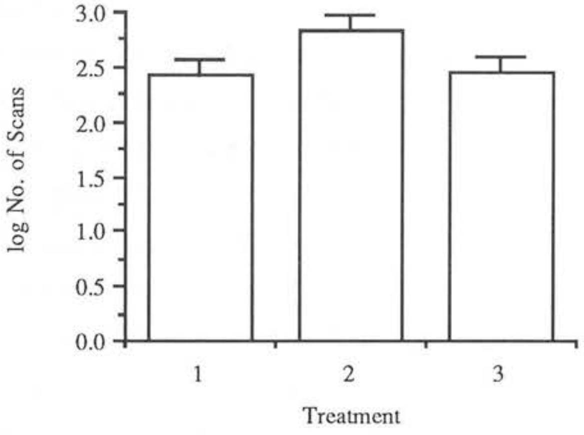
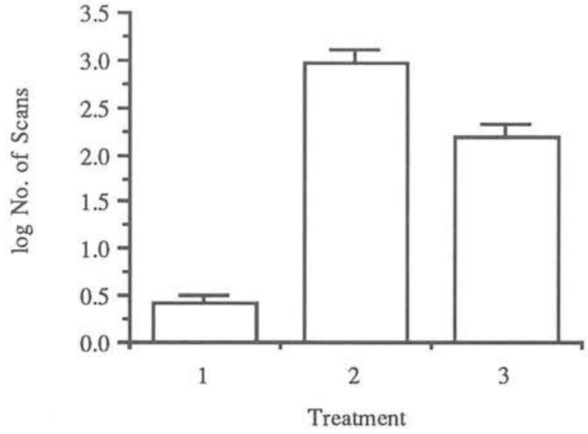


Fig. 2.2.c. Mean number of scans (logs) in which birds were seen in area 3 in each treatment (mean + s.e.).



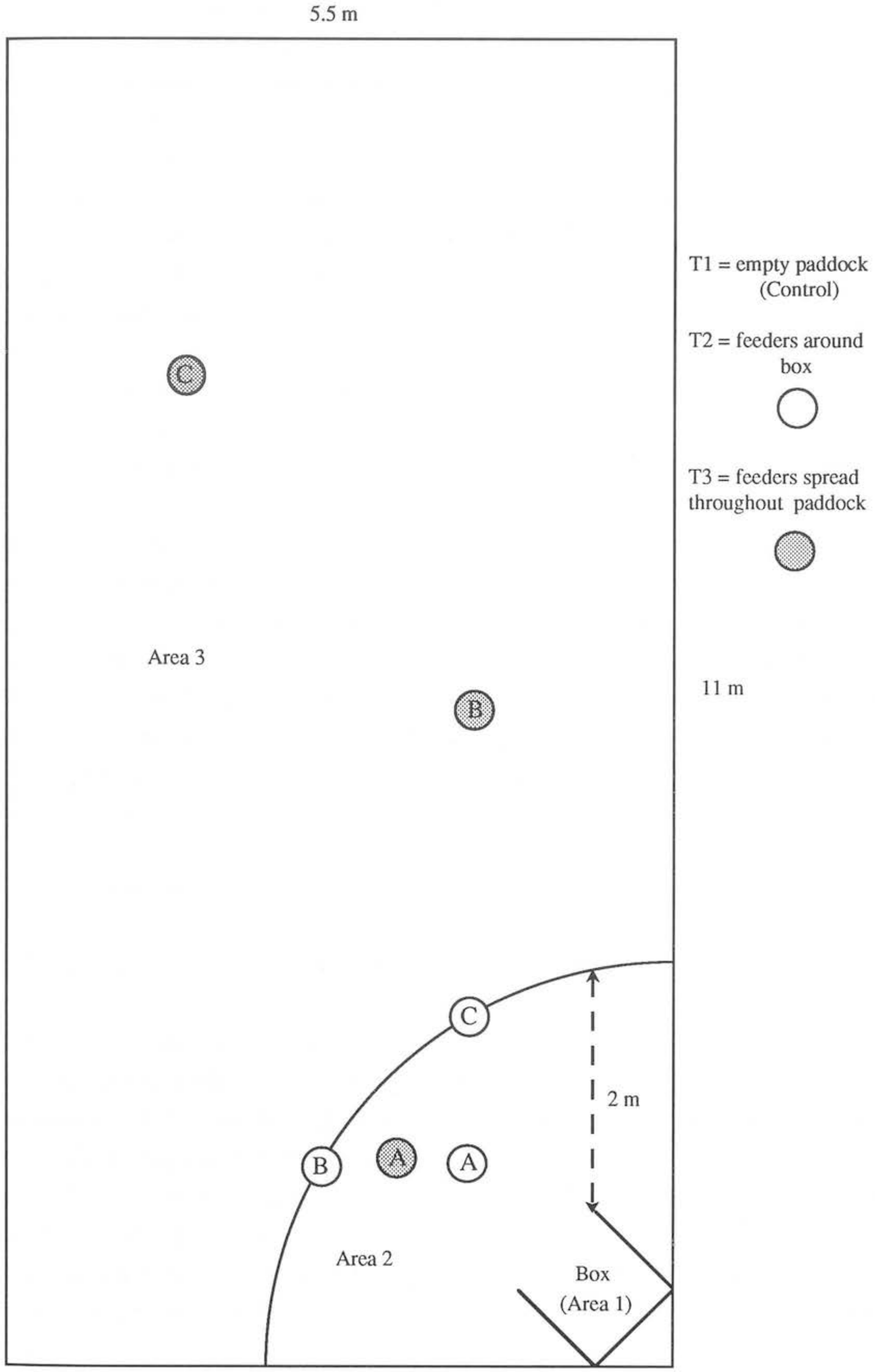
2.4. Experiment 3

2.4.1. Materials and methods

Experiment 3 examined birds' emergence and dispersal responses simultaneously, while varying the positions of 3 feeders (dispersed in the paddock, clustered round the box, or absent altogether). Birds' use of the feeders (where present) was also recorded.

Thirty-six 65-week-old medium hybrid (HISex) laying hens were housed in three indoor floor pens (12 birds per pen), as before. Birds were identified by coloured leg-rings, and were randomly assigned to test groups of four pen-mates each (i.e. 3 groups per pen). Each indoor pen contained a covered box and a "tower" feeder, so that all birds became familiarised to both stimuli in the pens. Birds' emergence and dispersal behaviour were tested in the same outdoor paddock as before, which again contained a covered box. During testing, each group was transported to the outside paddock in a holding crate and placed in the covered box (with the door closed), where they were left to acclimatise for two minutes.
There were 3 treatments (see Fig. 2.3.):
Treatment 1: empty paddock (control);
Treatment 2: three "tower" feeders within two metres of the box door (feeder A = 1 metre from the box; feeders B and C = 2 metres from the box);
Treatment 3: three feeders dispersed in the paddock (feeder A = 1.5 metres from the box; feeder B = 5 metres from the box; feeder C = 7.5 metres from the box).

Figure 2.3. : Experiment 3 - Plan view of paddock



Each group was given two replications of each treatment in a Randomised Block Design. For each group, the order in which the treatments was given was randomised. The order in which the 9 groups were tested was also randomised.

The following measures were recorded:

(a) the latencies of each bird to leave the box (once the box door was raised), and to reach two metres from the box. If a bird had not emerged (or reached two metres from the box door) within sixty minutes of the box door being raised, the test was terminated, and that bird given a score of 3600 seconds;

(b) the area in which each (test) bird was seen, scanning every 30 seconds over a 60-minute period (Fig. 2.3.).

Areas: 1 = inside box;
2 = within two metres of the box door;
3 = outwith two metres of the box door.

(c) the number of birds which were observed feeding at each feeder during each scan.

To permit log-transformations to be carried out, 1 was added to each total to allow for zero-scores. Thus, in each trial, the total number of scans per bird was 123. Analysis of the latencies to emerge and reach two metres from the box, as well as the number of scans in which birds were seen in area 3, were carried out on log-transformed data. The raw data had a skewed variation; log-transformation produced a more normal distribution and homogeneity of variance. The data for the number of scans in which birds were seen in areas 1 and 2 conformed to the conditions for parametric statistics, so analysis was carried out on untransformed data.

2.4.2. Results

2.4.2.a. *Latencies to emerge and reach two metres from the box*

Table 2.3.1. shows the mean times to emerge from the box and to reach 2 metres from the box door in each treatment, with log-transformed data in brackets. Analysis of variance of the (log-transformed) treatment means showed that the treatment used had a significant effect on the time taken to emerge from the box (F=10.87; 2, 159 d.f.; $p < 0.001$). To clarify which treatment or treatments had an effect, t-tests were carried out on the (log-transformed) means for each pair of treatments. The results of these t-tests (shown in Table 2.3.2.) indicate that, compared to Treatment 1 (empty paddock), birds emerged significantly earlier in both Treatment 2 (feeders clustered around box)

and Treatment 3 (feeders dispersed in paddock). There was no significant difference between T2 and T3.

Analysis of variance of the (log-transformed) treatment means showed that the treatment used did not have a significant effect on the time taken to reach two metres from the box (F=0.28; 2, 159 d.f.; $p > 0.05$). These results suggest that the presence of feeders in the outside area led to shorter emergence latencies, though times taken to reach 2 metres were not significantly affected. (Figure 2.3.a. shows the treatment effect on emergence time).

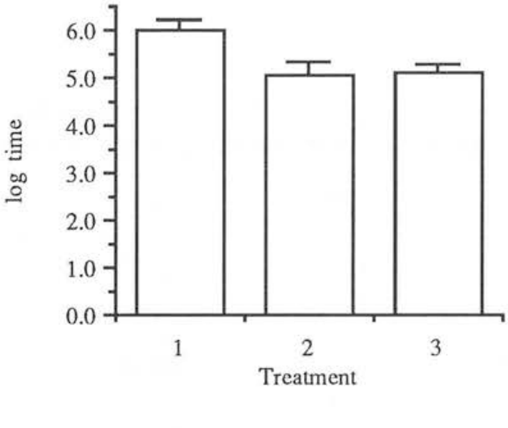
Table 2.3.1. Mean times to emerge and reach 2 metres in each treatment (secs) (log-transformed data in brackets)

Treatment	T1	T2	T3	ANOVA
Emerge	1307 (5.98)	910 (5.06)	580 (5.10)	$p < 0.001$
2 metres	2600 (7.54)	2658 (7.63)	2524 (7.52)	NS

Table 2.3.2. t-tests on means of (log) emergence times under each treatment

	t	d.f.	P	
T1 vs. T2	4.131	159	$p < 0.001$	(T2 < T1)
T1 vs. T3	3.934	159	$p < 0.001$	(T3 < T1)
T2 vs. T3	0.198	159	NS	

Fig. 2.3.a. Treatment effect on (log) emergence time (mean + s.e.)



2.4.2.b. *Number of scans in which birds were seen in each area*

Table 2.3.3. shows the mean number of scans in which birds were seen in areas 1, 2 and 3 in each treatment, with log-transformed data (for Area 3) in brackets. Analysis of variance of the treatment means showed that the treatment used had a significant effect on the number of scans in which birds were seen in area 1 (F=7.23; 2, 159 d.f.; $p < 0.001$). To clarify which treatment or treatments had an effect, t-tests were carried out on the means for each pair of treatments. The results of these tests (shown in Table 2.3.4.) indicate that, compared to T1, birds spent significantly less time inside the box (area 1) in both treatments where feeders were present in the paddock (T2 and T3). There was no significant difference between T2 and T3.

The significant analysis of variance of the treatment means showed that the treatment used had an effect on the number of scans in which birds were seen in area 2 (F=12.74; 2, 159 d.f.; $p < 0.001$). As before, t-tests were carried out on the means for each pair of treatments. These are shown in Table 2.3.5. Compared to T1, birds spent significantly more time in area 2 (within two metres of the box door) in both T2 and T3. There was no significant difference between T2 and T3.

Analysis of variance of the (log-transformed) treatment means showed that the treatment used did not have a significant effect on the number of scans in which birds were seen in area 3 (F=1.77; 2, 159 d.f.; $p > 0.05$). Thus, the presence of feeders in the outside area led to birds spending less time in the box and more time in the area immediately outside the box. However, birds spent equivalent amounts of time in the area furthest from the box, even when feeders were present in that area. (Figures 2.3.b. and 2.3.c. show the treatment effect on the number of scans in which birds were observed in area 1 and area 2, respectively).

Table 2.3.3. Mean number of scans in which birds were seen in each area in each treatment (log-transformed data in brackets)

Treatment	T1	T2	T3	ANOVA
Area 1	93.2	77.4	78.8	$p < 0.001$
Area 2	23.4	40.8	36.6	$p < 0.001$
Area 3	6.5 (0.64)	4.8 (0.61)	7.6 (0.90)	NS

Table 2.3.4. t-tests on means of the number of scans in which birds were seen in area 1

	t	d.f.	P	
T1 vs. T2	3.442	159	$p < 0.001$	(T2 < T1)
T1 vs. T3	3.137	159	$p < 0.01$	(T3 < T1)
T2 vs. T3	0.305	159	NS	

Table 2.3.5. t-tests on (log) means of the number of scans in which birds were seen in area 2

	t	d.f.	P	
T1 vs. T2	4.833	159	$p < 0.001$	(T2 > T1)
T1 vs. T3	3.667	159	$p < 0.001$	(T3 > T1)
T2 vs. T3	1.167	159	NS	

Fig. 2.3.b. Treatment effect on number of scans in which birds were seen in area 1 (mean + s.e.)

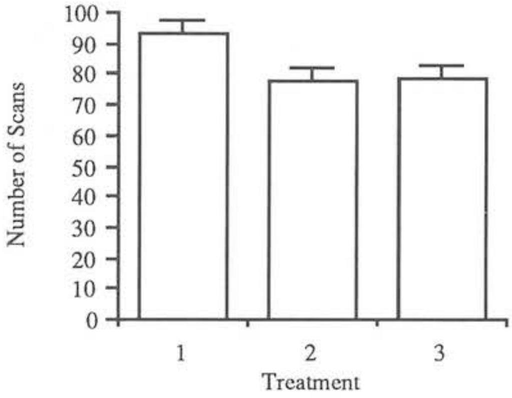
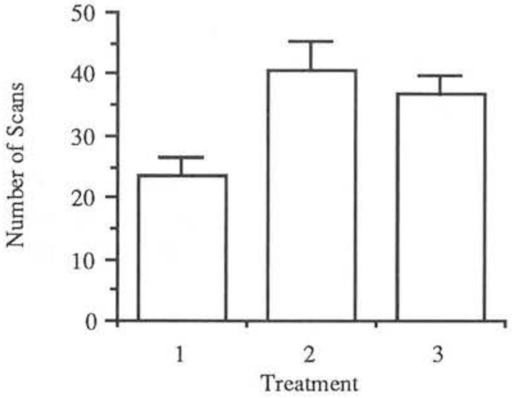


Fig. 2.3.c. Treatment effect on number of scans in which birds were seen in area 2 (mean + s.e.)



2.4.2.c. *Number of birds observed at the feeders*

Table 2.3.6. shows (1) the total number of occasions in which birds were seen outside the box in Treatments 2 and 3;

(2) the total number of occasions in which birds were seen feeding at the feeders in T2 and T3;

(3) the percentage of scans in which outside birds were seen feeding at the feeders.

Table 2.3.7. shows (1) the distribution of feeding events between the 3 feeders (A, B, C) in T2 and T3;

(2) distribution of feeding events expressed as percentages;

(3) feeding events expressed as percentages of all scans.

These tables show that birds were observed at the feeders in a higher proportion of scans in T2 (26.0%) than in T3 (18.3%). Birds were observed at Feeder A in approximately equal proportions in both treatments (T2 - 16.0%; T3 - 18.3%). In both T2 and T3, birds used Feeder A (the feeder nearest the box) more often than the other two feeders. In T3, birds were seen using Feeder B in less than 1% of the scans, and were never seen at Feeder C (the feeder furthest from the box). Thus, in both T2 and T3, birds were observed more frequently at the feeder which was closest to the box. This was especially so when the feeders were further away from the box (T3).

Table 2.3.6.

	Treatment	
	T2	T3
(1) birds seen outside	3141	3041
(2) birds seen feeding	818	557
(3) feeding occasions (%)	26.0	18.3

Table 2.3.7.

	Treatment					
	T2			T3		
Feeder	A	B	C	A	B	C
(1) number of feeding events	503	122	193	552	5	0
(2) distribution of feeding events	61.5	14.9	23.5	99.1	0.9	0
(3) feeding events as % of all scans	16.0	3.9	6.1	18.2	0.2	0

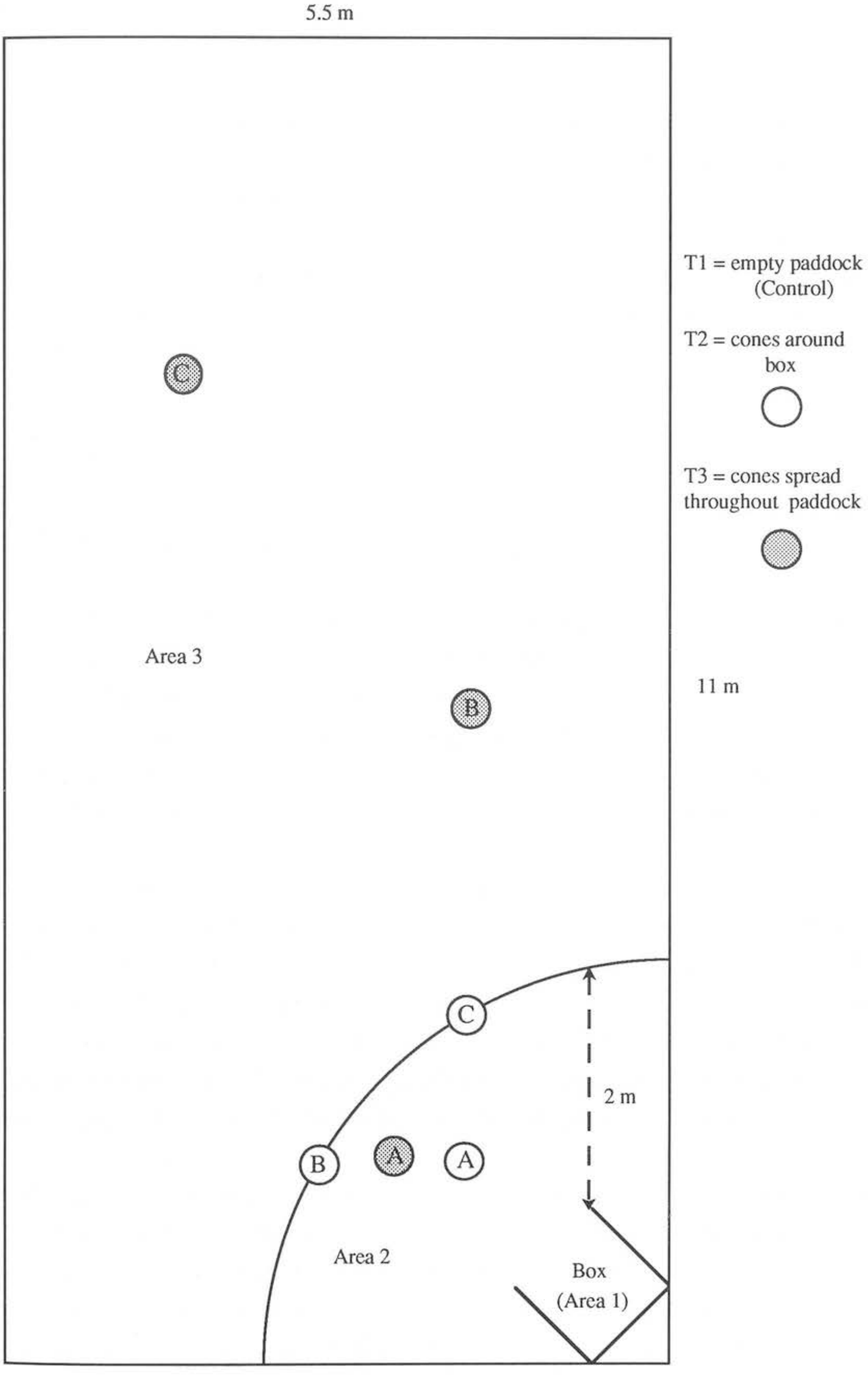
2.5. Experiment 4

2.5.1. Materials and methods

This experiment was similar to Experiment 3, but used traffic cones instead of feeders. Therefore, the familiar stimuli used to reduce the novelty of the outside area had little or no biological function. To investigate whether the birds' responses were dependent on prior familiarisation to these stimuli, half the birds were familiarised to the cones in their home pens prior to testing, and half were not.

Thirty-two 25-week-old (HISex) medium hybrid laying hens were housed in four indoor floor pens (A, B, C, D), with 8 birds in each pen. The birds were leg-ringed to aid identification. Birds were randomly assigned to test groups of four pen-mates each. As before, each indoor pen contained a covered box, so all birds became familiarised to these boxes in the pens. In addition, Pens A and C each contained two 60 cm x 30 cm (height x diameter) orange traffic cones; there were no cones in Pens B or D. The birds were left undisturbed in the pens for three weeks to allow them to become familiarised to both the boxes and (in Pens A and C) to the cones. Thus, birds in Pens A and C were "familiarised" (to the cones), birds in Pens B and D were "unfamiliarised." Following this familiarisation period, birds' emergence and dispersal behaviour were tested in the aforementioned outdoor paddock, which contained a covered box similar to those in the birds' home pens (Figure 2.4.). During testing, each test group was transported to the outside paddock in a holding crate and placed in another covered box (with the door closed), where they were left to acclimatise for two minutes. The groups were tested in each of the following treatments (analogous to those used in Experiment 3):
Treatment 1: empty paddock;
Treatment 2: 3 cones within 2 metres of the box;
Treatment 3: 3 cones dispersed in the paddock (1.5 m, 5 m and 7.5 m from the box).
Each group was given three replications of each treatment (in a randomised order). Following the two-minute acclimatisation period, the box door was raised, and, as before, the following measures were recorded:
(a) the latencies of each (test) bird to leave the box (once the box door was raised), and to reach two metres from the box. As before, if a bird had not emerged (or reached two metres from the box door) within sixty minutes of the box door being raised, the test was terminated, and that bird given a score of 3600 seconds.

Figure 2.4. : Experiment 4 - Plan view of paddock



(b) the area in which each (test) bird was seen, scanning every 30 seconds over a 60-minute period. As before, the areas were: 1 = inside the box, 2 = within two metres of the box door, 3 = outwith two metres of the box door.

All testing took place in the afternoon to reduce the possibility of birds' responses being influenced by egg-laying behaviour. To permit log-transformations to be carried out, 1 was added to each total to allow for zero-scores. Thus, in each trial, the total number of scans per bird was 123. Where the raw data had a skewed variation, analysis was carried out on log-transformed data; log-transformation produced a more normal distribution and homogeneity of variance. Where the data were more normally distributed, analysis was carried out on untransformed data.

2.5.2. Results

2.5.2.a. *Latencies to emerge and reach two metres from the box*

Table 2.4.1 shows the mean emergence times for "familiarised" and "unfamiliarised" birds ("familiarisation effect"), for each treatment, and for the familiarisation x treatment interaction, with log-transformed data in brackets. Analysis of variance on the (log-transformed) means showed that birds which had been familiarised to cones in their home pens emerged from the box significantly earlier than birds which did not have cones in their home pens (F=7.14; 1, 6 d.f.; $p < 0.05$). The non-significant analysis of variance on the (log-transformed) treatment means (F=0.67; 2, 252 d.f.; $p > 0.05$) indicates that the treatment used did not have a significant effect on birds' emergence latencies. Analysis of variance on the (log-transformed) means indicated that there was no significant familiarisation x treatment interaction (F=2.09; 2, 252 d.f.; $p > 0.05$). Neither familiarised nor unfamiliarised birds showed any significant difference in emergence times between the three treatments. Thus, only prior familiarisation to cones resulted in a significantly shorter latency to emerge from the box. (Figure 2.4.a. shows the familiarisation effect on emergence times).

Table 2.4.2. shows the mean times to reach 2 metres for "familiarised" and "unfamiliarised" birds, for each treatment, and for the familiarisation x treatment interaction, with log-transformed data in brackets. Analysis of variance on the (log-transformed) means indicated that there was no significant difference between familiarised and unfamiliarised birds in the time taken to reach two metres (F=2.83; 1,

6 d.f.; $p > 0.05$). The non-significant ANOVA (on log-transformed means) revealed that the treatment used had no significant effect on the time taken to reach two metres from the box ($F=0.39$; 2, 252 d.f.; $p > 0.05$). Analysis of variance on the (log-transformed) means indicated that there was no significant familiarisation x treatment interaction ($F=0.92$; 2, 252 d.f.; $p > 0.05$). Neither familiarised nor unfamiliarised birds showed any significant difference in the time taken to reach two metres between the three treatments. These results suggest that the time taken to reach 2 metres from the box door was not influenced by pre-test exposure to cones in the home pens, or by the presence of cones in the paddock during testing.

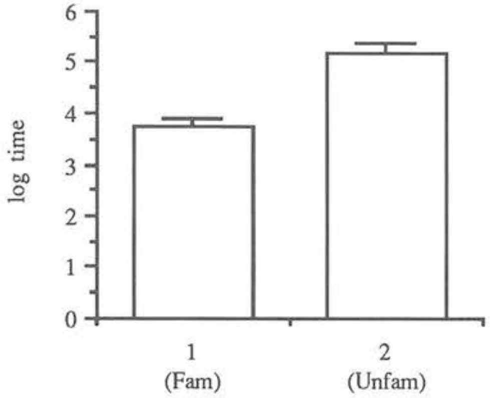
Table 2.4.1 Mean emergence times (secs) for each "familiarisation" (familiarised vs. unfamiliarised birds), treatment, and familiarisation x treatment interaction (log-transformed data in brackets).

Familiarisation	Unfamiliarised	Familiarised		ANOVA
	1038	346		
	(5.17)	(3.73)		$p < 0.05$
Treatment	T1	T2	T3	
	643	689	744	
	(4.27)	(4.55)	(4.54)	NS
Treatment	T1	T2	T3	
Unfamiliarised	804	1194	1115	
	(4.67)	(5.46)	(5.39)	NS
Familiarised	483	184	372	
	(3.87)	(3.64)	(3.69)	

Table 2.4.2. Mean times (secs) taken to reach 2 metres from the box for each "familiarisation", treatment, and familiarisation x treatment interaction (log-transformed data in brackets).

Familiarisation	Unfamiliarised	Familiarised		ANOVA
	2740	2011		
	(7.63)	(7.06)		NS
Treatment	T1	T2	T3	
	2418	2472	2237	
	(7.37)	(7.39)	(7.27)	NS
Treatment	T1	T2	T3	
Unfamiliarised	2674	2985	2562	
	(7.57)	(7.78)	(7.54)	NS
Familiarised	2163	1960	1911	
	(7.18)	(6.99)	(7.00)	

Fig. 2.4.a. "Familiarisation" effect on (log) emergence times (mean + s.e.)



2.5.2.b. *Number of scans in which birds were seen in each area*

Table 2.4.3. shows the mean number of scans in which birds were seen in area 1 for "familiarised" and "unfamiliarised" birds, for each treatment, and for the familiarisation x treatment interaction. Analysis of variance showed that familiarised birds were seen inside the box (area 1) in significantly fewer scans than unfamiliarised birds (F=6.03; 1, 6 d.f.; $p < 0.05$). A significant analysis of variance of the treatment means showed that the treatment used had an effect on the number of scans in which birds were seen in area 1 (F=3.18; 2, 252 d.f.; $p < 0.05$). To clarify which treatment or treatments had an effect, t-tests were carried out on the means for each pair of treatments. The results of these tests (shown in Table 2.4.4.) reveal that, compared to Treatment 1, birds spent significantly less time in area 1 in Treatment 3. There were no significant differences between T1 and T2, or between T2 and T3. Analysis of variance indicated that there was no significant familiarisation x treatment interaction (F=2.50; 2, 252 d.f.; $p > 0.05$). Neither familiarised nor unfamiliarised birds showed any significant difference in the amount of time spent in area 1 in the three treatments. Thus, birds spent less time in area 1 in Treatment 3 (in which cones were dispersed in the paddock) than when the paddock was empty, and birds which had cones in their home pens spent less time inside the box than those which did not. (Figures 2.4.b. and 2.4.c. show the familiarisation effect and treatment effect on the number of scans in which birds were observed in area 1).

Table 2.4.5. shows the mean number of scans in which birds were seen in area 2 for "familiarised" and "unfamiliarised" birds, for each treatment, and for the

familiarisation x treatment interaction. Analysis of variance on the above means showed that unfamiliarised birds were seen within two metres of the box door (area 2) on significantly fewer occasions than familiarised birds (F=6.99; 1, 6 d.f.; $p < 0.05$). A non-significant analysis of variance on the treatment means indicated that birds spent equivalent amounts of time in area 2 in all three treatments (F=2.66; 2, 252 d.f.; $p > 0.05$). Analysis of variance indicated that there was no significant familiarisation x treatment interaction (F=2.59; 2, 252 d.f.; $p > 0.05$). Neither familiarised nor unfamiliarised birds showed any significant difference in the amount of time spent in area 2 in the three treatments. These results show that only familiarisation had a significant effect on the time spent in area 2. (Figure 2.4.d. shows the familiarisation effect on the number of scans in which birds were observed in area 2).

Table 2.4.6. shows the mean number of scans in which birds were seen in area 3 for "familiarised" and "unfamiliarised" birds, for each treatment, and for the familiarisation x treatment interaction, with log-transformed data in brackets. Analysis of variance on the (log) means indicated that familiarisation to cones had no significant effect on the amount of time birds spent outwith two metres of the box (area 3) (F=2.31; 2, 252 d.f.; $p > 0.05$). The non-significant analysis of variance on the (log) treatment means indicated that birds spent equivalent amounts of time in area 3 in all three treatments (F=2.41; 2, 252 d.f.; $p > 0.05$). Analysis of variance (on the log-transformed means) indicated that there was no significant familiarisation x treatment interaction (F=0.40; 2, 252 d.f.; $p > 0.05$). Neither familiarised nor unfamiliarised birds showed any significant difference in the amount of time spent in area 3 in the three treatments. Thus, birds' dispersal in area 3 was not influenced by exposure to cones in the home pens, or by the presence of cones in the test area.

In summary, compared to "unfamiliarised" birds, "familiarised" birds emerged quicker, spent less time inside the box, and more time in the area immediately outside the box door (though not in the area furthest from the box). Compared to T1 and T2, birds spent least time in area 1 (significant), and most time in areas 2 (trend) and 3 (trend), when cones were dispersed in the paddock (T3). There were no significant differences between Treatments 2 and 3. There were no significant familiarisation x treatment interactions for any measure.

Table 2.4.3. Mean number of scans (from a total of 123) in which birds were seen in area 1 for each "familiarisation", treatment, and familiarisation x treatment interaction

Familiarisation	Unfamiliarised		Familiarised	ANOVA
	99.6		75.2	$p < 0.05$
Treatment	T1	T2	T3	
	91.7	87.6	82.8	$p < 0.05$
Treatment	T1	T2	T3	
Unfamiliarised	100.0	103.9	94.8	NS
Familiarised	83.4	71.4	70.8	

Table 2.4.4. t-tests on mean number of scans in which birds were seen in area 1 in each treatment.

	t	d.f.	P	
T1 vs. T2	1.17	252	NS	
T1 vs. T3	2.54	252	$p < 0.05$	(T3 < T1)
T2 vs. T3	1.35	252	NS	

Table 2.4.5. Mean number of scans (from a total of 123) in which birds were seen in area 2 for each "familiarisation", treatment, and familiarisation x treatment interaction

Familiarisation	Unfamiliarised		Familiarised	ANOVA
	21.1		40.4	$p < 0.05$
Treatment	T1	T2	T3	
	27.1	30.8	34.4	NS
Treatment	T1	T2	T3	
Unfamiliarised	20.9	17.4	25.0	NS
Familiarised	33.3	44.1	43.7	

Table 2.4.6. Mean number of scans (from a total of 123) in which birds were seen in area 3 for each "familiarisation", treatment, and familiarisation x treatment interaction (log-transformed data in brackets).

Familiarisation	Unfamiliarised		Familiarised	ANOVA
	2.4		7.4	
	(0.44)		(1.07)	NS
Treatment	T1	T2	T3	
	4.1	4.6	6.0	
	(0.68)	(0.66)	(0.92)	NS
Treatment	T1	T2	T3	
Unfamiliarised	2.1	1.7	3.5	
	(0.37)	(0.29)	(0.66)	NS
Familiarised	6.2	7.5	8.6	
	(0.99)	(1.04)	(1.18)	

Fig. 2.4.b. Familiarisation effect on number of scans in which birds were seen in area 1 (mean + s.e.)

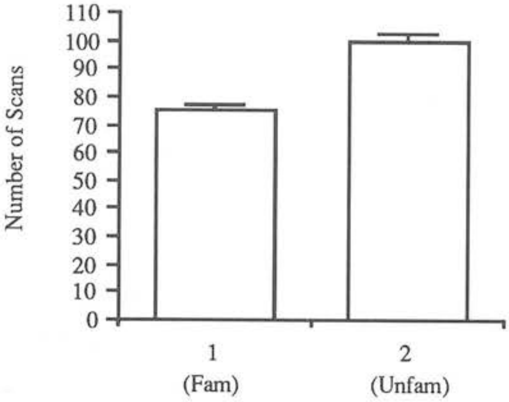


Fig. 2.4.c. Treatment effect on number of scans in which birds were seen in area 1 (mean + s.e.)

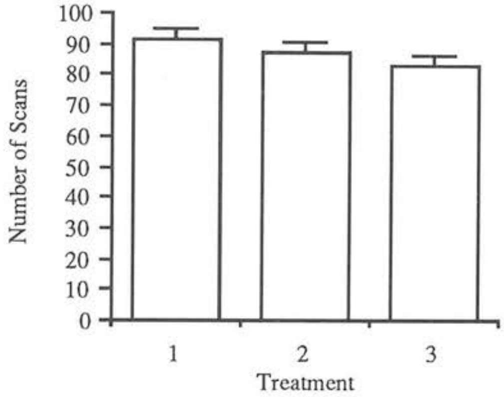
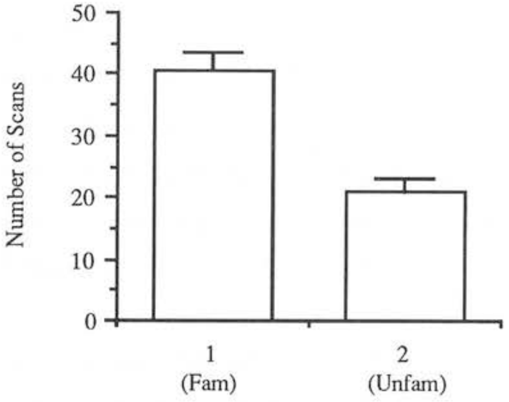


Fig. 2.4.d. Familiarisation effect on number of scans birds were seen in area 2 (mean + s.e.)



2.6. Discussion

In Experiment 1, birds emerged earlier when there was a single feeder outside (T2) than in either T1 (single feeder inside the box) or T3 (feeders in both positions). Birds displayed a slight (though non-significant) tendency to emerge earlier from the box when there was a feeder in both locations (T3) compared to when there was a single feeder inside the box (T1). This similarity in emergence times between T1 and T3 indicated that birds were no more willing to leave the familiar environment (the covered box) which contained a familiar object (the feeder) when there was another feeder in the otherwise unfamiliar open paddock. The open paddock had the same degree of familiarity (one feeder outside) in both T2 and T3, but in T2 the birds may have been more willing to sacrifice the familiar environment of the box as there was no feeder in the box to encourage them to remain there.

In contrast to the emergence latencies, results for the times taken to reach one metre from the box yielded significant differences between all three treatments. T2 again yielded the shortest latency, although this time T3 yielded a significantly shorter latency than T1. This might have been because the birds, having emerged from the box during T3, may have been encouraged to go on and visit the outside feeder (which was one metre from the box), even though the birds had free access to food in their home pens. Birds tested under T1, on the other hand, had no outside feeder to go to, so there was not the same incentive to go the one metre distance. Thus, a familiar feeder in an otherwise unfamiliar (and exposed) area increased birds' willingness to move out of the box and into the area, though only when a similar feeder was not present in the box. As previous studies have reported, the presence of a familiar stimulus in a novel area reduces an animal's fear of the area (Rubel, 1970; Zajonc *et al.*, 1974; Jones, 1977b). In this study, some emerging birds went to the outside feeder and fed, despite the fact that the birds had not been food-deprived beforehand. This introduced some degree of uncertainty as to whether the birds saw the outside feeder primarily as a source of food, or as a familiar stimulus, or both. In a similar study, Newberry (1992) found that broilers were more highly motivated to move into a novel area when the area contained resources (food, water, heat), even though these resources were available in the birds' home area.

Experiment 1 also showed that the times taken to emerge and to reach one metre from the box decreased with repeated testing (with the most marked reductions occurring over days 1-4), suggesting that birds' fear of the outside area decreased with repeated exposure to the area. One method of estimating fear is to measure an animal's adaptation or habituation to a novel environment or stimulus. Experience in a novel environment may lead to reduced fear responses in that environment. Jones (1977a), for example, reported that repeated testing of chicks in an Open Field led to a reduction in fear levels in the novel area.

Although the mean emergence times for the three ranks were in the predicted direction (as the lowest-ranked birds within the test groups yielded the shortest mean latency, and the top-ranked birds had the longest mean latency), the results were not significant. The lack of a significant rank effect on emergence times contrasts with Katzir's (1982) result that lower-ranking jackdaws emerged first, but is in line with with other studies on domestic fowl, which indicate that "leadership" is not linked with rank (Fischel, 1927; Allee, 1942). Banks and Allee (1957) found no consistent pattern in which flock members entered a pen, and concluded that the highest-ranking bird did not provide leadership for the rest of the group. The lack of a treatment x rank interaction indicates that high, middle and low-ranking birds acted similarly in all three treatments. Thus, a bird's willingness to emerge *was* influenced by feeder position, but not (significantly) by its social rank within a group. The hypothesis that low-ranking individuals should emerge from the box significantly earlier than middle or high-ranking birds was therefore rejected. Dawkins (1985) suggested that birds of different ranks may have alternative behavioural strategies, all of which are equally successful. By following such strategies, low-ranking hens might fare as well as those of higher rank; for instance, subordinate hens might remain near their dominants (despite being displaced from food), as familiar dominants might protect them against other dominants. Therefore, low-ranking hens might not find the presence of higher-ranking birds as aversive as originally thought. Dominant hens might in turn regard subordinates as a resource which they can use to help them find food, and will therefore tolerate their presence.

Experiment 2, which was concerned with the positions of birds in relation to the box and feeders, showed that, in all three treatments, birds were observed most frequently inside the covered box. Nevertheless, birds spent least time inside the box, and most time in both the area immediately outside the box and the area around the outside feeder, when there was a single feeder in the paddock (T2). Having one feeder in both positions (T3) also reduced the amount of time birds spent inside the box, though this was accompanied only by a subsequent increase in the time spent around the outside feeder. Birds spent equivalent amounts of time in the area furthest from the box in all three treatments. This shows that, although birds spent less time inside the box when a feeder was present in the outside area, they were reluctant to move further than the point of the feeder. Placing a single feeder in the outside area (in close proximity to the box) therefore only had a limited effect in increasing birds' use of the outside area.

In Experiment 3, which determined whether dispersing feeders throughout the paddock caused birds to disperse further, having feeders in the outside paddock (T2 and T3) encouraged birds to leave the box earlier (though not to reach two metres earlier), to spend less time inside the box, and to spend more time within two metres of the box (though not more time outwith two metres of the box). Compared to T2, birds did not show greater dispersal (in terms of spending more time in the area furthest from the box) in T3. Placing feeders further from the box (T3), therefore, did not encourage birds to spend more time in the area furthest from the box. This result contrasts with that of Gvaryahu *et al.* (1987), who reported an even distribution of broiler chicks in a novel area which contained familiar objects. Although birds used the feeder nearest the box more often in both T2 and T3, in T3 it was used to the almost total exclusion of the other two feeders. Högstad (1988) found that willow tits, when given a choice of feeding sites at increasing distances from cover, preferred feeding close to cover. Most (95%) of their visits were to the feeder within 3 metres of cover, while the feeders sited 10 metres and 20 metres from cover were never visited. In the present study, hens displayed a clear preference for feeding at the feeder nearest the covered box. This was probably because the box provided the only cover in an otherwise open paddock, and birds may have felt wary about venturing further from the box than was necessary.

In Experiment 4, "familiarised" birds might have been expected to show a greater readiness to enter (and disperse in) the outside area when cones were present, as the familiar cones would have reduced the novelty of the otherwise unfamiliar paddock. Brown (1975) stated that chicks "learn" the characteristics of their home cage, and the degree of discrepancy from the home cage affected chicks' responses in a novel area. The present results showed that "familiarised" birds emerged from the box earlier, used area 1 less, and used area 2 more than the "unfamiliarised" birds, regardless of the treatment used. (There were no differences between familiarised and unfamiliarised birds in the time taken to reach two metres from the box, nor in the number of scans in which birds were seen in area 3). This, together with the absence of any treatment x cones (familiarisation) interaction suggests that having traffic cones in the home pen may have made the "familiarised" birds slightly less fearful of the open paddock (indicated by their shorter latencies to emerge from the box, and a greater proportion of time spent in the outside area), but this was not affected by whether or not cones were actually present in the paddock. Although birds spent least time inside the box when cones were dispersed in the paddock, the lack of familiarisation x treatment interaction suggests that the observed result was not due to prior exposure to the cones. The cones may have provided a measure of 2-dimensional cover in an otherwise open area, thus reducing birds' fear of the outside environment (see Chapter 6).

The lack of familiarisation x treatment interaction contrasts with some previous studies which showed that it is the actual presence of a familiar object in an otherwise unfamiliar environment which is important in reducing an animal's fear or distress in the novel area (Stettner and Tilds, 1966; Jones, 1977b). Other studies, however, have shown that exposure to greater stimulation in the home environment may enhance birds' ability to adapt to novelty, and so reduce birds' fear of a novel area. This reduced fear of novel situations was not dependent on the presence of familiar cues (Jones, 1982). Although most studies have looked at the effects of early environmental enrichment and imprinting on chicks' reaction to novelty, enrichment of the home environment has also been shown to reduce fear levels in novel situations among adult birds (Jones, 1985; Church *et al.*, 1992). This phenomenon of animals from enriched home environments showing less fearful behaviour towards novel stimuli has also been shown in other species, such as pigs (Stolba and Wood-Gush, 1981). The results from the present study suggest that "familiarised" birds are less fearful of the outside area due to increased environmental complexity in the home pen, rather than through forming attachments to the cones.

In conclusion, the results from these four experiments indicate that the presence of familiar objects in an otherwise unfamiliar environment, and a greater complexity of the home environment, can have limited effects on increasing birds' use of the novel area. The presence of functional stimuli (such as feeders) reduced birds' emergence latencies (even though birds had free access to food in their home pens prior to testing), though birds tended not to disperse further than the point of the nearest feeder. Birds which had previously been familiarised to neutral stimuli in their ("enriched") home pens showed slightly greater willingness to use the outside area than those from "non-enriched" pens, regardless of whether these stimuli were present in the outside area. Finally, no relationship was found between "leadership" (in terms of the order of emergence into the paddock) and social rank.

CHAPTER 3: Effects of Regular Handling and Early Exposure to an Outside Area on Fearfulness and Dispersal in Domestic Hens

3.1. Introduction

An animal's early experiences or rearing conditions may affect its behaviour in later life; for example, a greater complexity of rearing conditions may lead to reduced reactions to subsequent environmental change. Animals gradually learn the characteristics of their environment (the "environmental model") which forms the basis for comparisons when the environment changes (Broom, 1969a). The type and magnitude of response to a subsequent novel (or unfamiliar) situation may depend on a variety of factors, such as the nature of the change, the animal's motivational state, the animal's previous experience, and the complexity of the rearing environment. Smaller responses to a novel change were reported in chicks reared with a moving object than by those reared with a stationary object (a less complex environment) (Broom, 1980). Environmental enrichment provides extra stimulation in the home environment, which may lead to the development of a more complex environmental model, thereby enhancing birds' ability to adapt to novelty. Jones (1982) reported that early environmental enrichment (where objects were placed in chicks' home boxes) reduced fearfulness when chicks were placed in fear-inducing situations, demonstrated by increased feeding and activity among "enriched" chicks, compared to those reared in comparatively "barren" home boxes. Similarly, Candland *et al.* (1963) found that socially-isolated chicks which had been reared with objects in their home cages displayed less fear behaviour in a fear-producing situation than chicks reared without objects. Similar findings have been reported in other species, such as pigs (Stolba and Wood-Gush, 1981). In addition to influencing approach and avoidance behaviour, the degree of novelty (or, rather, the degree of discrepancy between the environmental model and the current sensory input) may also be reflected in chicks' calls. Persistent and relatively intense contrast to what is familiar evokes "peeps" or distress calls, whereas moderate contrast evokes "twitters" (Andrew, 1964). Environmental enrichment may also affect birds' growth and physiology. Jones *et al.* (1980), for example, found that environmental enrichment had a growth-stimulating effect on chicks, but had no effect on the plasma concentrations of the growth hormone prolactin.

The rearing environment may influence an animal's behaviour in a second way. An animal which is exposed to a stimulus at an early age, and which shows a positive (following) response to that stimulus at a later age can be said to have formed an attachment or to have "imprinted" onto that stimulus. There may be a "sensitive period" for forming an attachment to a stimulus object. Rubel (1970), for example, reported that early exposure to an imprinting object (5 - 9 hours after hatching) led to a reduction of fear behaviour in chicks when the object was present, and to distress behaviour when the object was absent. Later exposure to the imprinting object (10 - 14 hours after hatching) was ineffectual in reducing fear behaviour. The sensitive period may be brought to an end as birds learn the characteristics of their home environment, and consequently avoid novel objects or areas which do not resemble that environment (Bateson, 1964). However, it has recently been suggested (for example, Bolhuis, 1991) that the reversibility of imprinting (see below) may indicate that the sensitive period may not be as circumscribed as originally envisaged, and that the length of what appears to be a sensitive period may be altered by varying the exposure conditions.

Imprinting or attachment to one stimulus does not necessarily lead to a generalisation of attachment to other stimuli. Jones (1977b), for example, found that when two groups of chicks were reared with two different cues, significantly more chicks first entered the area containing their familiar cue, and spent more time there than in the half containing the unfamiliar cue. Nevertheless, imprinting is more elastic than originally thought, and the preferences of chicks for an imprinting stimulus may be reversed if they are first exposed to an artificial stimulus (such as a coloured box), and later exposed to a more naturalistic stimulus, such as a stuffed jungle fowl (Johnson *et al.*, 1985; Bolhuis and Trooster, 1988). Thus, imprinting in chicks may be influenced by two underlying (and interacting) processes: a learning process in which chicks come to recognise particular objects to which they have previously been exposed, and a developing predisposition resulting in an increasing preference for objects resembling conspecifics. It is possible that this predisposition will serve to guide a young chick to imprint on an appropriate stimulus (such as an adult member of its own species), and that learning processes enable the chick to recognize individuals, such as its own mother (Bolhuis *et al.*, 1985). Where the predisposition is not expressed, preference for a stimulus is determined solely by prior exposure to an object, and even when the predisposition has developed, chicks are still able to learn the characteristics of other (visually conspicuous) objects by being exposed to them (Bolhuis *et al.*, 1989).

Once imprinting has occurred, an animal's behaviour may be influenced by whether the imprinted stimulus is present or absent. Porter *et al.* (1972) found that, when an imprinting object was placed on the far side of a visual cliff, chicks which had previously been exposed to the imprinting stimulus crossed more readily than non-exposed chicks. Furthermore, chicks which had formed an affiliative attachment to an object showed distress behaviour when the object was removed (Zajonc *et al.*, 1974). There was a reduction in distress calls when the imprinting object was reintroduced. The presence of a familiar stimulus in an otherwise unfamiliar environment often reduces an animal's fear of the novel area; for example, Peking ducklings which had been imprinted onto a stimulus object displayed distress behaviour (pacing, peeping, remaining in the corners) in an open field when the object was absent (Stettner and Tilds, 1966). When the object was present, the chicks spent significantly more time in the centre of the pen, and remained close to the object. Therefore, an animal's rearing environment may influence its subsequent behaviour in two ways: by determining the complexity of the environmental model, and by providing stimuli to which the animal becomes imprinted or attached.

The ability of domestic fowl to adapt to their adult housing conditions may depend (in part) on their rearing environment. Several studies have investigated the effects of early husbandry conditions on birds' behaviour in later life, such as nest choice and the incidence of floor laying. It is generally believed that hens prefer dark places in which to lay their eggs, but Wood-Gush and Murphy (1970) found that hens displayed no preference for dark nests unless they had some previous experience of them. Appleby *et al.* (1988) reported that the incidence of floor laying, which may be caused by a failure to learn to perch before point-of-lay, could be reduced by the introduction of perches during rearing. In contrast, early husbandry conditions (such as rearing birds together or apart, in flocks of various sizes) did not appear to affect feeding behaviour in later life, which was influenced more by social attraction and competition at the feeder (Meunier-Salaun and Faure, 1984). Nevertheless, adults' previous housing conditions have been shown to affect their responses in choice tests (Hughes, 1976; Dawkins, 1978).

In addition to environmental enrichment, early regular handling may have long-term effects on animals' production and physiology, and may also affect fearfulness (defined by Jones and Faure (1981b) as "the psychophysiological response to perceived danger"); for example, regularly handled (or "gentled") rats moved into an unfamiliar alley earlier than did non-handled rats (Meyers *et al.*, 1965). The effects of regular handling have been investigated in domestic fowl. Murphy and Duncan (1978), for example, examined the effect of different degrees of human contact during rearing on subsequent reactions of hens towards humans. Birds from two stocks (flighty and docile), with no human contact, both displayed greater withdrawal from humans than birds which had previous contact with humans. (The docile stock showed quick habituation to humans, but avoidance of humans in the flighty stock persisted after 21 days). Regular handling enhanced growth in broiler chicks and (female) layer chicks (Jones and Hughes, 1981). Jones and Faure (1981b) found that regular handling reduced birds' fear of humans (probably through habituation), though it did not reduce general fearfulness. Similarly, regularly handled growers and pullets displayed less avoidance behaviour ("flightiness") than non-handled birds, though this effect declined with age, and was absent in mature hens (Hughes and Black, 1976).

This chapter investigates the effects of both environmental enrichment (regular exposure to an outdoor area) and regular handling on birds' fear levels. There are various methods of estimating an animal's underlying fearfulness. One of the most common fear measures (and the one employed in the present study) is tonic immobility, described by Jones (1986a) as "a catatonic-like state of reduced responsiveness to external stimulation." Tonic immobility (T.I.) is induced by physical restraint, and may represent the terminal reaction in a sequence of anti-predator responses. During predatory attack, T.I. may serve to minimize the stimulation for further attack. Exposure to a hawk model, for example, resulted in prolonged T.I. reactions in hens as the distance between the predator model and the hens was reduced (Gallup *et al.*, 1971). An animal in T.I. is still able to respond to external stimulation, and is able to monitor its chances of escaping predatory attack. Arduino and Gould (1984), for example, manipulated chicks' chances of escape from a predator, and found that the duration of T.I. decreased as the opportunity to escape improved. Similarly, Hennig *et al.* (1976) found that the duration of tonic immobility in anoles (*Anolis carolinensis*) was attenuated if bushes (cover) were present. T.I. is positively related to fear, as the duration of T.I. is prolonged following exposure to fear-enhancing stimuli (such as electric shock, a loud noise, an adrenaline injection, suspension over a visual cliff, warning calls, or the presence of a higher-ranking bird), and reduced following exposure to fear-reducing stimuli (such as the presence of a subordinate conspecific, regular handling, or an injection of tranquilizer) (Gallup, 1979; Jones, 1986b). T.I. is positively correlated with other fear measures, such as the hole-in-the-wall test, the open field test, and reactions to a loud bell (Jones and Mills, 1983). A bird's fear level may be influenced by its home environment. Jones and Faure (1981a), for example, investigated T.I. reactions of caged and penned birds, and found that T.I. was significantly shorter in pen birds. Pens provide a more varied environment, which enables birds to adapt better to novel, additional stimuli. Similarly, birds housed in a top tier of cages (which therefore had restricted visual fields and less stimulation) had significantly longer durations of T.I. than those in the lower two tiers (Jones, 1985). In addition to the physical environment, a bird's social environment may also affect its fearfulness; for example, longer T.I. durations were reported in birds from 17-bird cages than in birds from floor-pens, single cages and 5-bird cages (Kujiyat *et al.*, 1983).

In addition to examining the effects of regular handling and/or exposure to the outside environment on birds' fear levels (as measured by T.I.), this chapter also investigates the effects of the same two factors on subsequent readiness to enter into and disperse in an outdoor area. In many free-range systems, only a low proportion of the flock go out on range (Davison, 1986; Keeling *et al.*, 1988). One possible explanation for this is that birds are not introduced to the free-range house until point-of-lay (at 18-20 weeks of age), so gain no experience of the outside environment during the rearing process (Hughes and Dun, 1982). Hence, this chapter tested the hypothesis that experience of the outside environment in immature birds will increase their readiness to disperse in the available (outdoor) area as adults. Tanaka and Hurnik (1992), in a study comparing the behaviour of hens in cages and in an aviary, expressed the view that birds take time to adapt to a new environment, and should be reared in a similar system to that which they will encounter as adults. Wiepkema (1989), in a C.E.C. Report, stated, "Hens should be reared in such a way that they adequately fit their housing conditions." In the present study, Experiment 1, using a flock of laying hens in a free-range system, tested the T.I. reactions of groups of predominantly "outside" birds (defined as those birds spending more than half the time outside) and predominantly "inside" birds (which were never seen outside). The effects of regular handling and prior exposure to an outside area on T.I. reactions and subsequent dispersal in the outside area were investigated in Experiments 2 and 3, respectively.

3.2. Experiment 1

3.2.1. Materials and methods

A flock of approximately 600 medium hybrid (HISex) laying hens, reared as a single flock from one day old, was housed in a 12 m x 8.5 m polythene tunnel at 18 weeks of age. Observations took place when the birds were 60 weeks old. The stocking density inside the house was about 5.9 birds/m^2. The flock had daytime access to an outside, grass-covered paddock. A sample of 200 birds was wing-tagged to allow identification of individuals. Over a three-day period, the paddock was scanned at 10-minute intervals (between 09.00 and 16.00h each day). A total of 62 scans was made. During each scan, the total number of birds in the paddock was recorded, and the identities of any tagged individuals in the paddock noted. Tagged birds which were seen on range in more than half the scans were classed as "outside" birds; birds which were never seen outside in any scan were classed as "inside" birds. Following these scans, a sample of both "outside" (N=16) and "inside" (N=16) birds were tested for their tonic immobility reactions. "Inside" and "outside" birds were tested alternately. Each bird was tested once only. Each test bird was caught and carried by the experimenter to a 3 m x 8.5 m service unit at one end of the free-range house. Tonic immobility was induced by inverting and placing each bird in a U-shaped cradle. The bird was restrained for fifteen seconds, with one hand on the sternum, the other hand over the head. The following measures were made:

(1) the number of inductions (15-second periods of restraint) necessary to attain T.I., which had to last for a minimum of ten seconds;

(2) the latency to the first alert head movement;

(3) the duration of TI (until the bird righted itself).

If no TI was induced after five attempts, that bird was given zero scores for measures (2) and (3). If, after being induced, there was no response after twenty minutes, the test was terminated, and that bird was given a maximum score of 1200 seconds.

Results displayed non-normal distribution, so were analysed using non-parametric tests (Mann Whitney U-test, two-tailed).

3.2.2. Results

From all 62 scans, the average number of birds seen in the paddock was 88 (i.e. approximately 15% of the whole flock). Of these, tagged birds made up an average of just over 30%. Table 3.1.1. shows the median number of inductions needed to induce T.I., the median latencies to the first alert head movements, and the median righting times for both "outside" (OUT) and "inside" (IN) birds. For each measure, Mann Whitney tests were carried out on the scores of both groups. The results of these tests, shown in Table 3.1.2. show that there was no significant difference between the two groups in either the number of inductions needed, or the latency until the first alert head movement. However, the "outside" birds (i.e. those seen outside on more than half the scans) showed a significantly shorter righting time than "inside" birds (i.e. those not seen outside on any of the scans).

Table 3.1.1. Median number of inductions needed to induce T.I., latencies to the first alert head movements, and righting times for both groups

	Inductions		1st Head Movement (secs)		Righting time (secs)	
	OUT	IN	OUT	IN	OUT	IN
Median	1.50	2.00	32.0	69.5	57.0	160.0

Table 3.1.2. Mann Whitney tests on the scores of each measure (Outside vs Inside birds)

Measure	U (n1, n2)	P
Number of inductions	111.0 (16, 16)	NS
Latency to 1st head movement	81.0 (16, 16)	NS
Righting time	61.5 (16, 16)	$p < 0.05$

3.3. Experiment 2

3.3.1. Materials and methods

Fifty-six HISex medium hybrid females were transferred from 3 rearing cages to 3 indoor floor pens at 8 weeks of age. Food and water were available *ad libitum*. Rearing groups were not mixed during the transfer. The birds were leg-ringed to aid identification. At 12 weeks of age, birds were randomly assigned to treatment groups of 6-7 pen-mates each. (Several deaths occurred over the subsequent eight-week "exposure" period, leading to uneven group sizes at the time of testing). Each pen contained 3 groups, one of which was subjected to each of the following treatments over the subsequent 8-week period:

T1: no handling + no outside exposure (Control);

T2: handling + no outside exposure;

T3: handling + outside exposure.

Therefore, each pen contained one T1 group, one T2 group, and one T3 group. The three T3 groups were exposed to the outside environment on 10 occasions (lasting 30 minutes each) over the first three weeks of the treatment period, followed by 20 occasions (lasting 60 minutes each) over the next five weeks. Thus, T3 birds were exposed to the outside on 30 occasions over the 8-week period, for a total of 25 hours. During an exposure, each group was captured, placed in a holding crate, and transported to the outside where it was released into an outdoor grass-covered paddock (measuring 11 m x 5.5 m). Following the 30 (or 60) minute exposure period, the group was recaptured and returned to its home pen.

While each T3 group was outside, the T2 group from the same pen was captured, placed in a holding crate, and released into an empty floor pen which was similar to the home pen. The T2 group spent the same 30 (or 60) minute period in the empty pen, after which it was recaptured and returned to its home pen. The T1 (Control) birds remained in their home pens, and were not handled during the 8-week period.

At 20 weeks old, Tonic Immobility tests were carried out on all 52 surviving birds. During testing, each bird was caught, carried to an empty room, where T.I. was induced by inverting and placing the bird in a U-shaped cradle. The bird was restrained for 15 seconds, with one hand on the sternum, the other hand over the head. The birds were tested in a randomized order, and each bird was tested only once. In this experiment, only the duration of T.I. (i.e. the time taken for each bird to right itself) was recorded. If no TI was induced after five attempts, that bird was given a zero score. If, after being induced, there was no response after twenty minutes, the test was terminated, and that bird was given a maximum score of 1200 seconds.

As the data did not display a normal distribution (and group size was uneven), non-parametric (Kruskal Wallis and Mann Whitney) tests were carried out on the results.

3.3.2. Results

Table 3.2.1. shows the median righting times for each pen. Analysis of the scores showed that there were no significant differences in righting times between pens (Kruskal Wallis test: $H=1.72$; 2 d.f.; $p > 0.4$). Table 3.2.2 shows the median righting times for each treatment. Analysis of the scores showed differences between treatments tended towards significance (Kruskal Wallis test: $H=5.80$; 2 d.f.; $0.06 > p > 0.05$). Mann Whitney tests were carried out on the medians for each pair of treatments. The results of these tests, shown in Table 3.2.3., indicate that Treatment 3 birds (handled + outside experience) had shorter righting times than Treatment 1 birds (Control). There were no differences between Treatment 1 and Treatment 2 (handled only) birds, or between Treatment 2 and Treatment 3 birds.

Table 3.2.1. Median righting times for each pen

Pen	1	2	3
Time (secs)	224.0 (n=18)	165.0 (n=19)	217.0 (n=15)

Table 3.2.2. Median righting times for each treatment

Treatment	1	2	3
Time (secs)	224.5 (n=18)	206.0 (n=16)	96.0 (n=18)

Table 3.2.3. Mann Whitney tests for each treatment pair

	U (n1, n2)	P
T1 vs. T2	134.0 (18, 16)	NS
T1 vs. T3	83.5 (18, 18)	$p < 0.05$
T2 vs. T3	100.5 (16, 18)	NS

3.4. Experiment 3

3.4.1. Materials and methods

The subjects used were the same birds used in Experiment 2. In this experiment, birds' emergence and dispersal behaviour were tested in the same outdoor paddock to which the T3 groups had been exposed. Testing began two days after the T.I. tests were completed. Each indoor pen contained a covered box (0.9 m x 0.9 m x 0.9 m), which was present when the birds were moved into the pens, so all birds became familiarised to these boxes. Within each pen, 4 birds from each treatment (Control, handled only, handled plus outside experience) were randomly assigned to test groups. During testing, each (test) group was transported to the outside paddock in a holding crate and placed in a similar covered box (which was placed in one corner of the paddock) with the door closed, where it was left to acclimatise for 2 minutes. The 9 groups were tested in a randomised order, and the following measures were recorded:

(a) the latencies of each (test) bird to leave the box (once the box door was raised), and to reach 2 metres from the box. If a bird had not emerged (or reached two metres from the box door) within sixty minutes of the box door being raised, the test was terminated, and that bird given a score of 3600 seconds;

(b) the area in which each (test) bird was seen, scanning every 30 seconds over a 60-minute period.

Areas: 1 = inside the box;
2 = within two metres of the box door;
3 = outwith two metres of the box door.

To permit log-transformations to be carried out, 1 was added to each total to allow for zero-scores. Thus, in each trial, the total number of scans per bird was 123. To determine whether the number of scans in which birds were observed in each area varied with treatment, each area was analysed separately. (Given that an increase in the use of one area will automatically result in a decrease in the use of the other two areas, it is recognised that the data are not independent).

Two-way analyses of variance for the emergence times, the latencies to reach 2 metres, and the scans from areas 1 and 3, were carried out on log-transformed data. The raw data had a skewed variation; log-transformation produced a more normal distribution and homogeneity of variance. The results from area 2 were more normally distributed, allowing analysis of the untransformed data.

3.4.2. Results

3.4.2.a. *Latencies to emerge and reach two metres from the box*

Table 3.3.1. shows the mean times to emerge from the box and to reach two metres from the box door in each treatment, with log-transformed data in brackets. Analysis of variance of the (log-transformed) treatment means showed that the treatment used had a significant effect on the time taken to emerge from the box (F=208.4; 2, 90 d.f.; $p < 0.001$). To clarify which treatment or treatments had an effect, t-tests were carried out on the (log) means for each pair of treatments. The results of these tests, shown in Table 3.3.2. indicate that, compared to T1 birds (Control), T2 birds (handled only) emerged significantly earlier. T3 birds (handled + outside experience) emerged significantly earlier than the other two groups.

A significant analysis of variance of the (log-transformed) treatment means showed that the treatment used had an effect on the time taken to reach two metres from the box (F=152.8; 2, 90 d.f.; $p < 0.001$). As before, t-tests were carried out on the (log) means for each pair of treatments (Table 3.3.3.). This table shows that T3 birds reached two metres significantly earlier than birds in the other two treatments. There was no significant difference between T1 birds and T2 birds.

(Figures 3.3.a. and 3.3.b. show the treatment effect on times taken to emerge and to reach 2 metres from the box door).

Table 3.3.1. Mean times to emerge and reach 2 metres in each treatment (secs) (log-transformed data in brackets)

Treatment	T1	T2	T3	ANOVA
Emerge	2785 (7.22)	1909 (6.61)	38 (3.17)	$p < 0.001$
2 metres	2850 (7.58)	2590 (7.63)	274 (4.96)	$p < 0.001$

Table 3.3.2. t-tests on means of (log) emergence times under each treatment

	$\underline{t}$	d.f.	P	
T1 vs. T2	2.853	90	$p < 0.01$	(T2 < T1)
T1 vs. T3	18.935	90	$p < 0.001$	(T3 < T1)
T2 vs. T3	16.081	90	$p < 0.001$	(T3 < T2)

Table 3.3.3. t-tests on means of (log) time to reach two metres under each treatment

	$\underline{t}$	d.f.	P	
T1 vs. T2	0.257	90	NS	
T1 vs. T3	15.009	90	$p < 0.001$	(T3 < T1)
T2 vs. T3	15.266	90	$p < 0.001$	(T3 < T2)

Fig. 3.3.a. Treatment effect on (log) emergence time (mean + s.e.)

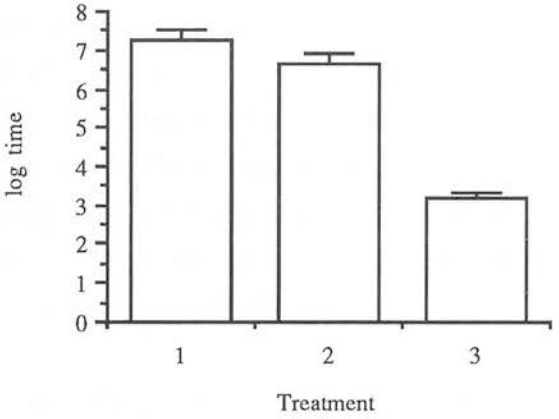
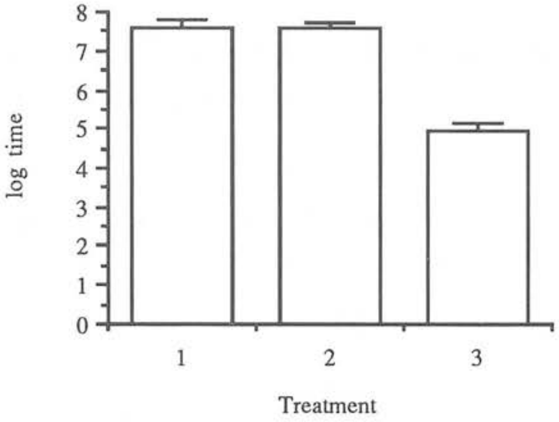


Fig. 3.3.b. Treatment effect on (log) time to reach 2 metres from the box (mean + s.e.)



3.4.2.b. *Distribution of birds in each area*

Table 3.3.4. shows the mean number of scans in which birds were seen in areas 1, 2 and 3 in each treatment, with log-transformed data in brackets. Analysis of variance of the (log) treatment means showed that the treatment used had a significant effect on the number of scans in which birds were seen in area 1 (F=114.1; 2, 90 d.f.; $p < 0.001$). To clarify which treatment or treatments had an effect, t-tests were carried out on the (log-transformed) means for each pair of treatments (Table 3.3.5.). These results show that T3 birds spent significantly less time inside the box (area 1) than birds from either of the other treatments. There was no significant difference between T1 birds and T2 birds.

A significant analysis of variance of the treatment means showed that the treatment used had an effect on the number of scans in which birds were seen in area 2 (F=29.72; 2, 90 d.f.; $p < 0.001$). As before, t-tests were carried out on the means for each pair of treatments. These results, shown in Table 3.3.6., indicate that T3 birds spent significantly more time in area 2 (in the paddock, within two metres of the box door) than birds from either of the other treatments. There was no significant difference between T1 birds and T2 birds.

Analysis of variance of the (log) treatment means showed that the treatment used had a significant effect on the number of scans in which birds were observed in area 3 (F=161.6; 2, 90 d.f.; $p < 0.001$). As before, t-tests were carried out on the (log-transformed data) means for each pair of treatment (Table 3.3.7.). T3 birds spent significantly more time in area 3 (outwith two metres of the box) than birds from either of the other treatments. There was no significant difference between T1 birds and T2 birds. (Figures 3.3.a., 3.3.b. and 3.3.c. show the treatment effect on the number of scans in which birds were observed in each area).

Table 3.3.4. Mean number of scans in which birds were observed in each area in each treatment (log-transformed data in brackets)

Treatment	T1	T2	T3	ANOVA
Area 1	103.2	94.1	18.1	
	(4.487)	(4.399)	(2.038)	$p < 0.001$
Area 2	14.5	23.0	47.4	$p < 0.001$
Area 3	5.3	5.9	57.5	
	(0.655)	(0.905)	(3.833)	$p < 0.001$

Table 3.3.5. t-tests on means of the number of scans in which birds were seen in area 1

	t	d.f.	P	
T1 vs. T2	0.479	90	NS	
T1 vs. T3	13.317	90	$p < 0.001$	(T3 < T1)
T2 vs. T3	12.838	90	$p < 0.001$	(T3 < T2)

Table 3.3.6. t-tests on means of the number of scans in which birds were seen in area 2

	t	d.f.	P	
T1 vs. T2	1.919	90	NS	
T1 vs. T3	7.427	90	$p < 0.001$	(T1 < T3)
T2 vs. T3	5.508	90	$p < 0.001$	(T2 < T3)

Table 3.3.7. t-tests on means of the (log) number of scans in which birds were seen in area 3

	t	d.f.	P	
T1 vs. T2	1.272	90	NS	
T1 vs. T3	16.165	90	$p < 0.001$	(T1 < T3)
T2 vs. T3	14.893	90	$p < 0.001$	(T2 < T3)

Fig. 3.3.a. Treatment effect on (log) no. of scans in which birds were seen in area 1 (mean + s.e.)

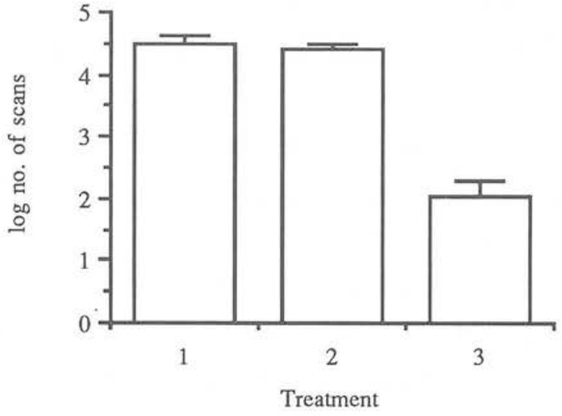


Fig. 3.3.b. Treatment effect on number of scans in which birds were seen in area 2 (mean + s.e.)

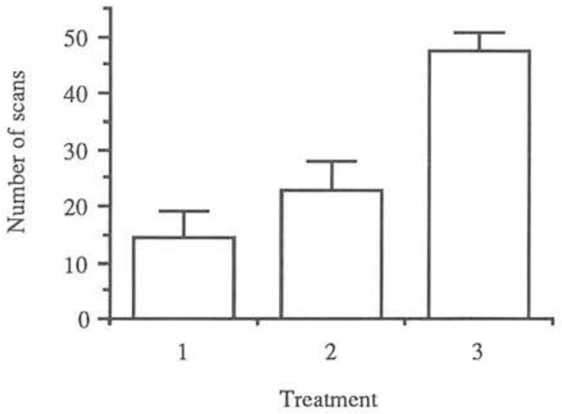
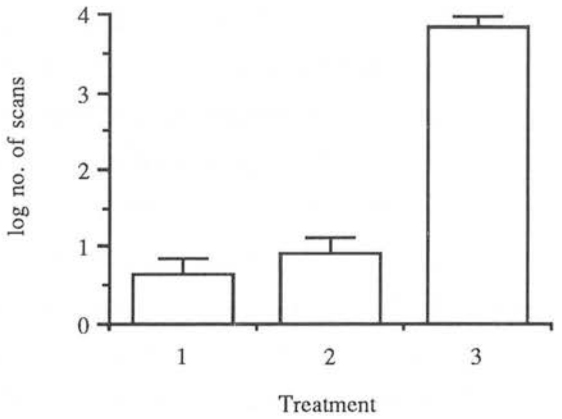


Fig. 3.3.c. Treatment effect on (log) no. of scans in which birds were seen in area 3 (mean + s.e.)



3.5. Discussion

The result from Experiment 1 showed that birds which were seen in the paddock in more than half the scans had a lower underlying fearfulness (as measured by tonic immobility) than birds which were never seen in the paddock. This may have been because the former were exposed to a wider variety of stimuli in the outside paddock, so were less fearful of novel stimuli. Alternatively, the observed lower underlying fearfulness in outside birds may have been the reason why these birds went outside in the first place, as they may have been less fearful of the open or novel environment. Previous studies with domestic fowl (Jones and Faure, 1981a; Jones, 1985), which showed that birds exposed to a wider variety of stimuli have lower fear levels, would tend to support the former explanation. This phenomenon has also been observed in other species; for example, beef calves from restricted (barren) housing were more highly motivated to display fear responses to a novel stimulus in an unfamiliar area than calves from loose (enriched) housing (McKay and Wood-Gush, 1980). Similarly, pigs from impoverished environments displayed stronger reactions (such as intense exploratory behaviour) towards a novel stimulus than did pigs from enriched environments (Stolba and Wood-Gush, 1980).

The results from Experiment 2 provide support for the theory that exposure to an outside area, which could be regarded as a form of environmental enrichment, reduces fear. In addition to having reduced fear levels (as measured by tonic immobility "righting times"), in Experiment 3, Treatment 3 birds emerged from the box into the paddock and reached two metres earlier, spent less time inside the box and more time in areas 2 and 3 than either "handled-only" or control birds. As well as reducing fear levels by providing a more complex environment (with a wider variety of stimuli), repeated exposure to a novel environment reduces an animal's fear responses in that environment. Jones (1977a) reported significant decreases in fear responses among chicks in an Open Field test as the chicks' experience in the novel area increased. Similarly, Murphy (1976) stated that birds' reactions to novel stimuli (such as an unfamiliar environment) are related to the degree of novelty associated with such stimuli. Extreme or intense novelty evokes fear reactions, whereas a moderate amount of novelty leads to exploration. Broom (1969b) stated that an animal's reaction to a novel experience is related to the degree of novelty, and reaction to a change is greater the longer the "environmental model" has had to become established. In chicks, the closer the resemblance between the home (rearing) environment and a novel (test) environment, the shorter the avoidance period and the shorter the latency to the first positive response (Bateson, 1964). Similarly, Seitz *et al.* (1973) reported that chicks' behaviour in a normally aversive situation may be modified by manipulating the rearing environment. Chicks, which normally show strong avoidance of the deep side of a "visual cliff," displayed a clear preference for the deep side after only 4 days' exposure. In the present study, Treatment 3 birds, which had previously been regularly exposed to the outside area, displayed little or no fear of that area. (The mean emergence time for these birds was around 38 seconds, they were seen outside the box on more than 85% of the scans, and area 3 was occupied most frequently). Thus, regular exposure to an outside area in relatively mature birds (exposure period = 12-20 weeks of age) greatly reduced birds' fear of that area.

Regular handling alone did not significantly reduce T2 birds' fear levels (as measured by tonic immobility) compared to T1 (Control) birds, and although it increased birds' willingness to use the (unfamiliar) outside area, the effect was relatively slight. "Handled-only" birds emerged from the box earlier than control birds, but there was no significant difference between the two groups in the time taken to reach two metres, or in the amount of time spent in each of the three areas. Jones and Waddington (1992) reported that early environmental enrichment significantly reduced fear levels among chicks (measured by an array of tests, including tonic immobility), whereas regular handling alone had only limited effects, and had no additional fear-reducing effect when used in conjunction with environmental enrichment. In the present study, the experimenter regularly entered the birds' home pens in order to catch and transfer birds either to the outside paddock (T3), or to the empty pen (T2). Control birds would therefore have had considerable experience of the experimenter's presence. This may have reduced birds' fear levels to a certain level, and actual handling had little extra effect. Thus, both Treatment 1 (Control) birds and Treatment 2 (handled only) birds, in addition to displaying similar T.I. reactions, showed a similar reluctance to disperse in the paddock (compared to Treatment 3 birds), as neither group had received any prior exposure to the outside area before testing.

In conclusion, the results from this study indicate that regular exposure to the outside environment during the rearing process can affect birds' readiness to move outside and disperse in an outdoor area. This was achieved even though the total exposure period was only 25 hours, and subjects were not introduced to the paddock until the (relatively) mature age of 12 weeks old. Thus, the hypothesis that experience of the outside environment in maturing birds increases their readiness to enter into and disperse in an outdoor area as adults was confirmed. Repeated exposure to an outside area also reduced birds' fear levels to a greater degree than did regular handling alone. These results are in accord with studies which suggest that increasing the complexity of a rearing environment reduces fearfulness, and enhances birds' ability to adapt to novelty. Compared to Control birds, however, regular handling alone had little effect on either T.I. duration, or on birds' dispersal in an outdoor area.

CHAPTER 4: Social Inhibition of Movement in Domestic Hens

4.1. Introduction

In flocks of domestic fowl, there is often a wide variation in individuals' use of available area, with some birds restricting themselves to certain parts of the house, but others ranging widely (Appleby *et al.*, 1989). Individual variation in movement may be influenced by a variety of factors, such as strain of bird, stocking density, localisation of facilities, and aggressive interactions between individual birds. A home range was defined by Jewell (1966) as "the area over which an animal normally travels in pursuit of its routine activities." Furthermore, a core area was defined as "a particular part of the home range used more frequently, and with more regularity, than other such parts". Movement of individuals in flocks of domestic fowl, and the possible existence of such home ranges, have been investigated in various studies. Hughes *et al.* (1974), using a docile strain (Shaver 288) and a low level of illumination, reported a wide range of individual movements among tagged birds (with some areas favoured over time), though most birds were sighted in all available areas. Appleby *et al.* (1985, 1988a) observed that movement of individuals in a deep-litter house was constrained by crowding, as time spent in locomotion decreased with increasing stocking density. Birds in a covered strawyard displayed a non-random distribution due to the heterogeneity of the strawyard environment (Gibson and Dun, 1985). Craig and Guhl (1969) found that, in large flocks, selected birds spent disproportionate amounts of time in specific areas of the house. This was related to social status, with individuals occupying higher ranks in the areas they used most frequently; thus, "pecking pressure" may have restricted an individual's area of movement. A relationship between movement and aggression has also been reported in broilers. Preston *et al.* (1983) found that increased bird density and decreased space available for movement led to a decline in aggression in the last two weeks of growth. In addition to the above, other factors, such as an element of competition, may also influence spatial organization. Lill (1968) found that spatial distribution was activity-dependent; for example, no clear-cut or constant minimal approach distance was found among individuals when feeding (a non-competitive situation). Similarly, Meunier-Salaun and Faure (1984) found that aggression among hens was unaffected by the distance between feeding positions.

A number of studies have reported that an individual's area of movement may be restricted by the social influence exerted by other birds, and that high-ranking birds may have greater freedom of movement in the available area. Gibson *et al.* (1986a), for example, found that low-ranking birds in a strawyard system had restricted areas of movement, as well as reduced bodyweight and poor feather cover. (In contrast, van Enckevort (1965) found that birds with restricted areas of movement tended to be high-ranking individuals). During the formation of the peck-order, birds learn to peck or displace their subordinates and to avoid their dominants. Birds can discriminate between lower and higher-ranking birds, and may be unwilling to pass or approach higher-ranking individuals. Murchison (1935a) tested birds in a "Social Reflex" runway, in which birds of differing ranks were placed at either end, and released into the runway. Results showed that the higher-ranking bird moved further along the runway than the subordinate of the pair. In a subsequent experiment, an individual bird was released into an area containing two caged males. The test bird's choice in favour of one of the caged birds was shown by moving towards and remaining close to one or the other caged birds. Male test birds frequently chose the lower-ranking caged bird, while females chose the dominant of the pair (Murchison, 1935b). Syme *et al.* (1983) showed that when birds in a competitive feeding situation were given a simultaneous choice between a dominant or a subordinate bird, there was a significant tendency for birds to avoid the higher-ranking bird. Similarly, Wiley and Hartnett (1980), in a study on juncos (*Junco hyemalis*), found that subordinate birds were unlikely to approach their dominants when the feeding sites were close together. This apparent reluctance to approach a dominant bird may be overcome by manipulating an individual's motivation. Individual birds were reluctant to approach a tethered dominant in order to obtain food, but the approach distance reduced to zero following three hours' food-deprivation (King, 1965). Using groups of three birds, Keeling and Duncan (1989) found that when there was sufficient pen space to allow dominance-subordinance relationships to influence inter-individual distances, dominant birds monopolised the centre of the pen (the "preferred" area), and distances between pairs of birds were greatest when one of the pair was the highest-ranking individual. This relationship between rank and use of space has also been reported in other species. In a study on pigs, for example, McCort and Graves (1982) found that, compared to dominant animals, subordinate individuals showed a greater tendency to face away from their nearest neighbour, and pigs tended to space further from high-ranking individuals than from lower-ranking pigs. A further example of hens finding the close presence of higher-ranking individuals aversive is provided by Jones (1986a), who reported that birds had longer durations of tonic immobility (an indication of higher underlying fearfulness) in the presence of dominant birds. As well as having greater freedom of movement, high-ranking birds may also gain priority of access to resources. Mankovich and Banks (1982) reported differential use of areas by individuals, with high-ranking birds frequently beside the food dispenser, and the lowest-ranking individuals spending most time on the perch, which served as a refuge.

In addition to avoiding high-ranking birds, an individual might also choose to avoid meeting unfamiliar birds, since, as previous studies have indicated, encountering strangers often leads to an increase in agonistic activity, and to signs of physiological stress. During a first meeting, a pair of birds will often fight to establish a dominance-subordinance relationship. Frequent meetings reinforce recognition, and once the relationship becomes established, overt aggressive acts are replaced by threats or rituals. Physical separation for 2-3 weeks results in a loss of recognition, and birds fight to re-establish the relationship (Maier, 1964). The head and comb region plays an important role in recognition, and comb size may be a major factor determining success in initial encounters between birds (Collias, 1943; Guhl and Ortman, 1953). Dubbing (removal of the comb and wattle) is now uncommon; however, when practised, it often led to a loss of recognition. Marks *et al.* (1960) looked at dubbed and undubbed birds in large and small flocks. In large groups, dubbed birds were significantly more likely to be subordinate to undubbed birds, and there were more agonistic encounters among dubbed birds than among undubbed birds. In small flocks, in which some birds were dubbed and returned to the flock, there was a consistent trend for dubbed birds to shift to lower positions in the hierarchy. In addition, top-ranking individuals were always undubbed birds. Similar findings were reported by Siegel and Hurst (1962), which suggests that recognition is more difficult among dubbed birds. As well as aiding recognition, a bird's head also acts as a social force on its neighbours. McBride *et al.* (1963) found that birds maintained their heads at regular (non-random) spacing, and orientated them to avoid the frontal aspects of other birds. A social group was defined by McBride (1964a) as "a unit of lowered intraspecific aggression, which requires recognition of others". The level of overt aggression in a small stable flock decreases in time as each bird learns its relationship with all other individuals, and a hierarchy or peck-order is formed (which may or may not be linear). In experimentally established unstable flocks, however, with regular changes in flock membership, a high level of aggressive activity persists (Craig *et al.*, 1969; O'Keefe *et al.*, 1988). There is a limit to the number of individuals any one bird can remember. Guhl (1953) reported a peck-order among 96 birds, though many dominance-subordinance relationships were unresolved. Douglis (1948) found that it was possible for hens to recognise and react to 27 other hens, though this may not be the upper limit. McBride and Foenander (1962) stated that, in large indoor flocks, birds were unable to remember all other individuals, and suggested that they might have avoided meeting strangers by "territorial" behaviour, which restricted their areas of movement. Al-Rawi and Craig (1975) found that agonistic interactions were more frequent in larger flocks, as birds have more difficulty in recognising flock-mates in large flocks. In addition to increased aggression, frequently encountering strangers may lead to physiological stress. Constant stimulation of the pituitary-adrenal axis leads to an increase in adrenal gland weight, and the left adrenal glands of single males placed in a new group were significantly heavier than those remaining in their own flocks (Siegel and Siegel, 1961). Candland *et al.* (1969) reported a large increase in heart rate when birds were first exposed visually to one another. There was an increase in plasma corticosterone levels seven days after flocks of cockerels were assembled, due to the high frequency of agonistic interactions among strange birds during the formation of dominance relationships (Williams *et al.*, 1977). As social strife was replaced by social inertia (as dominance-subordinance relationships became established), and the level of overt aggression decreased, there was a reduction in plasma corticosterone levels.

Given that an individual bird may be unwilling to approach higher-ranking or unfamiliar birds, it is possible that, in large flocks, "pecking pressure" may limit birds' movements to certain areas of the house (Craig and Adams, 1984). This theory might explain why, in many flocks of free-range domestic fowl, a large proportion of birds rarely, if ever, leaves the house (Davison, 1986; Keeling *et al.*, 1988), and, as flock size increases, the proportion of hens out on range decreases. As flock size increases, the number of unfamiliar birds which an individual has to pass in order to move round the house (and reach a pop-hole) increases. The Farm Animal Welfare Council, in its report on colony systems, recommended that 'research should be conducted into the conditions which minimise aggression and maintain social stability within the colony, and which allow all hens, including subordinate birds, to move freely between resources" (F.A.W.C., 1991). This chapter presents a series of experiments which investigated the theory that individual birds may restrict their areas of movement in order to minimise the number of higher-ranking and/or unfamiliar birds encountered. Experiments 1 and 2 were studies of individual birds' movements under controlled conditions; Experiment 3 was a series of observations of focal birds in a large free-range flock.

Experiment 1 examined the time taken by individual birds to move down a runway (and pass a second bird) in order to reach a "preferred area" (a large cage containing shavings, food and water). The second bird was of higher rank, lower rank, or unfamiliar to the first bird. Experiment 2 varied the number of unfamiliar birds which an individual had to pass in order reach the preferred area, and recorded not only the time taken to reach the large cage, but also the reaction of the test bird towards the unfamiliar birds. Experiment 3 involved monitoring the short-term movements of individual birds in a free-range house to examine the possibility that birds restricted themselves to certain areas of the house, and to what extent this restriction was influenced by "pecking pressure." This final study also investigated the possibility that high-ranking (or aggressive) hens situated near the pop-holes might inhibit the movement of other birds in and out of the house.

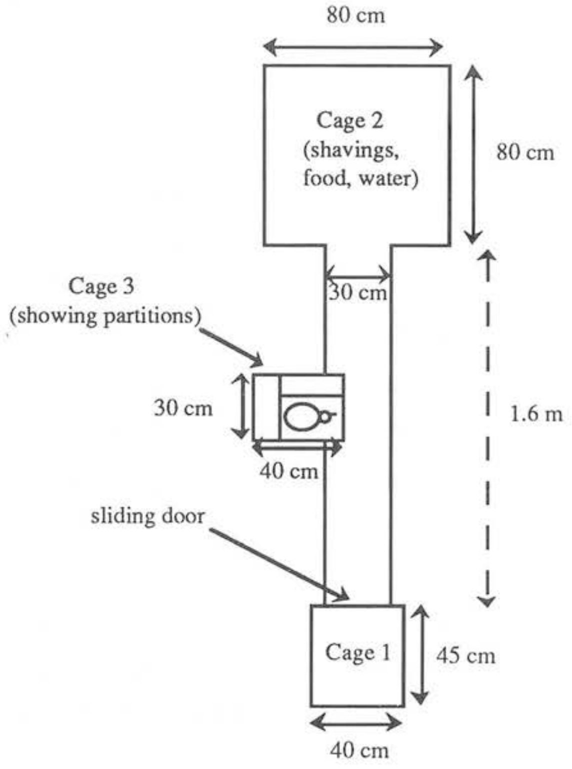
4.2. Experiment 1

4.2.1. Materials and methods

Nineteen 40-week-old ISA Brown medium hybrid laying hens were removed from single cages and assigned to 3 floor pens (A, B, C), each pen measuring 2.4 m x 2.4 m. Pen A contained 7 birds, Pen B 5 birds, and Pen C 7 birds. The birds were leg-ringed to aid identification. Observations on agonistic interactions began one week after the birds were moved into the pens. An aggressive interaction was counted when one bird pecked, chased, threatened or displaced another. About 60 hours of observation were made over a 6-week period. A total of 1612 aggressive interactions were observed during this time. The winner and loser of each interaction were noted. Dominance-subordinance hierarchies were determined for each pen, and each bird was assigned a social rank.

In the training and test situations, a bird was placed in a small (40 cm x 45 cm) wire cage (cage 1), from which it moved along a wire-mesh runway (1.6 metres long) and into a larger (80 cm x 80 cm) wire cage (cage 2) which contained shavings, food and water (Figure 4.1.). There was a third cage (cage 3) midway down the runway which protruded approximately 10 cm into the runway. A Perspex sliding door divided cage 1 from the runway. The bird could only move from cage 1 into the runway once the sliding door was raised by the experimenter.

Fig. 4.1. : Plan view of apparatus (Experiment 1)



Prior to formal training, birds were allowed to become accustomed to the apparatus in pairs. (Birds placed in a novel environment tend to be less fearful if a familiar conspecific is present). Pairs of pen-mates (which had not been food-deprived) were transported in a holding crate to cage 1. The sliding door was then raised. If the birds had not moved in 20 minutes, they were gently touched with a metal pole until they moved into cage 2, where they were left to feed for 5 minutes. Each bird was given 2 practice sessions, with a different companion bird being used on each occasion. Following this preliminary practice, each bird was trained in a more formal manner. Training took place in the afternoon to reduce the possibility of the birds' responses being affected by egg-laying behaviour. In addition, birds were palpated prior to training to ensure that they were not about to lay. Birds were food-deprived for 4.5 - 5 hours before training. During training, each bird was removed from its home pen and placed in cage 1, where it was left undisturbed for 60 seconds. The sliding door was then raised by means of a string pulley which ran into the corridor outside the test room, thus allowing it to be raised remotely by the experimenter. A video camera mounted in one corner of the room allowed the bird's movements to be monitored and recorded. Each bird was trained separately and was given 4 training trials each (on separate days). The time taken for each bird to move from cage 1 to cage 2 (once the sliding door was raised) was recorded. Once a bird had reached cage 2, it was allowed to feed for 5 minutes, after which it was returned to its home pen.

Once all birds were trained, they were tested in a randomised order in each of the following treatments:

T1: cage 3 empty (control);
T2: cage 3 bird of lower rank than test bird;
T3: cage 3 bird of higher rank than test bird;
T4: cage 3 bird unknown to test bird.

The protocol was similar to the training procedure. The test bird and the cage 3 bird were transported separately to their respective cages (having been palpated to ensure they were not about to lay), the test bird being moved first. Recognition among domestic fowl is largely based on features of the head and neck region (Guhl and Ortman, 1953; Siegel and Hurst, 1962; Wilson, 1974), and a bird's head may exert a social force on its neighbours (McBride *et al.*, 1963). In order that the test bird could see the caged bird's head and neck, partitions were placed in cage 3 so that the middle bird was restricted to the corner of cage 3 which was nearest cage 1, with its head perpendicular to that of the test bird. The birds were then left for 60 seconds before the sliding door was raised.

As it was impossible to test the lowest ranking bird in each pen under T2, and the highest ranking under T3, only the middle-ranking birds in each pen could be tested under each of the four treatments. Apart from this restriction, each bird was given 2 replications of each treatment. As far as possible, the cage 3 bird was selected at random from those of lower rank to the test bird under T2, those of higher rank under T3, and from a different pen under T4. In addition, different cage 3 birds were used in the first and second trials in Treatments 2, 3 and 4 (as far as possible). If a test bird had not emerged within 20 minutes of the sliding door being raised, the test was terminated and that bird given the maximum score of 1200 seconds. The order in which each bird received the four treatments was randomised.

The raw data had a skewed variation, so analysis was carried out on log-transformed data. Log-transformation produced a more normal distribution and homogeneity of variance.

4.2.2. Results

Table 4.1.1. shows the mean times taken to enter cage 2 for each replication, pen and treatment, with log-transformed data in brackets. The ANOVA table (Table 4.1.2.) shows that there was a significant reduction in time taken to enter cage 2 in the second series of trials, and there were no significant differences between the three pens, so it did not matter which pen a bird came from. Analysis of variance of the treatment means showed that the treatment used had an effect on the time taken to enter cage 2. To clarify which treatment or treatments had an effect, t-tests were carried out on the (log-transformed) means for each pair of treatments (Table 4.1.3.). Compared to the Control (cage 3 empty), there was no significant difference (in the time taken to enter cage 2) when cage 3 contained a subordinate bird, but having either a higher-ranking bird or an unfamiliar bird in the middle cage significantly increased the time taken to enter cage 2. There was no significant difference between having a subordinate or a dominant bird in cage 3. Having an unfamiliar bird in cage 3 resulted in a significantly longer time taken to enter cage 2 than in any other treatment. (Figure 4.1.a. shows the treatment effect on time taken to enter cage 2).

Table 4.1.1. Mean times to enter cage 2 for each replication, pen and treatment (secs) (log-transformed data in brackets).

Replication	1	2		
Mean Time (secs)	85.2 (3.257)	27.9 (2.925)		
Pen	1	2	3	
Mean Time (secs)	60.4 (3.145)	63.7 (3.047)	38.3 (3.075)	
Treatment	1 (Control)	2 (Sub)	3 (Dom)	4. (Unfam)
Mean Time (secs)	14.8 (2.608)	18.2 (2.793)	45.7 (3.145)	147.6 (3.810)

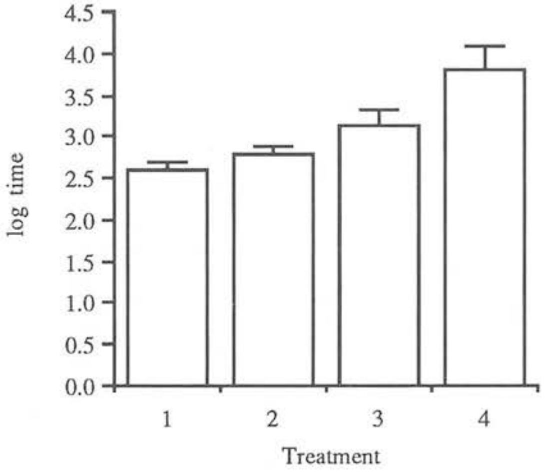
Table 4.1.2. Analysis of Variance (log transformation on raw data).

Source	d.f.	S.S.	M.S.	F	P
Pen	2	0.199	0.100	0.04	NS
Residual	10	26.334	2.633	4.45	
Replication	1	2.858	2.858	4.83	$p < 0.05$
Treatment	3	21.887	7.296	12.34	$p < 0.001$
Pen x Replication	3	2.086	1.043	1.76	NS
Pen x Treat	6	1.334	0.222	0.67	NS
Pen x Replication x Treatment	6	3.531	0.588	1.00	NS
Residual	70	41.385			

Table 4.1.3. t-tests on the (log-transformed) treatment means

Treatments	t	d.f.	P	
T1 vs. T2	0.867	70	NS	
T1 vs. T3	2.522	70	$p < 0.05$	(T1 < T3)
T1 vs. T4	5.635	70	$p < 0.001$	(T1 < T4)
T2 vs. T3	1.655	70	NS	
T2 vs. T4	3.113	70	$p < 0.01$	(T2 < T4)
T3 vs. T4	4.768	70	$p < 0.001$	(T3 < T4)

Fig. 4.1.a. Treatment effect on time to enter cage 2 (mean + s.e.)



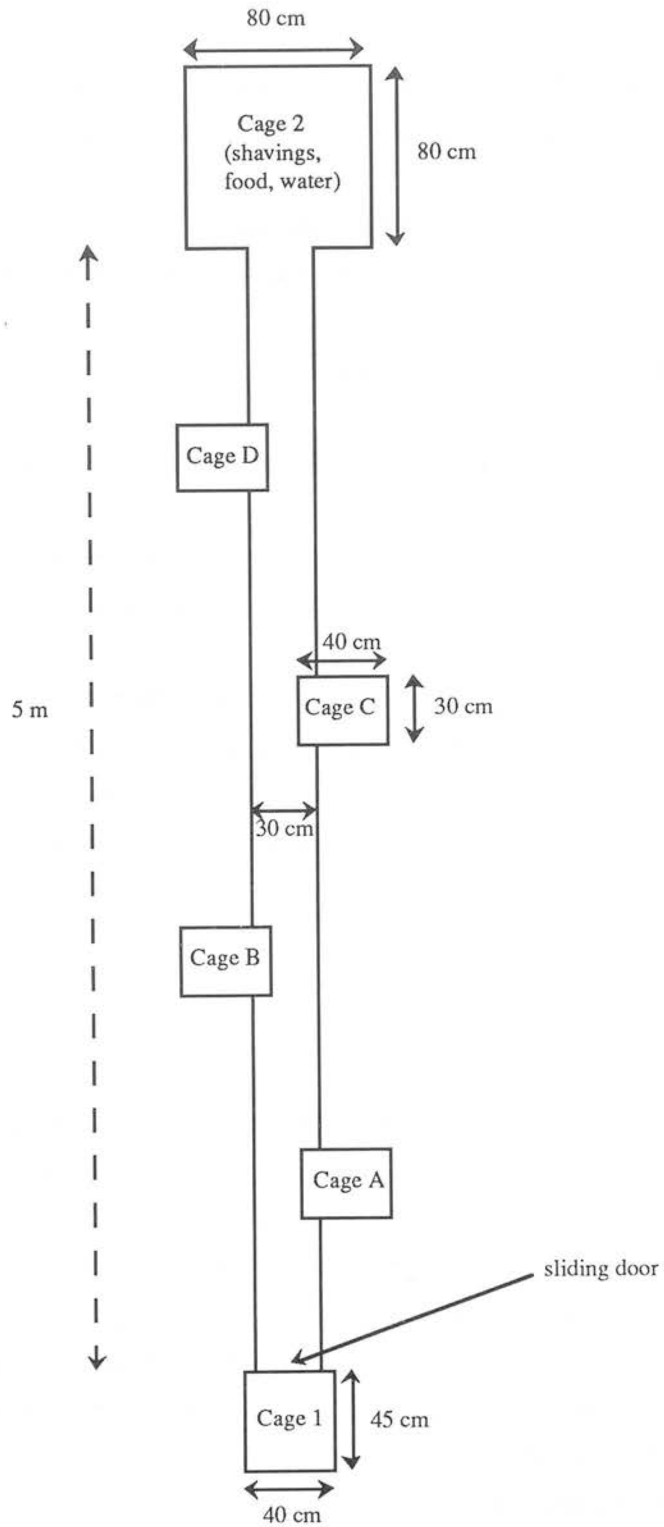
4.3. Experiment 2

4.3.1. Materials and methods

The subjects were twenty-four 28-week-old ISA Brown medium hybrid females, housed in single cages since 18 weeks old. In this experiment, a longer runway (5 metres) was used, with four middle cages between cage 1 and cage 2 (Figure 4.2.). Birds were trained to move along the runway, using the same method as that used in Experiment 1. Once all birds were trained, they were tested in a randomised order under each of the following treatments:

T0: no middle cage birds (Control)
T2: 2 " " " (two middle cages occupied)
T4: 4 " " " (all four middle cages occupied).

Fig. 4.2. : Plan view of apparatus (Experiment 2)



In half the Treatment 2 trials, cages B and C were occupied; in the other half, A and D were occupied. The same food deprivation as before was used, and each bird was tested twice under each treatment. To ensure that each test bird was unfamiliar to every middle (caged) bird, birds from neighbouring home cages were not used in the same trial, and, for each test bird, different middle birds were used in each replication. The following were recorded:

(a) time taken for each test bird to enter cage 2 once the sliding door was raised;

(b) reactions of the test bird to each middle cage bird. These were categorised as follows:

Aggression (A): the test bird stopped and attempted to peck the caged bird through the cage wire;

Hesitation (H): the test bird paused before moving past the caged bird, or turned and walked back towards cage 1;

No Reaction (NR): the test bird moved past the caged bird without showing any hesitation, and did not interact with the caged bird.

If a bird had not entered cage 2 within 30 minutes of the sliding door being raised, the test was terminated and that bird given the maximum score of 1800 seconds. The raw data had a skewed variation, so analysis was carried out on log-transformed data, which produced a more normal distribution and homogeneity of variance.

4.3.2. Results

4.3.2.a. *Time to enter cage 2*

Table 4.2.1. shows the mean times taken to enter cage 2 for each replication, treatment and replication x treatment interaction, with log-transformed data in brackets. The ANOVA table (Table 4.2.2.) revealed a significant replication x treatment interaction, indicating that the differences between treatments were not constant over both sets of replications. To investigate whether there was a significant reduction in moving time on the second replication for each treatment, t-tests were carried out on the means of both replications within each treatment. The results of these tests, shown in Table 4.2.3., indicate that birds showed a significant reduction in moving time only in Treatments 2 and 4. T-tests were also carried out on each pair of treatment means within each replication set. The results, shown in Table 4.2.4., show that there were significant differences (in the time taken to reach cage 2) between each pair of treatments in the first set of replications (T0 < T2 < T4). Birds also moved

significantly quicker in T0 than in T2 or T4 in the second set of replications, but there was no significant difference between T2 and T4 on the second set of replications. (Figure 4.2.a. shows the replication x treatment interaction on the time taken to enter cage 2).

Table 4.2.1. Mean times to enter time to enter cage 2 for each replication, treatment and replication x treatment interaction (secs)
(log-transformed data in brackets)

Replication	1	2
Mean Time (secs)	449 (4.972)	170 (4.117)

Treatment	0	2	4
Mean Time (secs)	30 (3.288)	344 (4.920)	555 (5.425)

		Treatment	
	T0	T2	T4
Replication			
1	33 (3.363)	503 (5.457)	809 (6.095)
2	26 (3.213)	184 (4.382)	301 (4.755)

Table 4.2.2. Analysis of Variance (log transformation on raw data).

Source	d.f.	S.S.	M.S.	F	P
Replication	1	26.32	26.32	22.89	$p < 0.001$
Treatment	2	119.75	59.88	52.09	$p < 0.001$
Repl. x Treatment	2	9.35	4.68	4.07	$p < 0.05$
Residual	115	132.20	1.15		

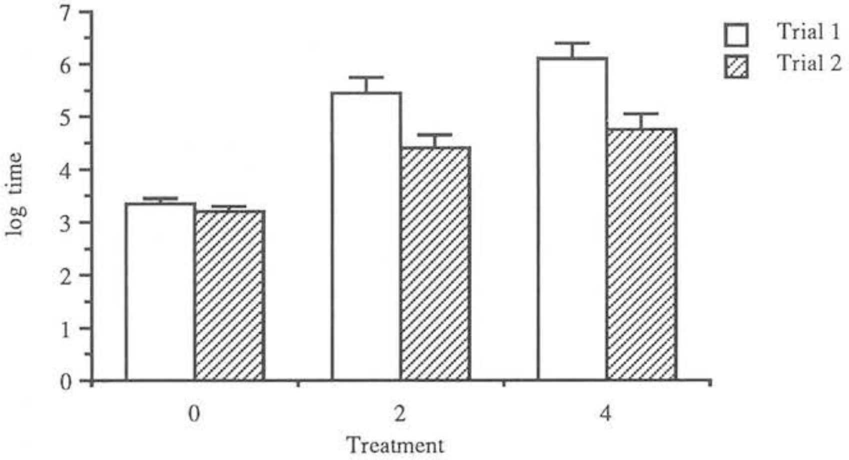
Table 4.2.3. t-tests of (log-transformed) replication means, within treatments

Treatment	t	d.f.	P
T0	0.485	115	NS
T2	3.473	115	$p < 0.001$ (Repl. 1 < Repl. 2)
T4	4.330	115	$p < 0.001$ (Repl. 1 < Repl. 2)

Table 4.2.4. t-tests of treatment means, within replications (log-transformed data)

Replication	Treatment	t	d.f.	P
1	T0 vs. T2	6.766	115	$p < 0.001$ (T0 < T2)
	T0 vs. T4	8.827	115	$p < 0.001$ (T0 < T4)
	T2 vs. T4	2.061	115	$p < 0.05$ (T2 < T4)
2	T0 vs. T2	3.777	115	$p < 0.001$ (T0 < T4)
	T0 vs. T4	4.982	115	$p < 0.001$ (T0 < T4)
	T2 vs. T4	1.205	115	NS

Fig. 4.2.a. Replication x Treatment effects on time to enter cage 2 (mean + s.e.)



4.2.2.b. *Reactions Towards Caged Birds*

Table 4.2.5. shows the total number of each reaction type (hesitation, aggression, no reaction) shown by test birds towards middle birds in both sets of replications in Treatments 2 and 4. To investigate whether there was a change in the proportion of each reaction type (shown by test birds to caged birds) between the first and second series of replications, Chi-Square tests were carried out on the proportions of each reaction type in both T2 and T4. The results of these tests indicated that there were changes in the proportion of each reaction type in T2 (significant) (χ^2=9.281; 2 d.f.; $p < 0.01$) and T4 (trend) (χ^2=5.614; 2 d.f.; $0.10 > p > 0.05$).

Table 4.2.5. Number of each reaction type seen in both replications of Treatments 2 and 4.

Treatment	Reaction	Replication 1	Replication 2	Total
T2	A	15	6	21
	H	19	14	33
	NR	14	28	42
T4	A	21	17	38
	H	24	13	37
	NR	51	66	117

Figures 4.2.b. and 4.2.c. show the percentage of each reaction type seen in Treatments 2 and 4 respectively, for both sets of replications.

Fig. 4.2.b. Percentage of each reaction type seen in Treatment 2 (Replications 1 + 2).

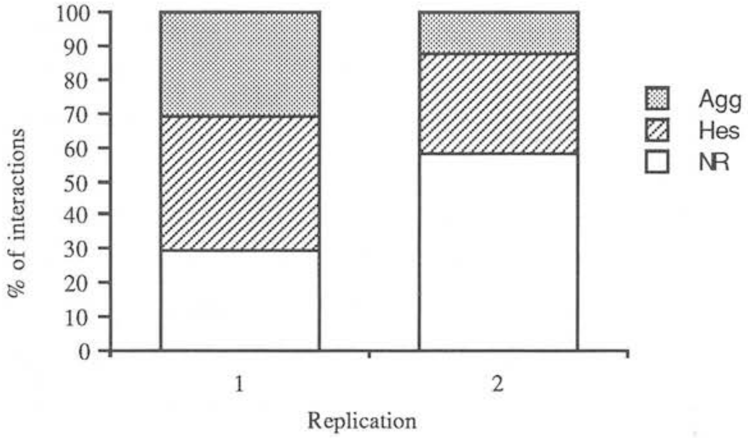
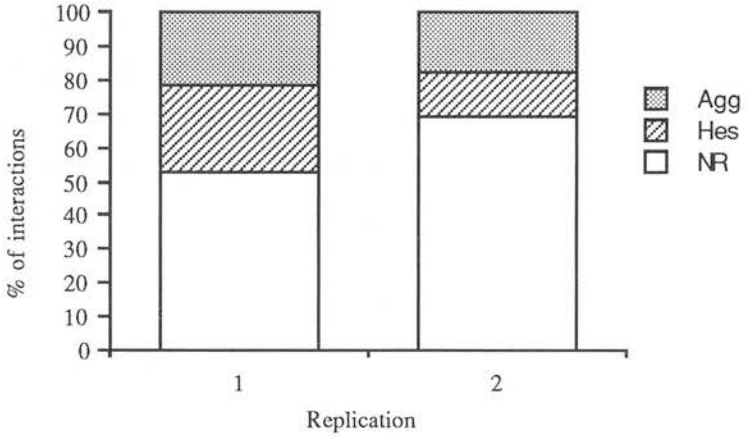


Fig. 4.2.c. Percentage of each reaction type seen in Treatment 4 (Replications 1 + 2).



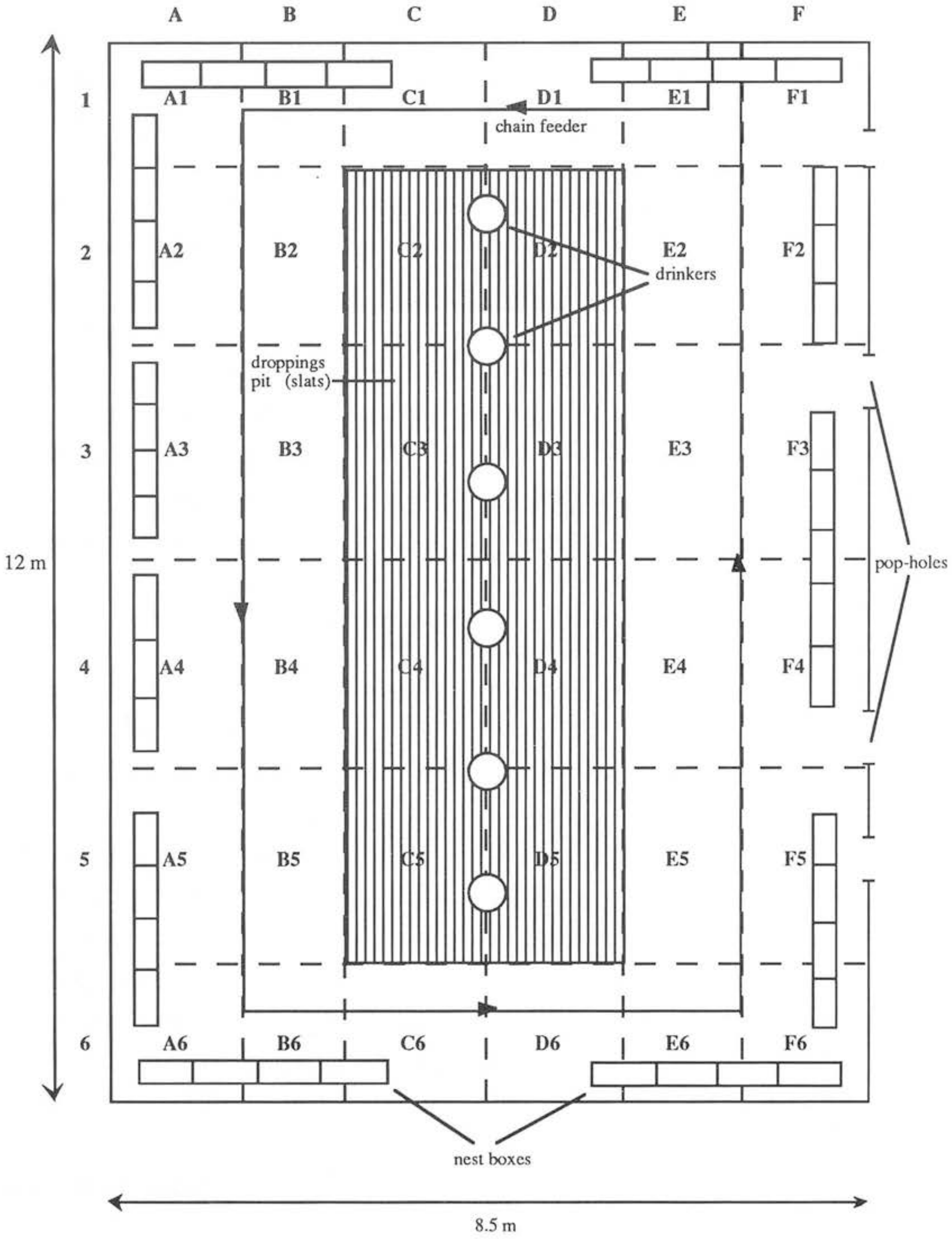
4.4. Experiment 3

4.4.1. Materials and methods

A flock of about 700 medium hybrid (ISA Brown) laying hens was housed in a 12 m x 8.5 m polythene tunnel at 18 weeks of age. Observations took place when the birds were 26 weeks old. The stocking density inside the house was 7 birds/m^2. The flock had daytime access to an outside, grass-covered paddock. The birds had not been beak-trimmed. A sample of 150 birds was wing-tagged to allow identification of individuals. The house was subdivided into 36 (imaginary) areas, each area measuring approximately 2.5 - 3 square metres (Figure 4.3.). Observations were made over a 5-day period. During each observation, a tagged bird (the "focal" bird) was selected at random, and its position monitored over a 60-minute period. The area in which the focal bird was seen was recorded every 30 seconds. During an observation period, the observer kept a minimum distance of five metres between himself and the focal bird, in order to minimise the likelihood that the bird's movements were influenced by the presence of the experimenter. (In addition, the observer moved repeatedly round the house over a period of several hours prior to commencing the observations, in order to get the birds used to his presence). An observation was terminated if a bird went out on to the range, or entered a nest-box. All agonistic interactions involving the focal bird (including the outcome and the location) were recorded. A total of 27 focal birds was followed, each from different starting areas. Thus, the total number of areas in which each bird was seen, and the outcome and location of each aggressive interaction were recorded for each focal bird.

In addition to the above, four 30-minute periods of observation were made of birds moving in and out of the pop-holes. The pop-holes measured 90 cm wide x 35 cm high. Two periods of observation were made in the morning (between 09.00 and 11.00h), and two in the afternoon (between 14.00 and 16.00h). During each observation period, the number of exits and entries through the pop-holes were recorded, together with the number of aggressive acts directed towards birds moving in both directions.

Figure 4.3.: Plan view of house



4.4.2. Results

4.4.2.a. *Movement around the house.*

Of the 27 birds selected, the movements of 19 birds were monitored for the entire 60-minute periods; recordings of the other 8 birds were prematurely terminated, due to birds either entering a nest-box, or leaving the house via a pop-hole. The mean length of a scanning period was 52.9 minutes. There was much variation between individuals in the number of areas entered during a scanning period. The mean (and also the median) number of areas entered was 13.0 (range: min = 4, max = 24) - this represented 36.0% of the total number of areas (range: min = 11.1%, max = 66.7%).

In the total scanning period for all 27 birds (about 24 hours), only 10 agonistic interactions involving focal birds were observed. This low level of aggression, together with the fact that at least some birds moved over a large area of the house (with some being observed in two-thirds of the available sections) in such a short space of time, suggests that any restriction of movement was not due to "pecking pressure" by other birds.

4.4.2.b. *Movement through the pop-holes.*

During the 120 minutes of observation, a total of 485 passages through the pop-holes were recorded, 254 in the morning (132 entries + 122 exits), and 239 in the afternoon (124 entries + 115 exits). Only 2 aggressive interactions (involving birds moving through the pop-holes) were observed. Thus, overt aggression did not appear to be an important factor in inhibiting birds' movement through the pop-holes. The presence of other birds may nevertheless have made passage through a pop-hole more difficult, as birds used the thresholds of pop-holes as perches, with up to six birds at a time perching at a (95 cm-wide) pop-hole. Therefore, a bird entering or leaving the house had either to crawl under these birds, or to push its way through. However, birds did continue to move in and out, despite this obstruction.

4.5. Discussion

Results from Experiment 1 indicate that the time taken for a test bird to move into cage 2 when cage 3 contained a subordinate bird was similar to that when cage 3 was empty. A lower-ranking hen would have posed little or no threat, so a test bird would have had no cause to hesitate. However, birds took longer to move past a higher-ranking bird than they did to move past an empty cage. An individual hen may be surrounded by a zone of "personal space"; Keeling and Duncan (1989) reported that when spatial allowances were small, hens tended to maximise inter-individual distances, with changes in bird-to-bird orientation occurring at distances of 25 cm or less. In order to reach cage 2, the test bird would have to pass the cage 3 bird at a distance of 10 - 20 cm. This is within the possible sphere of influence of a dominant bird. This might have resulted in an aggressive act being directed towards the test bird, thus causing hesitation.

Overall, test birds did not take significantly longer to pass a dominant bird than they did to pass a subordinate bird. In small groups with stable peck orders (as in this study), the frequency of overt aggressive interactions is reduced over time as dominance relationships become established (Guhl, 1968). Social strife is gradually replaced by social inertia, and aggressive acts are replaced by symbolic dominance-submission rituals or threats (Williams *et al.*, 1977). It is possible that these threats, plus an occasional aggressive act, are sufficient to maintain recognition and, therefore, the relationship (Maier, 1964). Therefore, the threat posed by passing a known dominant bird is not as great as it may seem (and not significantly different to passing a lower-ranking bird), as is demonstrated here.

Test birds reacted to unfamiliar cage 3 birds in a variety of ways, including fear (shown by hesitation in moving out of cage 1 and past cage 3), aggression (in which the test bird attempted to fight with the caged bird), or no reaction (in which the test bird moved past the cage 3 bird without hesitating). The net result of these reactions was a significantly longer time taken to enter cage 2 when cage 3 contained an unfamiliar bird than in any of the other treatments. This suggests that hens are less willing to move (in close proximity) past unfamiliar birds than they are to move past familiar birds, even those of higher rank. Previous studies have shown that, in preference tests, hens chose a familiar group of hens over an unfamiliar group or an empty cage, and chose an empty cage over an unfamiliar group (Dawkins, 1977, 1982; Hughes, 1977b). In addition to the studies by Siegel and Siegel (1961) and Candland *et al.* (1969), which showed that constantly encountering strangers led to physiological signs of stress (increased adrenal weight, increased heart rate), Hughes (1983) showed that headshaking (a response to a disturbing influence) was greater when a strange bird was added to the group than for three other potentially disturbing stimuli. Furthermore, the strange bird always elicited agonistic responses from the group. Thus, encountering strangers appears to be an aversive experience for laying hens, at least if, as here, they have hitherto been in small, stable groups.

Experiment 2 showed that test birds took significantly longer to move into cage 2 as the number of unfamiliar caged birds increased, though only on the first set of trials. Birds took a significantly shorter time to move into cage 2 on the second set of trials in both T2 and T4, though not in T0. The greatest reduction occurred in T4, with the result that there was no significant difference between T2 and T4 on the second series of trials. There was a change in the proportions of each reaction type (hesitation, aggression, no reaction) shown by the test bird towards the caged birds between the first and second series of trials. In both T2 and T4, the number of hesitations and aggressive reactions fell, while the number of non-reactions rose. This may have been due to the test birds "learning" (over the first set of trials) that, even though they were passing very close to the caged birds, the caged birds could not physically reach them through the cage wire. The perceived threat, therefore, was not as great as test birds may first have thought. This probably accounts for the reduced time taken to enter cage 2 in the second replications of T2 and T4, and also for the greater reduction in T4. Birds are able to recognise previously unfamiliar birds in a relatively short space of time, and respond differently to them once their familiarity increases (Dawkins, 1982). Hens initially show a significant preference to associate with familiar rather than unfamiliar birds (Bradshaw, 1992), but show a significant tendency to associate with previously unfamiliar birds during the course of a day, indicating that hens are able to recognise other birds in a relatively brief period. In this study, however, the short test duration (maximum = 30 minutes) would have been insufficient to allow familiarity among test and caged birds to develop. In addition, different caged hens were used in the first and second trials for each test bird in both T2 and T4, and birds from neighbouring cages were not used in the same test, so the observed reduction in the time taken by test birds to enter cage 2 on the second set of trials would not have been due to increasing familiarity of caged birds. It is reasonable to assume that, had the test birds not been food-deprived (thereby reducing their motivation to reach cage 2), and if the middle birds had been tethered instead of caged (thus allowing actual physical contact between test and caged birds), the times taken for the test birds to move past the other birds would have been longer. Nevertheless, the results from Experiments 1 and 2 suggest that, if birds in large flocks (where number of birds exceeds an individual's limit for individual recognition) behaved in the same way as these birds from small, stable flocks, a bird might be expected to restrict its movements to a limited area in order to minimise the number of strangers encountered.

In contrast to Experiments 1 and 2, birds in the free-range house showed no hesitation and practically no aggression when moving past other birds. The average number of "areas" (each measuring 2.5 to 3 m^2) in which an individual was observed over a sixty-minute period was 13.0 (range: 4 - 24). Thus, a bird was (on average) able to move over more than one third of the available house area in a relatively short time period. During its movement, a bird must have passed many unfamiliar birds, but the lack of overt aggressive activity (10 aggressive pecks from a total of 24 hours' observation) suggests that any restriction of movement was not due to aggressive behaviour by strange birds. This result concurs with those of Preston and Murphy (1989), and Lewis and Hurnik (1990), who found that short-term movement of broilers was variable, with some birds moving more than 20 metres in a 60-minute period, while the least mobile bird moved over an area of about 3 square metres. Similarly, Newberry and Hall (1990) found that movement among broilers, although non-random, was not restricted to small areas in which birds could become familiar with their neighbours. Furthermore, it was concluded that the observed reduction in movement with time was mainly due to increased difficulty in walking with age and to the increased body mass of other birds, rather than to pecking pressure. (Selection for growth in broilers appears to have resulted in a decrease in aggressiveness (Mench, 1988)). Therefore, a bird might limit its area of movement due to the physical restriction imposed by other birds, rather than to social pressures.

Why do birds show apparent reluctance to move past unfamiliar birds in a small-scale situation (Experiments 1 and 2), but relatively free movement in the larger-scale free-range set-up (Experiment 3)? Jones (1984b) found that chicks reared in pairs displayed less fear of a novel area when tested with their cage-mates, but chicks reared in groups of ten showed no reduction of fear when tested with a flock-mate. He concluded that the pair-reared chick recognised and responded to the presence of its familiar companion, whereas the group-reared chick had failed to learn the characteristics of its flock-mates, as, even in a group of 10, its capacity for individual recognition had been exceeded. In the present study, an individual in a small group of pen-housed birds will (probably) learn the characteristics of its pen-mates (Experiment 1), and a bird in a single cage will (probably) only learn the characteristics of its immediate neighbours (Experiment 2). Strange individuals will therefore be immediately obvious to birds such as these which were only used to seeing or encountering a limited number of other individuals. In a large flock, on the other hand, such as that studied in Experiment 3, where a bird's limit for recognition is exceeded (and where the flock is reared as a large group from one day old), an individual may be unable to learn the characteristics of other individuals in the same way. In this situation, birds may not even attempt to establish recognition of other individuals, and therefore do not make any distinction between individuals. As a result, birds did not form themselves into small, mutually exclusive groups (based on inter-individual recognition), with well-defined home-ranges. Instead, there was a wide range of individual movement patterns, with some birds observed in two-thirds of the available areas in only a short time period. This, together with a lack of overt aggression directed towards birds as they moved around the house, suggests that any restriction of movement to a certain area was primarily due to familiarity with that area, and localisation of resources (such as feeders, drinkers and nest-sites) within the area, but not due to "pecking pressure" from other birds. Furthermore, the lack of agonistic interactions around the pop-holes suggests that birds' movements in and out of the house are not inhibited by the presence of high-ranking or aggressive hens situated near the pop-holes.

CHAPTER 5: Gregariousness in Domestic Hens

5.1. Introduction

Group-living is a widespread phenomenon in the animal kingdom. The basic feature of gregarious behaviour was described by McBride (1964b) as "the mutual attraction which draws animals together", whereas Wynne-Edwards (1962) described it as a "centripetal social force". It is assumed that group-dwelling occurs when the fitness of a group member is greater than that of a solitary animal. The costs and benefits of sociality have been widely documented (for example, Hoogland and Sherman, 1976). Possible costs associated with group-living include the following: (1) increased aggression among group members (2) increased competition for resources such as food, mates and nests (3) increased conspicuousness to predators (4) increased possibility of rearing unrelated young (5) greater chance of ectoparasite and disease transmission. Animals may be expected to form groups when the benefits associated with gregariousness outweigh the costs. Such benefits include the following: (1) decreased risk of an individual being subject to predation (2) exploitation of other group members' knowledge of patchy resources (3) cooperation in feeding strategies (4) communal defence against predators (5) temperature or thermoregulatory effects (6) improved breeding success due to cooperation among related individuals.

Flocking is an important aspect of bird social behaviour. It arises as a balance between two opposing forces - a centripetal (positive) force which acts to bring birds together, and a centrifugal (negative) force which acts to keep birds apart. Variations in flock size and density are a result of different balances of positive and negative forces (Emlen, 1952). Among its advantages, flocking serves to conceal individual prey animals from predators, and to enhance the detection of predators (Treisman, 1975a, 1975b). Peripheral predation of groups has an important influence on flocking behaviour. An animal may minimize its "domain of danger" by moving towards its neighbours, and animals in the centre of an aggregation are more protected than animals on the periphery (Pulliam, 1973). The decision to establish flocks is influenced by some environmental variables, such as proximity of a feeding patch to a safe area (Elgar, 1986). Some animals also form larger or tighter groups in the presence of predators; for example, juncos formed larger flocks in the presence of a hawk (Caraco *et al.*, 1980a), while Grubb (1977) reported closer aggregations among American coots when predators were present overhead.

Individual birds often spend less time on anti-predator vigilance (and more time on feeding) as flock size increases (Bertram, 1980; Elgar and Catterall, 1981; Lima, 1987), but there is no reduction in overall flock vigilance (Barnard, 1980). Individual vigilance level is also influenced by a bird's position within a flock. Jennings and Evans (1980) reported that in a feeding flock of starlings (*Sturnus vulgaris*), peripheral birds had higher vigilance levels (and fed less) than birds in central or mid-way positions. Although the benefits of flocking are lower for peripheral birds than for central birds, they are still at an advantage compared to solitary birds (Ekman, 1987). Peripheral predation may explain why individuals in larger flocks spend less time vigilant for predators. If peripheral birds are more vigilant than birds in central positions, then the proportion of the flock which are vigilant at any one time would decrease as flock size increases, as the number of peripheral birds would represent a diminishing proportion of the whole flock (Lazarus, 1978). An alternative explanation is that individuals in a flock are able to estimate flock size, and adjust their vigilance behaviour accordingly. Individuals in flocks are together able to detect predators earlier than single birds (Lazarus, 1979), and birds in large flocks are less fearful and have fewer false alarms than solitary birds or birds in small flocks (Siegfried and Underhill, 1975). Mixed-species flocks are as effective in detecting predators as single-species flocks (though without the disadvantage of competition for food), as environmental information can be communicated across species boundaries (Powell, 1974; Sullivan, 1984). Mixed-species flocking may not benefit all flock members equally, however, as one species may take advantage of the presence or behaviour of another species, with no apparent benefit to the latter. Barnard and Stephens (1983) found that fieldfares (*Turdus pilaris*) benefit from the presence of redwings (*Turdus iliacus*) in mixed-species flocks, as they use information from redwings about the whereabouts of prey. Redwings, however, did not derive any apparent benefit from the presence of fieldfares.

A further feature of gregariousness is that animals tend to prefer associating with familiar conspecifics, rather than with unfamiliar individuals (McBride, 1964a; Winfield *et al.*, 1981). Preference tests have shown that domestic fowl are able to discriminate between conspecifics, and choose to associate with familiar birds (Keeling and Duncan, 1991; Bradshaw, 1992). Given the choice between a group of familiar birds, a group of unfamiliar birds, and an empty cage, hens chose the familiar group over the unfamiliar group and the empty cage, and chose the empty cage over the unfamiliar group (Hughes, 1977b; Dawkins, 1977, 1982). Appleby *et al.* (1984) found that, when birds which were about to lay were given the choice between an isolated area and an area containing caged flock-mates, most laid near the other birds. Social isolation may increase an animal's fear level, as measured by a prolonged tonic immobility response (Salzen, 1963; Jones, 1986b), or it may serve to increase the stressfulness of a situation which is already disturbing (Rowell and Hinde, 1963). The presence of familiar companions reduced fear in chicks placed in an unfamiliar environment (Faure *et al.*, 1983). A familiar conspecific may reduce the novelty of an otherwise unfamiliar area by functioning as a familiar stimulus, and may also reduce distress caused by separation from other chicks. Jones (1984b) found that chicks which had been reared in pairs displayed less fear of a novel area when tested with a familiar conspecific than when tested with a strange chick. Some studies, however, have indicated that it is the presence of other birds, rather than their familiarity, which is important in reducing fear of the environment. Hogan and Abel (1971) found that the presence of social companions reduced chicks' fear reactions in an unfamiliar environment, even when these companions were unfamiliar. Similarly, Jones (1984c) reported that the presence of either familiar or unfamiliar conspecifics in an otherwise unfamiliar situation reduced chicks' fearfulness.

In a study on laying hens in a free-range system, Keeling *et al.* (1988) reported that a lower proportion of the flock went outside as flock size increased. In addition, the larger number of birds outside, the greater the average distance from the house. This study raised the hypothesis that hens in free-range systems show gregarious behaviour, in that if the majority of the flock go outside (as is the case in small flocks), then the remaining inside birds may be more likely to join them. Conversely, if the majority of birds remain inside the house (as is the case in large flocks), then birds which are outside might be attracted back into the house, and inside birds might be unwilling to leave the house in the first place.

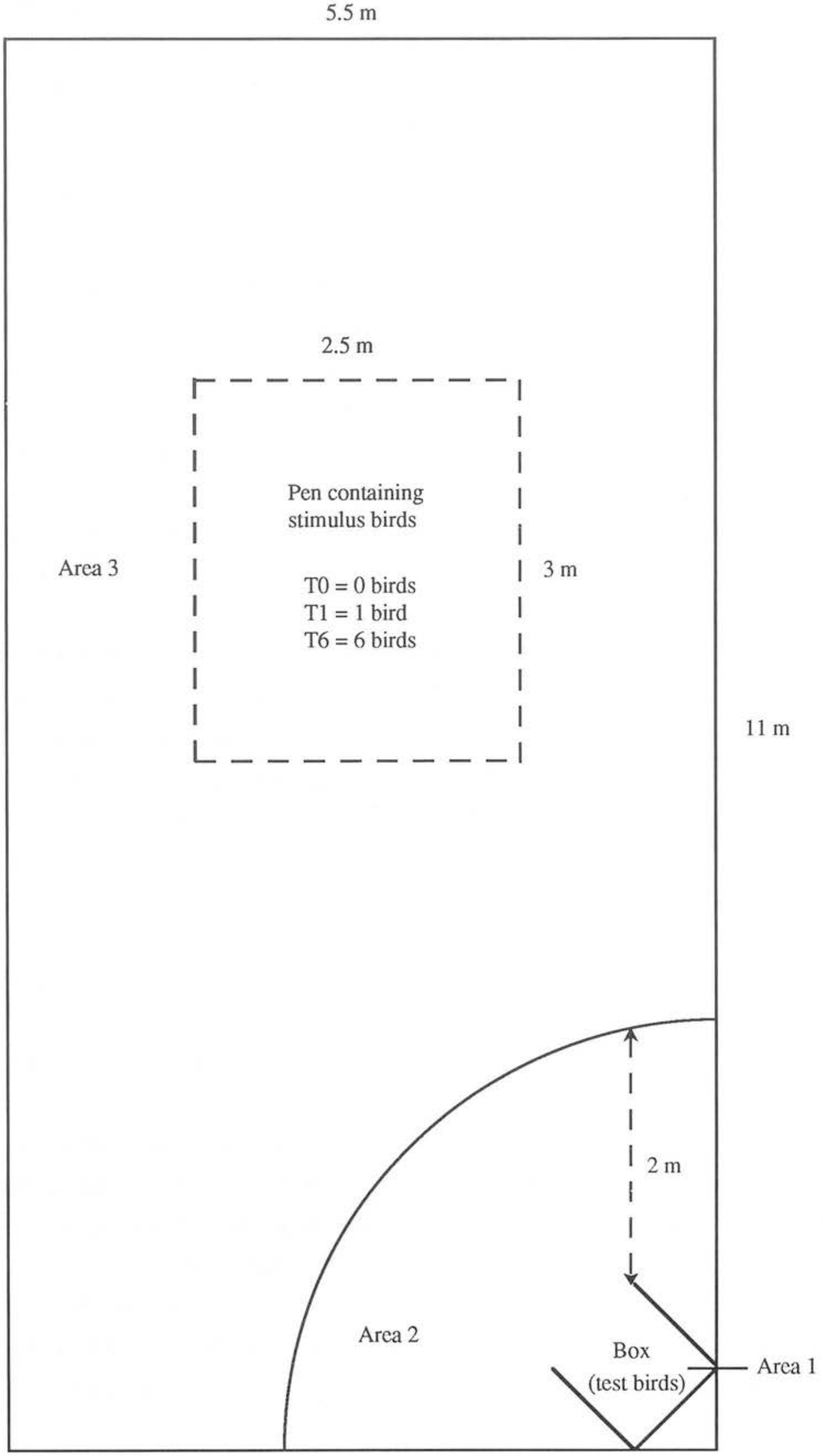
Previous studies have shown that domestic fowl are less fearful of a novel area when conspecifics are present; for example, Jones (1983) found that the presence of other birds in an Open Field promoted activity and vocalisation, while the presence of companions in a novel environment reduced distress calling, searching and escape behaviour in domestic chicks (Collias, 1952; Salzen, 1962). Furthermore, a bird's responses may be influenced by the number of conspecifics present, as a group of birds may provide stronger stimulation (and a greater attraction) than an individual; for example, a single chick is more attracted towards a group of chicks than to another single chick (Guiton, 1959). The objective of the present study was to test the hypothesis that birds' readiness to move from a familiar covered area into an unfamiliar outdoor paddock (and subsequently disperse in the outside area) would be influenced by varying the number of birds already present in the paddock. By keeping the test group size constant, and by varying the number of "outside" (or stimulus) birds (which were retained in a wire pen in the paddock), the test birds were either in the minority or the majority. In addition, responses of test birds to either familiar or unfamiliar stimulus birds were investigated.

5.2. Materials and methods

This experiment examined the effects of varying the number of conspecifics in an unfamiliar outdoor area on the readiness of laying hens to emerge from a familiar area (a covered box) into the novel area, measured by the times taken to enter the test area and to move two metres from the box door. In addition, the amount of time which birds spent in different areas of the paddock was used as an alternative measure of their readiness to disperse in the outside area.

Twenty-seven 24-week-old HISex medium hybrid laying hens were housed in 3 indoor floor pens (A, B, C). Each pen measured 2.4 m x 2.4 m, and contained 9 birds. The birds were leg-ringed to aid identification. Birds were randomly assigned to test groups of three pen-mates each. Each indoor pen contained a covered box (0.9 m x 0.9 m x 0.9 m), so all birds became familiarised to these boxes in the pens. Birds' emergence and dispersal behaviour were tested in a grass-covered outdoor paddock (11 m x 5.5 m) - see Figure 5.1. During testing, each (test) group was transported to the outside paddock in a holding crate and placed in another covered box (which was placed in one corner of the paddock) with the door closed, where it was left to acclimatise for two minutes. The paddock also contained a wire pen (2.5 m x 3 m) in which the "outside" (stimulus) birds were placed prior to the test group being moved. The covered box faced into the middle of the paddock, so the birds in the test group had a clear view of the wire pen, once the box door was raised. The groups were tested in a randomised order under each of the following treatments:
T0: no birds in outside pen (empty paddock);
T1: one bird in outside pen (test birds were in the majority);
T6: six birds in outside pen (test birds were in the minority).
Each group was given two replications of each treatment (in a randomised order). In Treatments 1 and 6, half the trials used familiar stimulus birds (from the test group's home pen), and half used unfamiliar birds (from another pen).

Figure 5.1. : Plan view of paddock



The following measures were recorded:

(a) the latencies of each test bird to leave the box (once the box door was raised), and to reach two metres from the box. If a bird had not emerged (or reached two metres from the box door) within sixty minutes of the box door being raised, the test was terminated, and that bird given a score of 3600 seconds.

(b) the area in which each test bird was seen, scanning every 30 seconds over a 60-minute period.

Areas: 1 = inside the box;
2 = within 2 metres of the box door;
3 = outwith 2 metres of the box door.

To permit log-transformations to be carried out, 1 was added to each total to allow for zero-scores. Thus, in each trial, the total number of scans per bird was 123. To determine whether the number of scans in which birds were observed in each area varied with treatment, each area was analysed separately. (Given that an increase in the use of one area will automatically result in a decrease in the use of the other two areas, it is recognised that the data are not independent).

Analyses of the latencies to emerge and reach two metres from the box, as well as the number of scans in which birds were seen in area 3, were carried out on log-transformed data. The raw data had a skewed variation; log-transformation produced a more normal distribution and homogeneity of variance. The results of the area 1 and area 2 observations were more normally distributed, allowing analysis of the untransformed data.

5.3. Results

5.3.1. *Latencies to emerge and to reach 2 metres from the box*

Table 5.1.1. shows the mean times to emerge from the box and to reach two metres from the box door in each treatment, with log-transformed data in brackets. Analysis of variance of the (log-transformed) treatment means showed that the treatment used had an effect on the time taken to emerge from the box (F=4.18; 2, 114 d.f.; $p < 0.05$). To clarify which treatment or treatments had an effect, t-tests were carried out on the (log) means for each pair of treatments. These are shown in Table 5.1.2. Birds emerged significantly earlier in T6 (six stimulus birds) than in the other two

treatments. There was no significant difference between T0 (no birds outside) and T1 (one bird outside).

A significant analysis of variance of the (log) treatment means showed that the treatment used had an effect on the time taken to reach two metres from the box (F=11.25; 2, 114 d.f.; $p < 0.001$). As before, t-tests were carried out on the (log-transformed) means for each pair of treatments. These are shown in Table 5.1.3. Birds reached two metres significantly earlier in T6 than in the other two treatments, and reached two metres significantly earlier in T1 than in T0. (Figures 5.1.1. and 5.1.2. show the treatment effect on times taken to emerge and to reach 2 metres from the box door).

Table 5.1.1. Mean times to emerge and reach 2 metres in each treatment (secs) (log-transformed data in brackets)

Treatment	T0	T1	T6	ANOVA (logs)
Emerge	1141	891	707	
	(5.18)	(5.06)	(4.48)	$p < 0.05$
2 metres	2903	2413	1892	
	(7.72)	(7.28)	(6.77)	$p < 0.001$

Table 5.1.2. t-tests on means of (log) emergence times under each treatment

	t	d.f.	P	
T0 vs. T1	0.458	114	NS	
T0 vs. T6	2.672	114	$p < 0.01$	(T6 < T0)
T1 vs. T6	2.214	114	$p < 0.05$	(T6 < T1)

Table 5.1.3. t-tests on means of (log) time to reach two metres under each treatment

	t	d.f.	P	
T0 vs. T1	2.198	114	$p < 0.05$	(T1 < T0)
T0 vs. T6	4.735	114	$p < 0.001$	(T6 < T0)
T1 vs. T6	2.537	114	$p < 0.05$	(T6 < T1)

Fig. 5.1.1. Treatment effect on (log) emergence time (mean + s.e.)

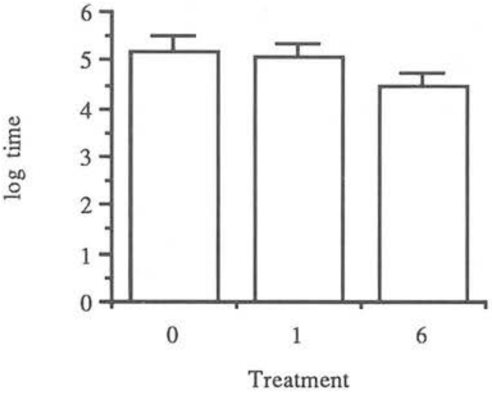
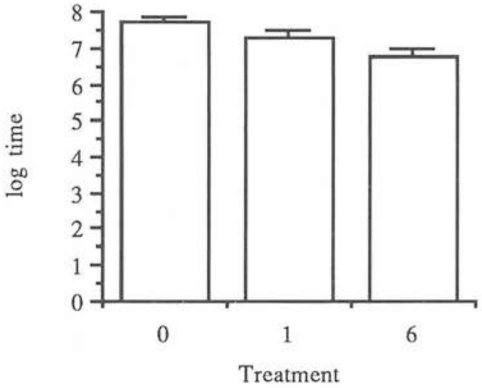


Fig. 5.1.2. Treatment effect on (log) time to reach 2 metres from the box (mean + s.e.)



5.3.2. *Distribution of birds in each area.*

Table 5.2.1. shows the mean number of scans in which birds were seen in areas 1, 2 and 3 in each treatment, with log-transformed data in brackets. Separate analyses of variance revealed significant treatment effects for the number of scans in which birds were seen in each area (area 1: F=7.80; 2, 114 d.f.; $p < 0.001$; area 2: F=3.70; 2, 114 d.f.; $p < 0.05$; area 3: F=11.69; 2, 114 d.f.; $p < 0.001$). To clarify which treatment or treatments had an effect, t-tests were carried out on the means for each pair of treatments in each area. These are shown in Tables 5.2.2. (area 1), 5.2.3. (area 2) and 5.2.4. (area 3). Table 5.2.2. shows that, compared to T0, birds spent significantly less time inside the box (area 1) in both T1 and T6. There was no significant difference between T1 and T6. Table 5.2.3. shows that, compared to T0, birds spent

significantly more time in area 2 (in the paddock, within two metres of the box door) in both T1 and T6. There was no significant difference between T1 and T6. Table 5.2.4. shows that birds spent significantly more time in area 3 (outwith two metres of the box) in T6 than in the other two treatments. Birds were also seen significantly more often in area 3 in T1 than in T0. (Figures 5.2.1., 5.2.2. and 5.2.3. show the treatment effect on the number of scans in which birds were observed in each area).

Table 5.2.1 Mean number of scans in which birds were seen in each area in each treatment (log-transformed data in brackets)

Treatment	T0	T1	T6	ANOVA
Area 1	91.8	75.7	70.5	$p < 0.001$
Area 2	28.3	40.0	38.5	$p < 0.05$
Area 3	2.9	7.3	14.0	
	(0.443)	(0.959)	(1.460)	$p < 0.001$

Table 5.2.2. t-tests on means of the no. of scans in which birds were seen in area 1

	$\underline{t}$	d.f.	P	
T0 vs. T1	2.860	114	$p < 0.01$	(T1 < T0)
T0 vs. T6	3.783	114	$p < 0.001$	(T6 < T0)
T1 vs. T6	0.924	114	NS	

Table 5.2.3. t-tests on means of the no. of scans in which birds were seen in area 2

	$\underline{t}$	d.f.	P	
T0 vs. T1	2.490	114	$p < 0.05$	(T1 < T0)
T0 vs. T6	2.170	114	$p < 0.05$	(T6 < T0)
T1 vs. T6	0.319	114	NS	

Table 5.2.4. t-tests on means of the (log) no. of scans in which birds were seen in area 3

	$\underline{t}$	d.f.	P	
T0 vs. T1	2.451	114	$p < 0.05$	(T0 < T1)
T0 vs. T6	4.831	114	$p < 0.001$	(T0 < T6)
T1 vs. T6	2.380	114	$p < 0.05$	(T1 < T6)

Fig. 5.2.1. Treatment effect on number of scans in which birds were seen in area 1 (mean + s.e.)

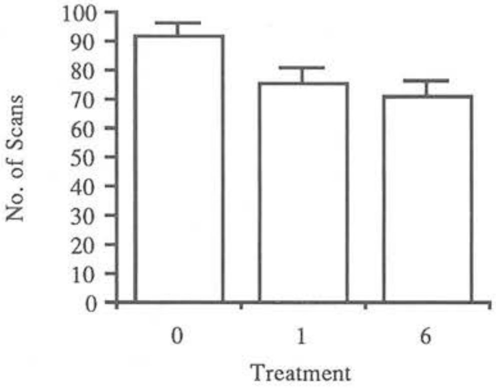


Fig. 5.2.2. Treatment effect on number of scans in which birds were seen in area 2 (mean + s.e.)

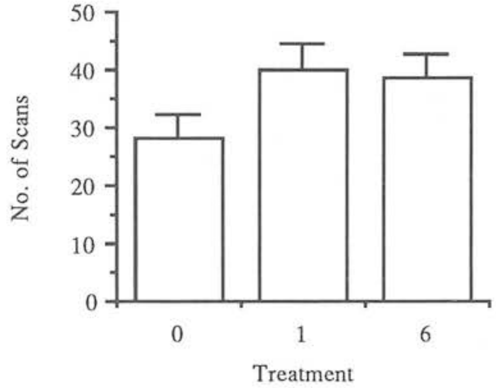
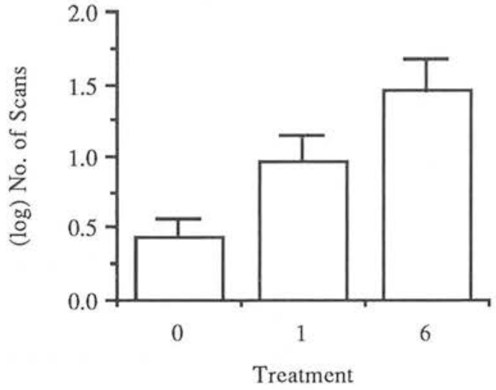


Fig. 5.2.3. Treatment effect on (log) no. of scans in which birds were seen in area 3 (mean + s.e.)



5.3.3. *Test birds' responses towards familiar versus unfamiliar stimulus birds*

Table 5.3.1. and 5.3.2. show the mean responses of test birds (with logs in brackets) for each measure (latencies to emerge and reach two metres from the box, and the number of scans in which birds were seen in areas 1, 2 and 3) in Treatments 1 and 6 respectively, using familiar and unfamiliar stimulus birds. One-way analyses of variance were carried out on the means of each measure. In both treatments, there were no significant differences between the reactions of test birds towards familiar and unfamiliar stimulus birds for any measure. Thus, in both T1 and T6, test birds' emergence and dispersal behaviour was unaffected by whether the outside pen contained familiar or unfamiliar birds.

Table 5.3.1. Means of each measure in T1, familiar vs. unfamiliar stimulus birds (logs in brackets)

Measure	"Outside" Birds			
	Familiar	Unfamiliar	F (1, 24 d.f.)	P
Emerge (secs)	1166 (5.29)	617 (4.83)	0.74	NS
2 metres (secs)	2510 (7.50)	2316 (7.05)	1.86	NS
Area 1	76.0	75.4	0.00	NS
Area 2	40.3	39.8	0.00	NS
Area 3	6.7 (0.89)	7.8 (1.02)	0.18	NS

Table 5.3.2. Means of each measure in T6, familiar vs. unfamiliar stimulus birds (logs in brackets)

Measure	"Outside" Birds			
	Familiar	Unfamiliar	F (1, 24 d.f.)	P
Emerge (secs)	952 (4.82)	463 (4.13)	1.98	NS
2 metres (secs)	1921 (6.71)	1863 (6.82)	0.07	NS
Area 1	77.5	63.5	1.86	NS
Area 2	32.2	44.8	3.62	NS
Area 3	13.3 (1.45)	14.7 (1.47)	0.00	NS

5.4. Discussion

Overall, results indicate that birds were more willing to enter the novel area and to move away from the box when other birds (either 1 or 6) were already present in the paddock. Compared to when the paddock was empty (Control), birds spent more time in the outside area (as a whole) when either 1 or 6 birds were already outside. In addition, test birds had the shortest emergence latencies and spent most time in the area furthest from the box when 6 birds were already outside. For each measure, there were no significant differences between trials involving familiar and unfamiliar stimulus birds in either Treatment 1 or Treatment 6. It did not matter, therefore, whether the "outside" (stimulus) bird(s) were from the same pen as the test birds, or from a different pen.

The physical separation of test birds and stimulus birds did not appear to reduce test birds' willingness to move into the paddock when other birds were already outside. It would seem that presence alone was sufficient to enhance test birds' use of the outside area. Tolman (1965) reported a reduction in emotional behaviour among chicks in the visual (though not the physical) presence of a conspecific. Although the behaviour of birds retained in the outside pen was not recorded in detail, it was observed that these birds would often remain in the corner of the pen nearest the box, and some would attempt to push their way through the wire in order to reach the box. A study on geese showed that the attractiveness of an area is largely dependent on the postures adopted by birds in that area, as more birds landed in areas in which more individuals displayed "head down" (foraging) postures, and fewer displayed "extreme head up" (vigilant) postures (Inglis and Isaacson, 1978). In the present study, in spite of the agitated behaviour displayed by the stimulus birds, they made the outside area more attractive to the test birds, indicating the importance of the presence of other birds in influencing emergence and dispersion.

Novel stimuli (such as a strange environment) evoke both fear and exploration in animals, as both responses may contribute to an animal's survival; fearful responses allow animals to avoid potentially harmful stimuli, whereas exploratory behaviour will provide information about the environment. Which reaction is displayed depends on the degree of novelty: in general, extreme or intense novelty evokes fear, whereas a moderate amount of novelty evokes exploration (Murphy, 1976). A single conspecific in an otherwise novel area appears to act as a familiar stimulus in an otherwise novel area. This serves to reduce the novelty of the outdoor area (or, rather, the discrepancy between the inside and outside environments), which in turn enhances exploration. Furthermore, a larger group of birds appears be more effective in evoking exploration of the novel area than a single bird. Simmel (1962) found that, in laboratory rats, exploration of a novel area may be enhanced by the presence (and activity) of conspecifics. Therefore, exploration, along with other activities such as eating and drinking, may be enhanced by social facilitation.

Test birds displayed similar emergence and dispersal responses when the outside pen contained either familiar or unfamiliar birds. Jones (1984b) suggested that, in large groups, an individual may be unable to learn the characteristics of all its flock-mates, and may react similarly towards flock-mates and strangers. Douglis (1948) reported that it was possible for a hen to recognise 27 other birds, though this may not have been the upper limit. In the present study, each indoor pen contained 9 birds, which is well within an individual's capacity for recognising other hens. Therefore, it is unlikely that the observed similarity in test birds' responses in the presence of familiar and unfamiliar stimulus birds was due to test birds failing to recognise pen-mates.

Birds are able to recognise previously unfamiliar birds in a relatively short space of time. Dawkins (1982) found that birds responded differently to other birds once they were familiar with them. In a study on hens' ability to discriminate between conspecifics, birds initially showed a significant preference to associate with familiar rather than unfamiliar birds; however, birds showed a significant tendency to associate with the unfamiliar birds during the course of a day, indicating that hens were able to recognise conspecifics in a matter of hours (Bradshaw, 1992). In the present study, different stimulus birds were used in the two replications of both T1 and T6, and each trial only lasted sixty minutes. It is highly improbable that this relatively brief level of exposure would significantly enhance test birds' ability to recognise stimulus birds. It seems unlikely, therefore, that the similar reactions of test birds towards familiar and unfamiliar stimulus birds were due to test birds rapidly learning the characteristics of the unfamiliar stimulus birds. Thus, it appears that the *presence*, rather than the familiarity, of stimulus birds is the important factor in enhancing exploration in test birds. The findings of Hughes (1977b) and Dawkins (1977, 1982) that hens display a preference hierarchy of familiar birds > empty cage > unfamiliar birds may only apply when the empty cage is familiar to the birds. Present results indicate that the presence of conspecifics in a *novel* area may reduce test birds' fearfulness of the area, regardless of the familiarity of the stimulus birds.

Previous studies have indicated that a bird's fear level may increase as flock size decreases. In ducklings, for example, the greater the reduction in brood size, the more distress calls were emitted by the remaining birds (Gaioni *et al.*, 1977; Gaioni and Ross, 1982). There was also a reduction in distress calling when strangers were added to a group, indicating that the level of distress calling was not dependent on the familiarity of group members. Furthermore, the *proportion* of the flock remaining, rather than the absolute number, determined the level of distress calling, as a given number of ducklings remaining from a large group emitted more distress calls than the same number remaining from a small group. In the case of free-range laying hens, a given number of birds leaving the house would represent an increasing proportion of the flock as the flock size decreased. In the present study, the presence of birds in the outside area appeared to increase the attractiveness of the range to other individuals; therefore, it is hypothesised that if a sufficient proportion of the flock is outside, birds remaining inside may be more motivated to join them.

The finding that birds reached 2 metres earlier and spent more time in area 3 when the outside pen contained six birds than when it contained a single bird concurs with the findings of Guiton (1959) that a group of birds may provide stronger stimulation (and thus greater attraction) than a single bird. Furthermore, Suarez and Gallup (1983) found that individual birds moved more quickly along a runway when four birds were at the other end than when only a single bird was present, with the longest moving time displayed when no other birds were present. In the present study, the greater dispersion when the pen contained the majority (two thirds) of the whole group may be seen as a flocking response. Larger flocks provide benefits in terms of anti-predator behaviour (Lazarus, 1978), and may also provide valuable information on the location of good feeding sites (Ward and Zahavi, 1973). Approaching other birds in a flock reduces an individual's domain of danger (the "selfish herd" effect), which thereby reduces its vulnerability to predators (Hamilton, 1971). Lazarus (1978) found that when an individual in a flock of White-fronted geese (*Anser albifrons*) stopped grazing to stand vigilant, the larger its domain of danger (defined as the number of birds within nine goose-lengths of an individual), the longer the duration of the posture. It seems unlikely that an individual bird in a large flock is able to recognise and remember all other birds in a flock, especially in mixed-species flocks. It is therefore concluded that the *presence* of conspecifics (rather than their familiarity) in an unfamiliar outdoor area increased the readiness of test birds to move into the paddock, with birds showing greater willingness to leave a familiar covered area when the number of birds already outside was increased, and that this represents a form of flocking response.

CHAPTER 6: Effects of Cover on Vigilance and Dispersal Behaviour in Domestic Hens

6.1. Introduction

The role of cover in animals' behaviour and dispersion has been investigated in a number of species. One role of cover may be to protect prey animals from predators by placing barriers between the prey and the senses of the predator. If contact is made, and the predator pursues the prey, cover may make the predator lose track of the prey during the pursuit, or the prey animal may use cover as a refuge, impenetrable to the predator (Elton, 1939). For a prey animal, cover prevents detection from a horizontal or an overhead view, with the relative importance of either cover type depending on the expected direction of predatory attack.

A foraging animal's choice of habitat and feeding patch is influenced not only by the availability of food, but also by the risk of predation. For many species, predation risk is negatively related to the amount of cover or the availability of refuges within a habitat. Holmes (1984), for example, reported that when food was equally available in different patches, hoary marmots (*Marmota caligata*) spent most time feeding in "low-risk" patches, where "risk" was negatively related to burrow density within the patch. Some previous studies with wild birds (Caraco *et al.*, 1980b; Grubb and Greenwald, 1982; Lima, 1988; Lima, 1990; Lazarus and Symonds, 1992, etc.) have shown that certain species preferred to feed in or near cover. White-throated sparrows (*Zonotrichia albicollis*), for example, preferred habitats with dense shrubbery, and flew to the nearest bush when flushed or alarmed. The areas closer to cover were occupied first, and only when food was progressively less available close to cover did birds move out to more distant feeding sites. Food patches were depleted in order, from close-to-cover outward. Furthermore, the area closest to cover was eaten down to a very low level before birds began to use a more distant one (Schneider, 1984). Animals may prefer to carry a food item to the safety of cover before handling it (Högstad, 1988). Lima *et al.* (1985) found that squirrels were more likely to carry a food item to cover with decreasing distance to cover, and the smaller the food item, the more likely a squirrel was to carry food to cover.

Prey animals may be more fearful of open environments which provide little or no protective cover; for example, Hennig *et al.* (1976) found that the duration of tonic immobility (a measure of underlying fearfulness) in anoles (*Anolis carolinensis*) was attenuated if bushes (cover) were present. Birds often display more anti-predator vigilance with increasing distance to cover. Barnard (1980), for example, found that a feeding flock of house sparrows scanned more frequently the further they were from cover (for a given flock size), and overall flock vigilance was significantly higher in open fields than in cattlesheds. Where cover is limited, access to it might depend on exclusion by another species, or on social status. In a study on habitat preferences, Davis (1973) found that golden-crowned sparrows (*Zonotrichia atricapilla*) were able to exclude juncos (*Junco hyemalis*) from willow thickets, despite being outnumbered. When the sparrows (which restricted themselves to willow thickets) were removed, juncos (which had previously ranged along field borders) significantly increased their use of the thickets. High-ranking willow tits excluded younger birds (of lower rank) from the upper (denser) part of the tree canopy, which offered better protection against predators. When the adults were removed, the younger birds moved into the upper canopy (Ekman and Askenmo, 1984; Ekman, 1987).

In contrast to the above examples, some studies have shown that vigilance time increases with closer proximity to cover (for example, Lima, 1987). Although cover or obstructions may protect prey animals from predators, it may also conceal predators, and may reduce a prey animal's visual field, which will inhibit the early detection of approaching predators. Carey (1985), for example, found that yellow-bellied marmots (*Marmota flaviventris*) spent more time foraging in areas of high food plant abundance, and where they were better able to detect approaching predators. Metcalfe (1984) measured prey vigilance in relation to habitat complexity in two species of shorebird. Vigilance levels in turnstones (*Arenaria interpres*) and purple sandpipers (*Calidris maritima*) were recorded in two habitat types: coastline (which offered restricted visibility due to rock outcrops), and sand or mudflats (which offered an open view). Both species displayed an increase in vigilance time as the structural complexity of the habitat increased. Grazing ungulates may also spend more time vigilant while foraging in closed (forest) habitats than in open habitats (Underwood, 1982; Lagory, 1986). Dense vegetation may reduce communication between individuals, and increase a prey animal's susceptibility to predatory ambush. Cover provides a more complex visual environment, making a visual target (such as a predator) more difficult to detect.

This chapter examines the effects of providing various types of cover on the behaviour of laying hens in an unfamiliar outdoor environment. Domestic fowl in many free-range systems are often reluctant to leave the house and range over the available pasture (Davison, 1986; Keeling *et al.*, 1988). The openness of the outside area, which is usually devoid of all cover, may contribute to birds' reluctance to move away from the house.

In addition to enhancing protection against predators, cover may also serve other functions, such as providing protection against extreme weather conditions, and aiding the maintenance of body temperature (Broom, 1981). Grazing mammals often seek shade in response to adverse weather conditions (Lynch and Alexander, 1976; McDaniel and Roark, 1956). It is possible that domestic fowl seek out cover in response to climatic conditions, and previous studies with free-range hens have reported that fewer birds go out on range on bright, sunny days (Davison, 1986; Keeling *et al.*, 1988) or on wet, windy days (Innes, 1984).

In its report on the welfare of laying hens in colony systems, The Farm Animal Welfare Council (1991) proposed that "sufficient overhead cover should be provided" in the outdoor areas of free-range systems. Keeling and Duncan (1991), in a study on a mixed flock of bantams and medium hybrids in an outdoor enclosure, found that the bantams (which, due to later domestication, had the more recent natural selection pressures, including predation), formed the more cohesive group, and remained nearer the roost than the medium hybrid group. Domestic fowl are descended from Red jungle fowl, whose natural habitat is the dense rainforest of South East Asia, so any birds going outside may feel exposed and vulnerable to attack by predators. In a field study of wild Red jungle fowl, Collias and Collias (1967) reported that birds preferred habitats with dense vegetation (provided by trees and bunchgrass), but which also had open spaces to allow easy travel. In addition, both aerial and ground species were listed as (assumed) predators of jungle fowl, and studies by Löliger *et al.* (1981) reported that free-range hens suffered many losses due to predation by buzzards.

This experiment investigated whether domestic fowl show a greater willingness to make fuller use of the available (outside) area when cover was present, and whether their behaviour was dependent on the type of cover available: no cover, ground cover only, or ground-plus-overhead cover. Cover was provided by moveable solid structures which were placed in an outdoor area. One problem with this method was that these structures may have been perceived as novel objects by the birds (see

Chapter 2). Previous studies with domestic fowl (Murphy, 1977) found that birds were initially unwilling to approach and investigate novel objects. Cautious initial movements were later replaced by free movement, including exploration and investigation of the objects. When presented with novel objects which provide cover in an otherwise exposed area, therefore, birds might be expected to show initial avoidance of the cover objects, but might approach them more readily in time as their novelty value decreases, while the amount of cover they provide remains constant. Therefore, possible time-trends in the birds' responses were investigated (including the amount of time spent in close proximity to the cover objects), as birds became familiarised to the cover objects. In addition, birds' vigilance behaviour was examined in the presence of each cover type.

6.2. Materials and methods

Thirty-six 26-week-old medium hybrid (HISex) laying hens were housed in 3 indoor floor pens (12 birds per pen). The birds were leg-ringed to aid identification, and were randomly assigned to test groups of four pen-mates each (i.e. 3 groups per pen). Each indoor pen contained a covered box (measuring 0.9 m x 0.9 m x 0.9 m), so that all birds became familiarised to the boxes in the pens. Birds' responses to the cover objects were tested in an outside (grass-covered) paddock, measuring 11 m x 5.5 m (Fig. 6.1.). Another covered box (similar to those in the birds' home pens) was placed in one corner of the paddock. During testing, each (test) group was transported to the outside paddock in a holding crate and placed in the covered box (with the door closed), where they were left to acclimatise for two minutes.

The treatments provided 3 levels of cover in the outside area:
Treatment 1: empty paddock (Control) (Figure 6.1.);
Treatment 2: objects providing 2-dimensional cover were placed in the outside paddock. These consisted of 4 pairs of wooden boards, each board measuring 66 cm x 102 cm (height x width), and each pair made into cross-shaped wooden structures which afforded ground-level visual protection (Figure 6.2.; Plate 6.a.);
Treatment 3: objects providing 3-dimensional cover were placed in the outside paddock. These consisted of the above cross-shaped wooden structures with "lids" (hardboard circles, diameter 120 cm) placed on top, thus offering ground-level and aerial visual protection (Figure 6.3.; Plate 6.b.).

Figure 6.1. : Treatment 1 - no cover (Control)

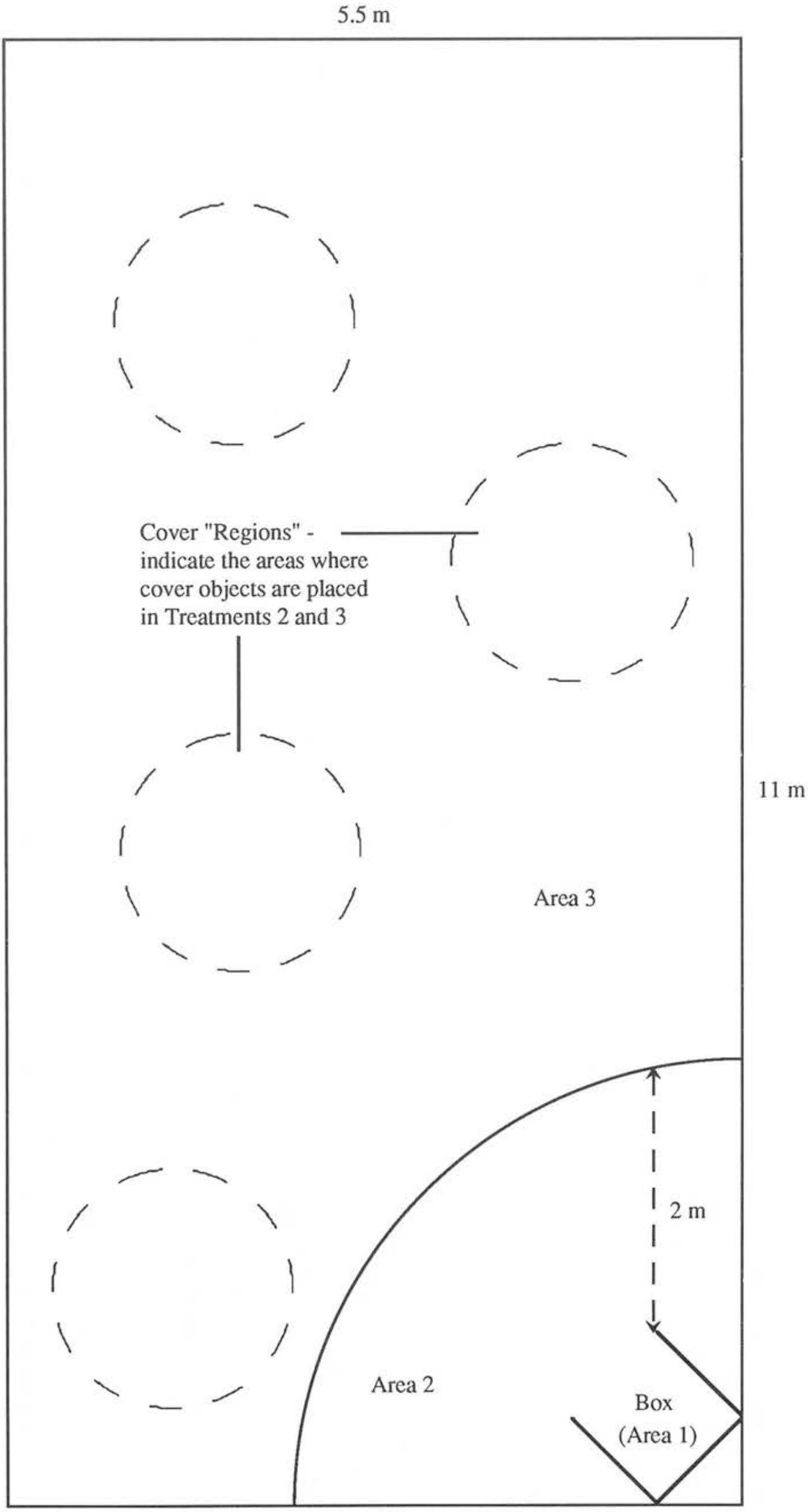


Figure 6.2. : Treatment 2 - 2-dimensional (ground-level) cover

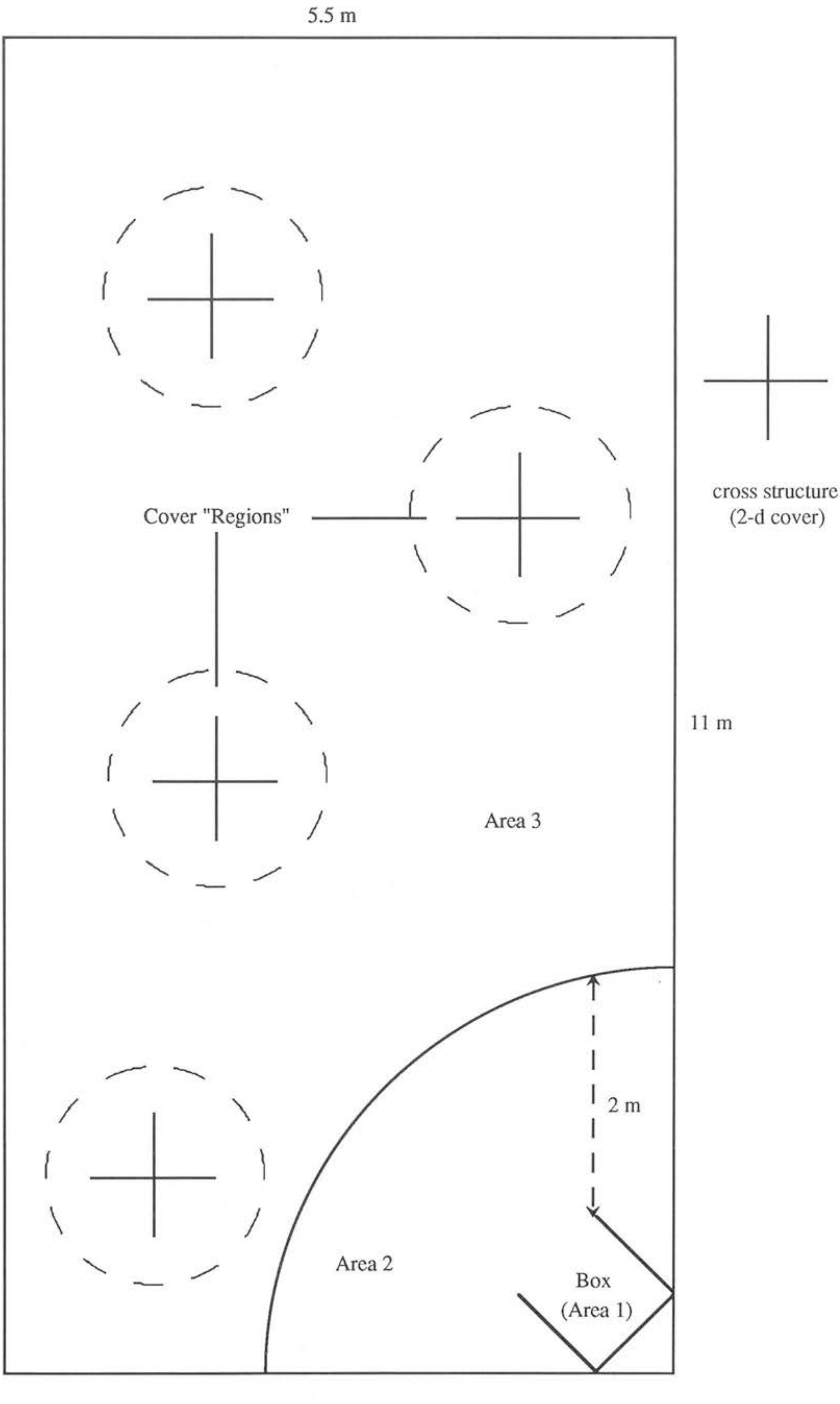


Figure 6.3. : Treatment 3 - 3-dimensional (ground-level + aerial) cover

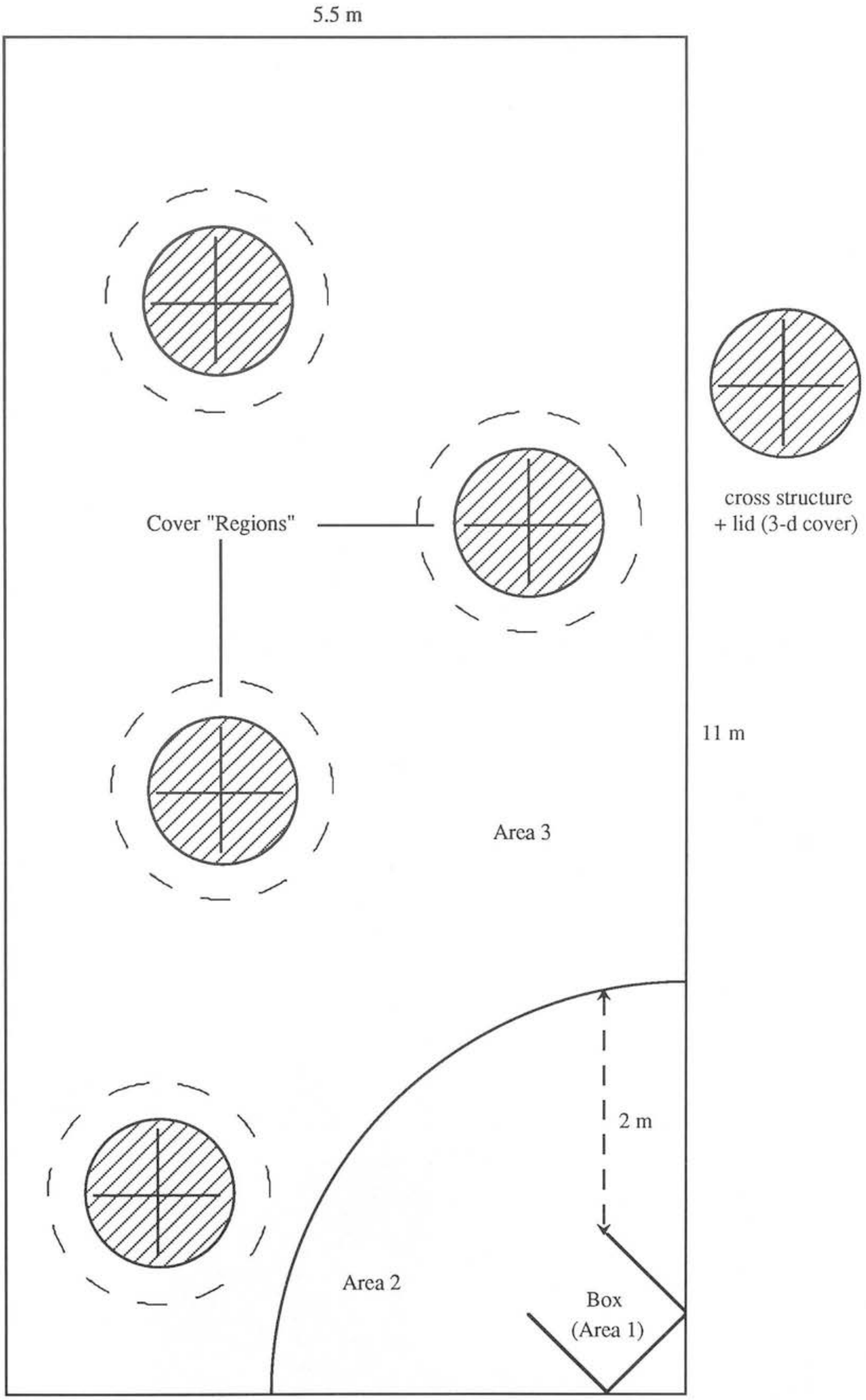


Plate 6.a. 2-dimensional (ground-level) cover object

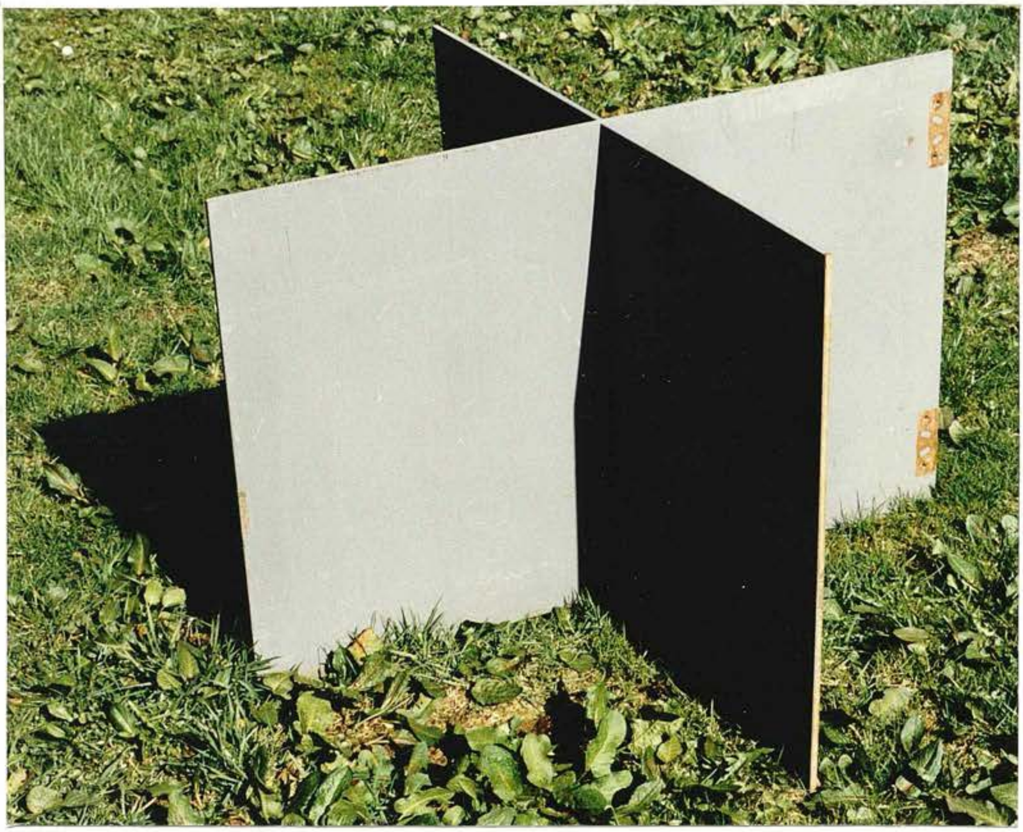


Plate 6.b. 3-dimensional (ground-level + aerial) cover object

Each group was given 3 replications of each treatment in a Randomised Block Design. For each group, the order in which the treatments were given was randomised. The order in which the 9 groups were tested was also randomised. Following the two-minute acclimatisation period, the box door was raised (and secured), and the following measures were recorded:

(a) the latencies of each bird to leave the box, and to reach two metres from the box. If a bird had not emerged (or reached two metres from the box door) within sixty minutes of the box door being raised, the test was terminated, and that bird given a score of 3600 seconds;

(b) the area in which each (test) bird was seen, scanning every 30 seconds over the 60-minute period. Areas: 1 = inside box; 2 = within two metres of the box door; 3 = outwith two metres of the box door (Figure 6.1.). To permit log-transformations to be carried out, 1 was added to each total to allow for zero-scores. Thus, in each trial, the total number of scans per bird was 123. To determine whether the number of scans in which birds were observed in each area varied with treatment, each area was analysed separately. (Given that an increase in the use of one area will automatically result in a decrease in the use of the other two areas, it is recognised that the data are not independent);

(c) in each scan, the posture of each bird in the outside area (areas 2 and 3) in each treatment. Following preliminary observations on birds in the outside area, it was decided to separate birds' postures into 3 categories, analogous to the postures of the geese models used by Inglis and Isaacson (1978), and those of vigilant curlews outlined by Abramson (1979):

Head Down (HD): head/neck below horizontal; usually adopted while foraging;

Head Up (HU): head/neck angle between horizontal and vertical; commonly used while moving, or between bouts of foraging;

Extreme Head Up (EHU): neck vertical, bird stationary; usually used to scan the environment ("vigilant"), or following an alarming stimulus, such as a sudden loud noise;

(d) the number of scans in which birds were seen in the cover "regions" in all 3 treatments. These were the areas immediately surrounding the cover objects (i.e. within 30 cm of the cover objects in Treatments 2 and 3) (see Figures 6.1., 6.2. and 6.3.).

(Although weather conditions were not recorded in detail, all testing took place on days which were dry, mild and overcast, with little or no wind).

Analyses of variance were carried out on the overall latencies to emerge and reach two metres from the box, as well as the number of scans in which birds were seen in each of the 3 areas. To investigate whether birds' emergence and dispersal behaviour were affected by time, each 3-day "block" was analysed separately for each measure. The analyses of all emergence times and latencies to reach 2 metres, as well as the scans from area 2 (Block 1) and area 3 (Blocks 1 and 3) were carried out on log-transformed data. The raw data had a skewed variation; log-transformation produced a more normal distribution and homogeneity of variance. The other results were more normally distributed, allowing analysis of the untransformed data. The results of the observations on birds' postures, as well as those of birds observed in the cover "areas" displayed non-normal distributions, so were analysed using non-parametric tests.

6.3. Results

6.3.1. *Latencies to emerge and reach two metres from the box*

Table 6.1.1 shows the mean times to emerge and to reach 2 metres from the box in each treatment (in all trials), with log-transformed data in brackets. Analysis of variance of the (log-transformed) treatment means showed that the treatment used had a significant effect on the time taken to emerge from the box ($F=4.55$; 2, 258 d.f.; $p < 0.05$). To clarify which treatment or treatments had an effect, t-tests were carried out on the (log) means for each pair of treatments. The results of these tests (shown in Table 6.1.2.) indicate that, compared to Treatment 1 (no cover), birds emerged significantly earlier in Treatment 2 (ground-level cover). There were no significant differences between T1 and T3 (ground + aerial cover), or between T2 and T3.

A significant analysis of variance of the (log) treatment means revealed that the treatment used had an effect on the time taken to reach two metres from the box ($F = 6.11$; 2, 258 d.f.; $p < 0.01$). As before, t-tests were carried out on the (log-transformed) means for each pair of treatments. These are shown in Table 6.1.3., and indicate that, compared to T1 and T3, birds reached 2 metres from the box significantly earlier in T2. There was no significant difference between T1 and T3. (Figures 6.1.a. and 6.1.b. show the treatment effect on the times to emerge and reach 2 metres from the box).

Table 6.1.1. Mean times to emerge and to reach 2 metres in each treatment (all trials) (secs) (log-transformed data in brackets)

Treatment	T1	T2	T3	ANOVA
Emerge	1028	717	887	
	(5.11)	(4.60)	(4.83)	$p < 0.05$
2 metres	1723	1603	1888	
	(6.74)	(6.51)	(6.91)	$p < 0.01$

Table 6.1.2. t-tests on means of (log) emergence times under each treatment

	t	d.f.	P	
T1 vs. T2	3.01	258	$p < 0.01$	(T2 < T1)
T1 vs. T3	1.65	258	NS	
T2 vs. T3	1.35	258	NS	

Table 6.1.3. t-tests on means of (log) time to reach two metres in each treatment

	t	d.f.	P	
T1 vs. T2	2.01	258	$p < 0.05$	(T2 < T1)
T1 vs. T3	1.48	258	NS	
T2 vs. T3	3.48	258	$p < 0.001$	(T2 < T3)

Fig. 6.1.a. Treatment effect on (log) emergence time (mean + s.e.)

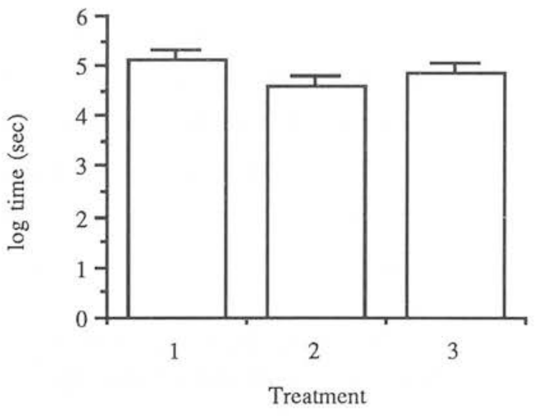


Fig. 6.1.b. Treatment effect on (log) time to reach two metres from the box (mean + s.e.)

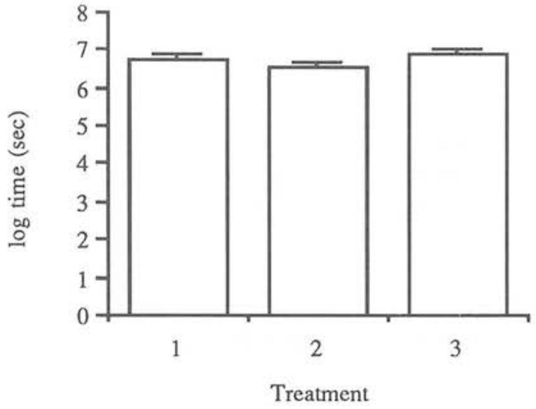


Table 6.1.4. shows the mean emergence time in each treatment in each 3-day block. Analyses of variance on the (log-transformed) treatment means indicate that there were no significant differences between any of the treatments within each 3-day block (Block 1 : F=3.03; 2, 66 d.f.; $p > 0.05$; Block 2 : F=0.22; 2, 66 d.f.; $p > 0.05$; Block 3 : F=2.64; 2, 66 d.f.; $p > 0.05$).

Table 6.1.5. shows the mean time to reach two metres in each treatment in each 3-day block, with log-transformed data in brackets. Analyses of variance on the (log-transformed) treatment means showed that there were no significant differences between any of the treatments within Block 2 (F=3.09; 2, 66 d.f.; $p > 0.05$) or Block 3 (F=1.62; 2, 66 d.f.; $p > 0.05$). The significant result in Block 1 (F=3.94; 2, 66 d.f.; $p < 0.05$) indicated that the treatment used had an effect on the time taken to reach two metres. To clarify which treatment or treatments had an effect, t-tests were carried out on the (log-transformed) means for each pair of treatments. These are shown in Table 6.1.6. Compared to T1, birds reached two metres significantly earlier in T2. There were no significant differences between T1 and T3, or between T2 and T3.

Table 6.1.4. Mean emergence time in each treatment in each 3-day block (log-transformed data in brackets)

Treatment	T1	T2	T3	ANOVA
Block 1 (Days 1-3)	1368 (6.30)	1092 (5.39)	1557 (6.12)	NS
Block 2 (Days 4-6)	870 (4.58)	736 (4.58)	626 (4.43)	NS
Block 3 (Days 7-9)	846 (4.46)	323 (3.87)	479 (3.92)	NS

Table 6.1.5. Mean time to reach two metres in each treatment in each 3-day block (log-transformed data in brackets)

Treatment	T1	T2	T3	ANOVA
Block 1 (Days 1-3)	2517 (7.50)	2124 (6.81)	2311 (7.29)	P < 0.05
Block 2 (Days 4-6)	1353 (6.47)	1377 (6.36)	1905 (6.80)	NS
Block 3 (Days 7-9)	1300 (6.25)	1307 (6.36)	1447 (6.63)	NS

Table 6.1.6 t-tests on means of (log) time to reach two metres in each treatment on days 1-3

	t	d.f.	P	
T1 vs. T2	2.74	66	p < 0.01	(T2 < T1)
T1 vs. T3	0.84	66	NS	
T2 vs. T3	1.91	66	NS	

6.3.2. *Number of scans in which birds were seen in each area*

Table 6.2.1. shows the mean number of scans in which birds were seen in areas 1, 2 and 3 in each treatment (in all trials). Analysis of variance of the treatment means showed that the treatment used had an effect on the number of scans in which birds were seen in area 1 (F=3.34; 2, 258 d.f.; $p < 0.05$). To clarify which treatment or treatments had an effect, t-tests were carried out on the means for each pair of treatments. These are shown in Table 6.2.2., and indicate that, compared to T1, birds spent significantly less time inside the box (area 1) in T2. There were no significant differences between T1 and T3, or between T2 and T3. Analysis of variance of the treatment means indicated that the treatment did not have a significant effect on the number of scans in which birds were seen in area 2 (F=0.16; 2, 258 d.f.; $p > 0.05$). Analysis of variance of the treatment means revealed that there was a significant treatment effect on the number of scans in which birds were seen in area 3 (F=6.95; 2, 258 d.f.; $p < 0.001$). As before, t-tests were carried out on the means for each pair of treatments. These are shown in Table 6.2.3., and indicate that, compared to T1, birds spent significantly more time in area 3 in both T2 and T3. There was no significant difference between T2 and T3.

(Figures 6.2.a. and 6.2.b. show the treatment effects on the number of scans in which birds were seen in areas 1 and 3 in each treatment).

Table 6.2.1. Mean number of scans in which birds were seen in each area in each treatment

Treatment	T1	T2	T3	ANOVA
Area 1	79.5	72.2	74.6	$p < 0.05$
Area 2	28.3	28.6	27.3	NS
Area 3	15.3	22.3	21.1	$p < 0.001$

Table 6.2.2. t-tests on means of the number of scans in which birds were seen in area 1

	$\underline{t}$	d.f.	P	
T1 vs. T2	2.53	258	$p < 0.05$	(T2 < T1)
T1 vs. T3	1.70	258	NS	
T2 vs. T3	0.83	258	NS	

Table 6.2.3. t-tests on (log) means of scan counts for area 3 under each treatment

	$\underline{t}$	d.f.	P	
T1 vs. T2	3.48	258	$p < 0.001$	(T1 < T2)
T1 vs. T3	2.90	258	$p < 0.01$	(T1 < T3)
T2 vs. T3	0.58	258	NS	

Fig. 6.2.a. Treatment effect on number of scans in which birds were seen in area 1

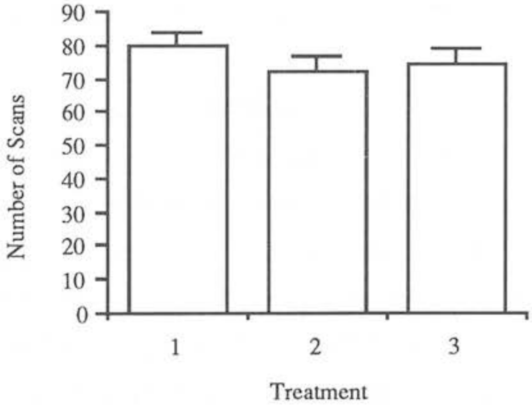


Fig. 6.2.b. Treatment effect on number of scans in which birds were seen in area 3

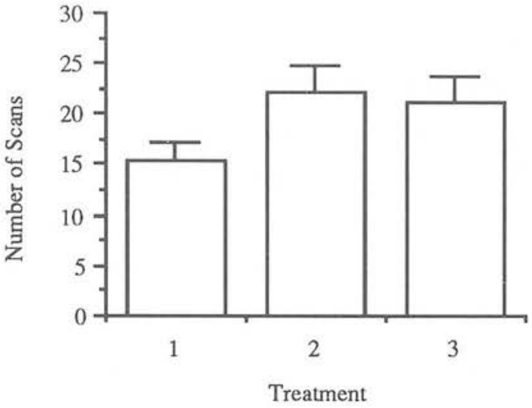


Table 6.2.4. shows the mean number of scans in which birds were seen in area 1 in each treatment within each 3-day block. Analyses of variance on the treatment means showed that there were no significant differences between any of the treatments within Block 1 (F=1.27; 2, 66 d.f.; $p > 0.05$) and Block 2 (F=0.90; 2, 66 d.f.; $p > 0.05$). However, the significant result in Block 3 (F=3.62; 2, 66 d.f.; $p < 0.05$) revealed that the treatment used had an effect on the amount of time birds spent in area 1. To clarify which treatment or treatments had an effect, t-tests were carried out on the means for each pair of treatments. These are shown in Table 6.2.5., and indicate that, compared to T1, birds spent significantly less time in area 1 in T3 in the last three-day block. There were no significant differences between T1 and T2, or between T2 and T3.

Table 6.2.6. shows the mean number of scans in which birds were seen in area 2 in each treatment in each 3-day block, with log-transformed data in brackets. Analyses of variance on the treatment means indicated that the treatment used had no significant effect on the amount of time birds spent in area 2 in the first three-day block (F=0.71; 2, 66 d.f.; $p > 0.05$). However, the analyses of variance of Block 2 (F=7.07; 2, 66 d.f.; $p < 0.01$) and Block 3 (F=8.88; 2, 66 d.f.; $p < 0.001$) indicated that there were significant treatment effects on the amount of time birds spent in area 2. T-tests were carried out on the means for each pair of treatments in Block 2 (Table 6.2.7.) and Block 3 (Table 6.2.8.). The results in this table show that, compared to T1 and T2, birds spent significantly less time in area 2 in the second 3-day block, but spent significantly more time in area 2 in T3 in the third 3-day block. There was no significant difference between T1 and T2. Thus, the pattern observed in Block 2 was reversed in Block 3.

Table 6.2.9. shows the mean number of scans in which birds were seen in area 3 in each treatment in each 3-day block, with log-transformed data in brackets. Analyses of variance on the treatment means revealed that the treatment used had a significant effect on the amount of time birds spent in area 3 only in Block 2 (F=5.71; 2, 66 d.f.; $p < 0.01$). Neither Block 1 (F=1.39; 2, 66 d.f.; $p > 0.05$) nor Block 3 (F=1.53; 2, 66 d.f.; $p > 0.05$) yielded a significant treatment effect. As before, t-tests were carried out on the means for each pair of treatments in Block 2. The results of these tests (shown in Table 6.2.10.) indicate that, compared to T1, birds spent significantly more time in area 3 in both T2 and T3 in the second three-day block. There was no significant difference between T2 and T3. Therefore, the overall result that birds spent more time in area 3 when cover was present was mainly due to birds' responses in the second 3-day block.

Table 6.2.4. Mean number of scans in which birds were seen in area 1 in each treatment in each 3-day block.

Treatment	T1	T2	T3	ANOVA
Block 1 (Days 1-3)	92.5	81.2	85.9	NS
Block 2 (Days 4-6)	66.3	63.3	70.2	NS
Block 3 (Days 7-9)	79.7	71.9	67.7	$p < 0.05$

Table 6.2.5. t-tests on means of number of scans birds were seen in area 1 in each treatment on days 7-9.

	t	d.f.	P	
T1 vs. T2	1.72	66	NS	
T1 vs. T3	2.65	66	$p < 0.05$	(T3 < T1)
T2 vs. T3	0.93	66	NS	

Table 6.2.6. Mean number of scans in which birds were seen in area 2 in each treatment in each 3-day block (log-transformed data in brackets).

Treatment	T1	T2	T3	ANOVA
Block 1 (Days 1-3)	22.0 (2.06)	23.6 (2.24)	21.8 (1.89)	NS
Block 2 (Days 4-6)	39.0	33.5	24.7	$p < 0.01$
Block 3 (Days 7-9)	23.7	28.6	35.4	$p < 0.001$

Table 6.2.7. t-tests on means of number of scans birds were seen in area 2 in each treatment on days 4-6.

	t	d.f.	P	
T1 vs. T2	1.42	66	NS	
T1 vs. T3	3.71	66	$p < 0.001$	(T3 < T1)
T2 vs. T3	2.29	66	$p < 0.05$	(T3 < T2)

Table 6.2.8. t-tests on means of number of scans birds were seen in area 2 in each treatment on days 7-9.

	t	d.f.	P	
T1 vs. T2	1.76	66	NS	
T1 vs. T3	4.19	66	$p < 0.001$	(T1 < T3)
T2 vs. T3	2.44	66	$p < 0.05$	(T2 < T3)

Table 6.2.9. Mean number of scans in which birds were seen in area 3 in each treatment in each 3-day block (log-transformed data in brackets).

Treatment	T1	T2	T3	ANOVA
Block 1 (Days 1-3)	8.5	18.1	15.3	
	(1.05)	(1.56)	(1.25)	NS
Block 2 (Days 4-6)	17.7	26.2	28.1	$p < 0.01$
Block 3 (Days 7-9)	19.6	22.5	19.9	
	(1.89)	(1.99)	(2.24)	NS

Table 6.2.10. t-tests on means of number of scans birds were seen in area 3 in each treatment on days 4-6.

	t	d.f.	P	
T1 vs. T2	2.59	66	$p < 0.05$	(T1 < T2)
T1 vs. T3	4.19	66	$p < 0.001$	(T1 < T3)
T2 vs. T3	2.44	66	NS	

6.3.3. *Treatment effect on birds' postures*

Percentages of each posture type (head down, head up or extreme head up) observed in each treatment were calculated as follows:

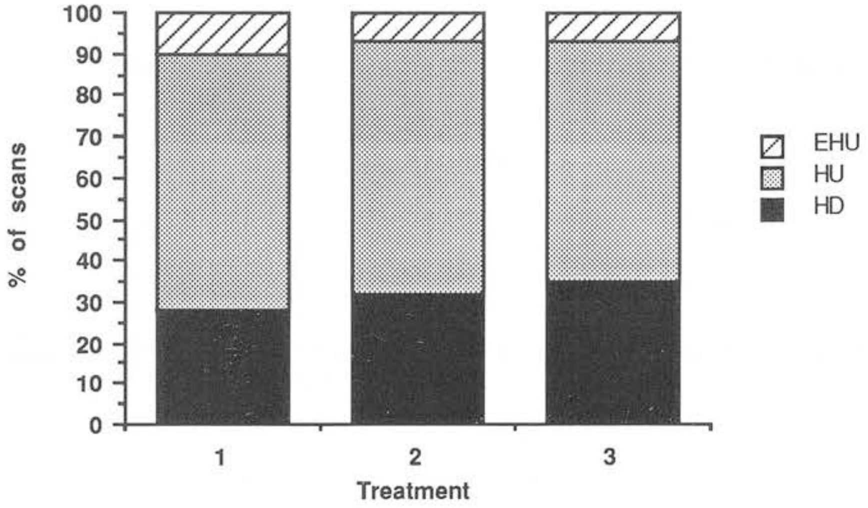
$$\frac{\text{total number of scans in which each posture was displayed}}{\text{total no. of scans in which birds were seen in the outside area (areas 2 \& 3)}} \times 100\%$$

Table 6.3.1. (and Figure 6.3.a.) show the percentages of each posture type observed in each treatment. To determine whether the proportions of each posture varied with treatment, each posture was analysed separately (by Friedman analyses of variance). The results of these tests indicate that, for each posture type, there was no significant treatment effect on the relative frequencies of birds' postures (head down: $\chi^2=4.056$, N=9, k=3, $p > 0.05$; head up: $\chi^2=0.222$, $p > 0.05$; extreme head up: $\chi^2=3.556$, $p > 0.05$).

Table 6.3.1. % of each posture type observed in each treatment

		Treatment	
	T1	T2	T3
Posture			
EHU	10.2	7.4	6.9
HU	62.1	60.5	58.3
HD	27.7	32.1	34.8

Fig. 6.3.a.



6.3.4. *Effects of treatment on time spent in cover "regions"*

Table 6.4.1. shows the mean numbers of scans in which birds were observed in the cover "regions" (in each treatment), expressed as percentages of the total number of scans in which birds were seen in area 3 :

i.e.
$$\frac{\text{total number of scans in which birds were seen within cover "regions"}}{\text{total number of scans in which birds were seen in area 3}} \times 100$$

Table 6.4.2. shows the mean numbers of scans in which birds were observed in the cover "regions" (in each treatment) in the first, second and third 3-day blocks. Analysis (by Friedman analysis of variance) indicated that there was a significant interaction between the proportion of area 3 scans in which birds were observed in the cover "regions" and "time", defined (here) as the three 3-day blocks ($\chi^2=6.222$; N=9, k=3; $p < 0.05$). Further analyses were carried out on each 3-day block. These

indicated that there were no significant interactions between birds' relative use of the regions and treatment in Block 1 (χ^2=4.750; $p > 0.05$) or Block 2 (χ^2=5.389; $p > 0.05$). However, there was a significant interaction in Block 3 (χ^2=6.889; $p < 0.05$). Tests between treatments revealed that there was a significant difference between T1 and T3 (Wilcoxon matched-pairs signed-ranks test, 2-sided; T=6, N=9; $p < 0.05$), though not between T1 and T2 (T=8, N=7; $p > 0.05$) or between T2 and T3 (T=10, N=9; $P > 0.05$). Therefore, by the third 3-day block, hens occupied the areas immediately around the cover objects relatively more frequently in T3 than in T1.

Table 6.4.1. Percentages of scans in which birds were observed in the cover "regions"

	Treatment	
T1	T2	T3
6.73	13.34	18.04

Table 6.4.2. Percentages of scans in which birds were observed in the cover "regions" in each 3-day block

		Treatment	
	T1	T2	T3
Block			
1 (Days 1-3)	0.31	6.34	10.94
2 (Days 4-6)	5.66	12.03	12.31
3 (Days 7-9)	11.59	20.07	25.87

6.4. Discussion

Overall, birds emerged from the box (and reached 2 metres from the box) earlier when 2-dimensional cover was present (T2) than when 3-dimensional cover was present (T3), or when cover was absent altogether (T1). This suggests that ground-level cover is an important factor in reducing the openness of the outside area, but, using these experimental conditions, aerial cover is no more attractive to domestic fowl. Compared to the other two treatments, birds also spent significantly less time inside the box when ground-level cover was available; however, closer examination of the separate 3-day blocks revealed a slight time trend, as birds spent significantly less time inside the box in T3 than in T1 on the third 3-day block. Overall, birds spent equivalent amounts of time in area 2 (within 2 metres of the box) in all three treatments. There were differences between the second and third 3-day blocks, however, with birds observed significantly less often in area 2 in T3 (compared to T1 or T2) on days 4-6, but significantly more often in T3 than the other two treatments on the last three days. These results suggest that, although birds displayed the earliest emergence and spent least time inside the box in the presence of 2-dimensional cover, birds were increasingly attracted towards 3-dimensional cover with repeated exposure. In addition, area 3 (outwith 2 metres of the box door) was occupied significantly more often when either cover type was present (Treatments 2 and 3) than when cover was absent.

Why were birds initially no more willing to leave the box when both aerial and ground-level cover were present (T3) than when only ground-level cover was present (T2)? There are several possible explanations. Firstly, as Collias and Collias (1967) reported, Red jungle fowl in nature may be subjected to attacks from both ground-dwelling predators and birds of prey. Thus, in the present study, hens could have perceived both types of cover as protective. A second explanation might be that overhead cover might obstruct the hens' view of approaching birds of prey. As previously stated, some studies have shown that vigilance decreases with increasing distance from obstructive cover (Metcalfe, 1984; Lazarus and Symonds, 1992), as obstructions restrict an animal's visual field. Lima *et al.* (1987) studied feeding behaviour in finches near "open" cover (which was easy to see into) and denser "closed" cover (which was more difficult to see into). All birds tended to feed nearer open cover and further from closed cover. Closed cover might obscure a bird's view of its surroundings, or it may conceal predators lying in ambush. In the present study, therefore, it is possible that the more obstructive nature of the 3-dimensional cover objects accounted for birds' initial apparent reluctance to leave the box, compared to when ground-level cover was present. Ground-level cover, on the other hand, affords protection by reducing the openness of the outside area, but does not restrict an animal's visual field to the same degree. However, birds spent equivalent amounts of time in the area furthest from the box (area 3) in both T2 and T3, so 3-dimensional cover was still perceived as providing safety relative to an open paddock. A final possibility is that birds were initially unwilling to approach the novel (3-dimensional cover) objects, and the observed time trend is due to birds becoming more familiar with these objects, which facilitated closer approach. This explanation seems unlikely, however, as the 2-dimensional cover also comprised novel objects, and birds spent least time inside the box when these objects were present.

Overall, birds were seen in the cover "regions" proportionately more often when cover objects were present (T2 and T3) than when cover was absent. This demonstrates that birds were willing to approach the novel (cover) objects, and tended to remain closer to the cover objects than would be expected by "chance" (when the paddock was empty). In addition, birds occupied the cover "regions" proportionately more often in T3 than in T1 in the third 3-day block, again showing that birds were increasingly attracted towards the 3-dimensional cover objects with repeated testing.

Although birds displayed fewer "head down" (foraging) postures, and more "extreme head up" (vigilant) postures when no cover was present, compared to either of the treatments when cover was present, the results were not significant. This may have been due (in part) to the enclosed nature of the paddock, which was bordered on two sides by solid walls (2.75 metres high), with solid fencing at one end. Thus, the openness of the outside area would have been reduced, even when no cover objects were present. This may have reduced birds' vigilance levels to a baseline, and increasing the available cover (by the introduction of cover objects) had no additional effect.

In conclusion, birds displayed earlier emergence, and greater dispersal (shown by less time spent in the box, and more time spent in the area furthest from the box), when cover objects were present in an outside area. Birds showed a disproportionate increase in their use of the cover "regions" when cover objects were present, showing that birds chose to remain in closer proximity to the cover objects than would be expected by chance. However, birds' vigilance behaviour was apparently unaffected by the presence of cover. These results suggest that the presence of cover in an outside area had a limited effect in increasing the attractiveness of the range to domestic fowl, though, in the present study, this was not reflected in the birds' vigilance behaviour.

CHAPTER 7: General Discussion

This chapter contains several sections which discuss the various factors influencing the use of space by hens in free-range systems. Detailed discussions of the experimental results have been contained within the preceding chapters; therefore, the following section (7.1.) presents only a brief summary of the social and environmental factors studied, and which of these factors were found to influence the use of space by domestic hens, with possible implications for free-range systems. The second section (7.2.) presents several theories as to what birds might gain by moving out on to the range. The third section (7.3.) examines various theories of exploration, including its relationship with fear, and attempts to explain the birds' behaviour in relation to these theories. The final section (7.4.) presents the main conclusions reached in this thesis.

7.1. Social and environmental factors influencing the use of space

The implications of the present study's findings for commercial free-range systems may not be straightforward, given the problems of extrapolating principles derived from experimental groups of four birds to flocks of several thousand. Nevertheless, some implications (based on the present findings) may be valid.

7.1.1. Social factors

The following social factors, and their influence on the use of space by domestic hens, were investigated: social rank, restriction of movement in order to minimise the number of unfamiliar birds encountered, and the attractiveness of larger groups of birds. The effect of social rank was examined as a possible factor influencing birds' emergence from a covered box into an outdoor paddock (Chapter 2), and in the willingness of individual (food-deprived) birds to pass a second bird in order to reach a large cage containing food, water and shavings (Chapter 4). In the former, rank was shown to have no significant effect on birds' order of emergence into the paddock, while in the latter case, the times taken by individual birds to move past a higher-ranking bird did not differ significantly from the times taken to move past a lower-ranking bird. Thus, neither in the case of movement down a runway nor in the case of emergence into an open space, did social rank appear to influence birds' use of space significantly.

The hypothesis that an individual bird, in order to minimise the number of strange birds encountered, might limit its area of movement to a restricted part of the house ("home range") was investigated in Chapter 4. Results indicated that birds from small penned groups were less willing to pass unfamiliar birds than familiar birds (Experiment 1), and birds from single cages took longer to reach the large cage as the number of unfamiliar birds which had to be passed increased (Experiment 2). In both cases, given the small group sizes involved, an individual bird was used to seeing only a limited number of other individuals (pen-mates in Experiment 1, birds in neighbouring cages in Experiment 2). Therefore, a strange bird would have been immediately obvious to these birds. In the free-range flock, however, birds were observed to move over a large area of the house in a short period, which, together with the lack of overt agonistic interactions, suggests that any restriction of movement was probably due to localisation of resources, rather than to social pressure (Experiment 3). In this situation, a bird's capacity for individual recognition would have been exceeded, so birds would have been unable to learn the characteristics (or become familiar with) a small group of other birds. As a result, a bird could not distinguish between individuals, so reacted to other birds in a neutral and non-aggressive way.

Of these three social factors investigated, only gregariousness was shown to have a significant effect on birds' use of space (Chapter 5). Birds, which were tested in groups of 3, displayed a greater readiness to leave the box, and to spend more time outside the box, when another bird was already in the paddock (compared to when the paddock was empty). Birds displayed the earliest emergence, as well as the most time spent outside the box (and in the area furthest from the box), when six birds were present in the paddock. No differences were found between test birds' responses towards familiar or unfamiliar stimulus birds. This suggests that it is the number of birds already present in the outdoor area, and not their familiarity, which is important in determining birds' use of space. As indicated in the General Introduction, the proportion of a flock out on range at any one time decreases as flock size increases. In addition, Keeling *et al.* (1988) reported a greater mean distance from the house as the number of birds on range increased. The attractive forces of larger flocks might decrease birds' willingness to leave the house or to move away from the house. The results from Chapter 5 support the prediction of Keeling *et al.* (1988) that birds are more likely to leave the house and use the range more evenly if a greater number of birds is already outside. Thus, as flock size increases, a given number of birds in the outdoor area will represent a decreasing proportion of the total flock. Reducing flock size, therefore, either by using smaller houses or by partitioning large houses, is one possible way of influencing birds' emergence into a novel area.

7.1.2. Environmental factors

The following environmental factors were studied: feeder position, increasing the complexity of the home pen, regular handling, early exposure to the outside area, and the provision of cover. Birds emerged from the box earlier and spent less time inside the box when a feeder (or feeders) was present in the paddock, though not if there was another feeder inside the box (Chapter 2, Experiments 1 and 2). However, the presence of a feeder (or feeders) in the paddock did not appear to enhance birds' use of the area furthest from the box. When three feeders were present in the paddock, birds tended to make most use of the feeder nearest the box, especially when the feeders were spread throughout the paddock (Experiment 3). Thus, feeder position had only a limited effect in influencing birds' use of space. Nevertheless, previous studies have shown that the use of space by free-ranging domestic animals may be influenced by manipulating the location of resources, such as food and water (Arnold and Dudzinski, 1978); for example, the use of space by cattle may be manipulated by altering the positions of salt-licks (Jardine and Anderson, 1919). Similarly, the behaviour of free-range hens may be influenced by altering the positions of feeders; for example, one flock of 1400 hens, which were fed twice a day from hoppers situated in the outdoor area, spent most of the day outside, and dispersed evenly over the outside area (Poultry World, 1990b). No food was provided inside the house. The birds were allowed access to the hoppers for two 30-minute periods per day - one in the morning, and one in the afternoon. The hoppers were covered with lids for the rest of the day to protect against contamination by wild birds. The results from Chapter 2 showed that birds displayed greater willingness to move outside when a feeder (or feeders) was present in the outside area (though not to disperse further than the point of the closest feeder), despite the fact that the birds had not been food-deprived prior to testing.

Increasing the complexity of the home pen (by the introduction of traffic cones) also had a (limited) effect on birds' emergence and dispersal responses (Chapter 2, Experiment 4). Birds from "enriched" pens (containing cones) emerged earlier and spent less time inside the box than birds from "non-enriched" pens. A more complex home environment may enhance birds' ability to adapt to novel situations. The presence of familiar cones in the paddock, however, did not influence emergence time or the use of paddock space.

In the large free-range flock, birds which were observed outside in more than half the scans had significantly lower underlying fear levels (as measured by tonic immobility) than birds which were never seen outside (Chapter 3). In the small experimental groups, relatively early exposure to the outside environment (starting at 12 weeks of age) had significant effects on birds' subsequent use of the outside area, as measured by emergence and dispersal responses. Prior experience in the paddock reduced birds' emergence latencies and increased the amount of time spent in the paddock, including the area furthest from the box. Regular exposure to the outside area also reduced birds' underlying fearfulness, as measured by tonic immobility. However, regular handling alone had no effect on birds' responses in the outdoor paddock (compared to Control birds, which had not been regularly handled or exposed to the outdoor area), or on tonic immobility. Thus, the age at which birds are first introduced to the outside environment can dramatically influence their subsequent use of space as adults. Previous studies have shown that the rearing environment can influence the ability of hens to adapt to their adult housing conditions; for example, Fröhlich (1989) reported that birds reared in cages or on deep litter without perches experienced difficulty in perching as adults. Furthermore, birds reared without perches tended to aggregate prior to roosting, and although some birds might develop perching behaviour as adults, agonistic behaviour associated with roosting remained higher among birds reared without perches than those reared with perches. Similar findings were reported by Faure and Jones (1982), and by Appleby *et al.* (1988b). Thus, the developmental experiences of laying hens (including exposure to the outside environment in free-range systems) can significantly affect their adaptation to adult housing conditions.

The introduction of cover into the paddock enhanced birds' willingness to emerge from the box and spend more time in the paddock (Chapter 6). Birds spent significantly more time in the area furthest from the box when either 2-dimensional or 3-dimensional cover was present. However, birds' vigilance levels in the outdoor area were largely unaffected by the presence of cover objects. Nevertheless, the introduction of some form of cover into the outside area would appear to be an important factor in influencing the use of space. In addition to the results reported in Chapter 6, Collias and Collias (1967) found that vegetational cover played an important role in habitat selection by Red jungle fowl, and birds quickly retreated to cover if disturbed while feeding in an open area on the edge of the forest.

Observations on Red jungle fowl, as well as other species such as Grey jungle fowl (*Gallus sonneratii*) and Ceylon jungle fowl (*Gallus lafayetii*), indicated that vegetation should be dense enough to provide good cover, but not so dense as to inhibit walking through it. A study on a feral population of domestic fowl (Duncan *et al.*, 1978) reported that birds roosted in bushes or trees at night, indicating that domestication had not erased the attractiveness of cover. The potential for agroforestry, in which woody perennials are combined with groups and/or animals in a spatial or temporal arrangement, was investigated by Dorward and Carruthers (1980). They concluded that the presence of trees in a free-range system may improve the technical feasibility and economic viability of the system. Trees provide perching sites, as well as greater security, allowing a more even use of the outside area. In addition, trees may have a favourable effect on the microclimate (by reducing windspeeds and temperature fluctuations), as well as providing shade and shelter from rain.

7.2. What might birds gain by leaving the house?

Given that most (if not all) of the hens' basic requirements are met inside the house (food, water, litter, nestboxes, etc.), and birds leaving the house may be exposed to extreme weather conditions and the dangers of predation, why do birds venture out on to the range in the first place? There are a variety of possible reasons, some of which refer to commodities which might only be available outside, others which indicate possible disadvantages of maintaining close contact with a large number of other birds.

Two of the commodities which are available outside, but which might not be readily available inside the house, are increased space and daylight. Fölsch *et al.* (1988), in a review of alternative housing systems, listed light as one of fowls' "needs." A number of studies on indoor floor systems have reported that hens are attracted to patches of light (including sunlight), and may accumulate (at densities of up to 50 birds per square metre) in such patches (Hüber and Fölsch, 1985; Hughes *et al.*, 1986). This is not an appropriate thermoregulatory reaction, as birds in such accumulations display mild heat stress symptoms. The lower the internal illumination level, the longer and more often birds will remain in a patch of light. Birds' attraction to patches of light inside the house contrasts with their aversion to bright, sunny conditions in the outside area. Several reports have indicated that more birds were observed outside on dry, overcast days than on bright, sunny days (Innes, 1984; Davison, 1986), and birds which did go outside actively sought shade (Poultry World, 1985). Greater outdoor light intensity may increase birds' conspicuousness and subsequent vulnerability to predation, thus reducing their willingness to leave the house.

A bird might move outside in order to increase its available space. As stated earlier (in the General Introduction), a single free-range flock may contain several thousand birds, and the maximum stocking density allowed in a free-range house is 7 hens per square metre for a deep-litter system, or 25 hens per square metre in a perchery. (The latter figure equates to 400 cm^2 per bird, which is less floor space than that given to caged hens, though perchery hens have access to more than one level). Choice tests have shown that birds prefer larger space, as they consistently chose larger over smaller cages (Hughes, 1975; Dawkins, 1978, 1981), and were willing to work for increased space in operant tests (Faure, 1986; Lagadic and Faure, 1987). Inside birds may be subject to overcrowding (especially in a perchery system), and may therefore move outside to increase their available area.

In addition to increasing its available space, a bird may move outside to escape or get away from other birds. A number of studies have examined the effects of stocking density and/or flock size on various welfare indicators (behaviour, physiology, production, mortality) in both cages and floor systems. Polley *et al.* (1974), for example, found that the frequency of severe agonistic encounters among birds increased in flocks with higher stocking densities, though absolute frequencies decreased. There may be a curvilinear relationship between stocking density and agonistic activity, as the frequency of social interactions increased then decreased as area per bird was reduced. A similar relationship was reported by Al-Rawi and Craig (1975), who also found an increase in the frequency of agonistic interactions in larger groups. Allen and Perry (1975) investigated feather pecking and cannibalism among caged hens in different-sized groups (with constant area/bird), and observed most feather pecking and cannibalism in the largest group. In addition, there was a significant tendency for one death (due to cannibalism) to be followed by another in the same cage. In a study on deep-litter hens, Appleby *et al.* (1988a) found that the severity of feather damage was correlated with stocking density. Higher mortalities (due to cannibalism) were reported at higher stocking densities in a strawyard (Gibson *et al.*, 1985). Using various behavioural measures, Eskeland (1977) reported reduced welfare with increased stocking density in both pens and cages. Crowding may also lead to signs of physiological stress, and have detrimental effects on production and mortality. Siegel (1960), for example, found that the adrenal glands of cockerels from the most crowded groups were significantly heavier than those from the least crowded groups. Higher stocking densities also led to a significant depletion of adrenal cholesterol, higher pituitary weights, and reduced bursa weights. Mashaly *et al.* (1984) found that plasma corticosterone concentrations were consistently higher in the serum of birds housed 5 per cage than in birds housed 3 or 4 per cage. A decline in egg production with increasing stocking density was reported by Roush *et al.* (1984). In addition, mortality increased as cage area per hen was reduced. Therefore, it may be concluded from the available evidence that prolonged close association with a large number of other birds can have detrimental effects on an individual hen's welfare (especially at high stocking densities), and, consequently, a bird may move outside in order to alter its social environment.

Free range is the only husbandry system which allows hens to engage in foraging behaviour on grass. In a study on free-ranging (zoo-kept) Red jungle fowl, birds were observed ground-pecking in 60% of observations, and ground-scratching in 34% of observations (Dawkins, 1989). Thus, the main part of the day was spent foraging (at all times of the year). Hughes and Dun (1983) found that free-range hens, with a mean food intake of around 140 g/day, could supplement their intake with about 50 g/day of grass from the pasture. Furthermore, in preference tests, in which a large cage was chosen over a small cage (indicating a preference for more space), hens chose a small cage with a grass floor over a large cage with a wire floor, indicating that a grass floor was relatively more important than cage size (Dawkins, 1978).

A final theory as to why birds go outside is that it fulfils a possible "need" or desire for locomotion. Lewis and Hurnik (1990) hypothesised that locomotion has adaptive survival value, and that some species may have evolved a need or desire to engage in locomotor behaviour that is independent of goal-acquisition; for example, the desire to walk in a foraging species may not be reduced substantially by the presence of abundant localised feed. Locomotion might therefore be seen as the consummatory phase rather than part of the appetitive phase of a behaviour. Such behaviour may have evolved as a biological safeguard to maintain physical fitness, and to maintain familiarity with the animal's home range or territory. Increasing the stocking density has been shown to reduce freedom of movement (Appleby *et al.*, 1988a), so birds may satisfy their "need" for locomotion by moving outside on to the range.

7.3. Theories of exploration

Exploratory behaviour is defined by Hughes (1965) as "behaviour which facilitates familiarization with the environment by bringing receptors into closer contact with components of the external stimulus field." Exploration includes orientation to novel stimuli, patrolling and moving about territories, and investigation of stimuli (Birke, 1980). Exploratory responses may be stationary (orienting) or locomotory, though locomotor activity may be influenced by other factors than exploration, such as food-seeking (Campbell *et al.*, 1966), or escape. Exploratory behaviour may be influenced by various environmental and experiential factors; for example, Simmel (1962) found that exploratory behaviour in rats may be socially facilitated in a manner similar to eating or drinking, while Joseph and Gallagher (1980) found that rats reared in enriched environments showed a greater tendency to explore than rats from restricted environments.

7.3.1. *Environmental information vs. predation risk*

One possible function of exploration may be to obtain information about the environment. Possession of environmental information reduces uncertainty, and an animal may be better able to function in the environment, as survival chances will be enhanced by the possession of information about the location of resources such as food and shelter. Both Metzgar (1967) and Ambrose (1972) found that rodents which were familiar with a test area suffered less predation than animals which were unfamiliar with the area. Possible explanations for this difference are that animals which were familiar with the environment were less active in the area, so were less exposed to predation, became aware of danger more quickly, and were able to escape more effectively. Thus, in free-range systems, it is possible that birds emerge from the house and explore the outside area in order to increase their familiarity with the environment. On the other hand, exploration also incurs costs, and animals may be at increased risk while they are gaining the experience, before they have become fully acquainted with the area. Glickman and Morrison (1969), for example, found that susceptibility to predation in mice could be predicted from their initial exploration scores in an open field test. Animals which showed greater exploration in the open field were more susceptible to predation by an owl. Therefore, fear of predation might be an important factor inhibiting the movement of laying hens out of (and away from) the house, and results from the present study indicate that readiness to explore the outside area might be enhanced by reducing the risk of predation, either by increasing the number of birds in the outdoor area (the "selfish herd" effect, Chapter 5), or by the provision of cover (Chapter 6).

7.3.2. *Problems with motivation*

Exploratory behaviour and its underlying motivation have been the subject of extensive research by psychologists and ethologists for many years. The role of novelty in exploration presents difficulties with the motivation of exploratory behaviour in terms of the classical drive theory. The classical theory predicts that deprivation of the opportunity to explore should increase the drive, but the exploratory drive seems unaffected by such deprivation. In addition, if the same stimuli elicit an exploratory drive and simultaneously serve as an exploratory reward, a strict drive-reduction theory would be unable to deal with these phenomena. An alternative theory is that confinement to a barren environment may produce anxiety, and such monotony may arouse a "boredom drive" (Myers and Miller, 1954). In addition, novel stimuli may produce a "curiosity drive." The boredom drive may be reduced by increasing an animal's sensory input, and such drive reduction may be the reinforcement involved for exploratory rewards. Alternatively, Barnett (1963) suggested that exploration itself, in which rats encountered novel visual stimuli or gained access to a large space, may have some reward value. He also proposed that exploration, like foraging, may be an appetitive behaviour, and variation of the stimuli acting on an animal (as a result of such exploration) may resemble a consummatory state.

7.3.3. *Exploration - seeking optimal arousal?*

Exploration may also serve to effect changes in psychophysiological arousal. Berlyne (1966) stated that the central nervous system of a higher animal is designed to cope with environments which produce a certain rate of influx of stimulation, information and challenge to its capacities. It is undesirable for an animal to be overstressed or understressed, though the optimal level of arousal may vary between individuals. Russell (1983) outlined two theories on the relationship between exploration and arousal. First, an unchanging or monotonous environment leads to low arousal, which may be increased by exploration. If arousal is increased to above the optimum, the animal may withdraw, or increase its familiarity with the new situation through experience. A second theory postulates a U-shaped relationship between stimulation and arousal, in which high or low levels of stimulation leads to high arousal. The purpose of exploration in this situation may be to seek out a change of stimulation in order to reduce arousal. Sheldon (1969) found that rats, when given a choice of entering a box containing a familiar stimulus or one containing a novel stimulus, displayed an initial preference for the box containing the familiar object, as the novel stimulus represented a supraoptimal level of novelty. However, once the rats were more familiar with the novel stimulus, the familiar stimulus represented a suboptimal level of novelty, so the novel stimulus was chosen. Exposure to another novel stimulus caused a rise in novelty to above the optimum, resulting in a significant tendency to revert to the familiar stimulus. It is difficult, however, to account for the behaviour of hens emerging from a free-range house in terms of seeking optimal arousal. The environment inside a free-range house is both varied and complex, providing adequate stimulation to the birds. Furthermore, most (if not all) of the hens' basic requirements (food, water, litter, nestboxes, etc.) are provided inside the house, and, as Fraser and Broom (1990) stated, it is quite possible that all of the advantages to the hen of free-range can be obtained within a well-designed building. Nevertheless, Nicol and Guilford (1991) argued that exploratory behaviour (in the absence of external stimulation) may result from a high level of internal causal factors for a particular behaviour pattern (such as foraging or locomotion). However, a lack of exploratory activity would not necessarily indicate that such internal causal factors were low, as other (external) factors (such as the risk of predation) may inhibit exploratory activity.

7.3.4. *Novelty and the "exploratory drive"*

Most studies on the role of novelty in exploration (involving laboratory or domestic rats) have indicated that exposure to novel external stimulation evokes an exploratory drive, leading to an initially high level of exploratory behaviour. Rats which had free access to familiar and unfamiliar halves of a box were seen in the novel half significantly more often than in the familiar half (Hughes, 1965). In addition, rats displayed more exploratory behaviour in the novel half. Continual exposure to such stimulation leads to a reduction in the strength of the exploratory drive. Berlyne (1950, 1955), for example, found that the response to an unfamiliar object or environment declined with duration of continuous exposure, and with repeated daily exposure. These studies led to the formation of the hypothesis of exploratory drive (Berlyne, 1950; Montgomery, 1953): (1) novelty evokes the exploratory drive, which in turn motivates exploratory behaviour (2) the strength of the exploratory drive (measured by the amount of exploratory behaviour) decreases with time of continuous exposure to a stimulus and recovers during a period of non-exposure. Furthermore, Montgomery (1954) found that novel stimulation can function as a reinforcing agent in learning, and the mechanism underlying this reinforcement was an increase rather than a decrease in the strength of the exploratory drive.

However, the above hypothesis of exploratory drive is unlikely to apply to free-range domestic fowl, as it is based mainly on studies involving "forced" exploration, in which rats were placed in a test area which offered little or no chance of escape. Thus, the initial locomotor hyperactivity displayed by rats in a novel environment might have been an attempt to escape or to seek cover. In a study on "free" exploration (analogous to the present study), Blanchard *et al.* (1974) found that rats pre-exposed to an alley displayed shorter latencies to leave the home cage and enter the alley, had higher rates of exploration in the alley, and spent less time in the home cage than rats with no prior experience of the alley. In addition, rats running towards their home cage displayed greater tolerance for electric shock than if moving towards another open field. These results provide support for the hypothesis that, in "free" exploration tests, novel situations elicit fear, not exploration.

Further evidence for this hypothesis comes from the observation that the behaviour of hens, when presented with novel stimuli, appears to resemble that of neophobic wild-type rat strains, rather than the more neophilic responses of laboratory and domestic strains (Barnett, 1963; Barnett and Cowan, 1976). Wild-type strains of *Rattus norvegicus* and *R. rattus* are subject to human predation, and avoid unfamiliar objects in familiar environments, though such objects are not avoided if present when the rats are first introduced into the environment (Cowan, 1976). As reported in the present study, hens consistently emerged from the covered box earlier, and spent a greater proportion of time in the outside area, with successive trials. Thus, birds initially displayed neophobic, rather than neophilic, behaviour. This concurs with the finding of Syme and Syme (1975), who reported that hens, when given the choice between novel and familiar environments, displayed a strong preference for the familiar environment. Furthermore, studies by Jones (1977a) indicated that as domestic chicks' experience in a novel environment increased (through repeated exposure), the fear level shown in the environment decreased. Thus, although it appears that the neophobic response in rats has been reduced through domestication (Dewsbury, 1978), there does not appear to have been such a reduction (to the same degree) in domestic fowl (Rose *et al.*, 1985). It may therefore be concluded that fear is the primary motivational response of domestic fowl towards novelty or unfamiliarity.

7.3.5. *Exploration, novelty and fear*

Is the novelty of the outside environment the primary fear-evoking property inhibiting birds' movement out of the house? The relationship between novelty, exploration and fear has been investigated by various authors (for example, Murphy, 1978). An environmental change will elicit either fear or approach, and Russell (1983) outlined two distinct theories which predict which response is shown. The biphasic theory (or inhibition model) states that fear and exploration are two distinct underlying motivational systems. There is an inverse relationship between exploratory behaviour and fear, and the level of exploration shown is the net outcome of competition between the tendency to approach and the tendency to avoid (Montgomery, 1955). The monophasic theory states that fear is the motivational basis for exploration, and the level of exploration is determined by the level of fear. Low or moderate fear levels will evoke exploration, and strong fear will evoke withdrawal. The monophasic theory was tested by Halliday (1966), who, using laboratory rats, varied (independently) the novelty and fear-evoking properties of a situation using enclosed and elevated mazes. Montgomery (1955) had already shown that both maze types evoked an exploratory drive, but rats displayed more fear and avoidance behaviour in the elevated maze than in the enclosed maze. Halliday predicted that, if the monophasic theory was valid, exploratory behaviour should vary with the fear-evoking properties of a situation, but not with the novelty. In fact, increasing familiarity (or reducing novelty) decreased exploration in the enclosed maze (an indication of reduced fear in neophilic rats), but had much less effect in the elevated maze, where fear remained high. These findings support the monophasic theory, suggesting that fear of the environment is the primary motivation controlling exploratory behaviour, and locomotor exploration is not determined in any simple way by the novelty or familiarity of environmental stimuli. As stated previously, exploration may serve to reduce fear by obtaining environmental information and thereby reducing uncertainty, and some authors (Evans, 1970; Salzen, 1979) have suggested that (low-level) fear *motivates* exploration. On the other hand, Russell (1973), in a review of the relationship between exploratory behaviour and fear, concluded that the evidence supported the biphasic theory, and although fear may facilitate exploration in certain circumstances, it cannot be regarded as the motivational source for *all* exploratory behaviour.

As indicated earlier, birds from the small groups in the present study, following initial neophobia, increased their use of the outside area with repeated exposure. However, birds typically spend twelve months in commercial free-range systems, and it is probable that most (if not all) birds will spend at least some time outside. (Davison (1986) found that only 6% of birds were never outside). The novelty of the outside area will therefore be reduced in time, but, as stated in the General Introduction, in large groups only a low proportion of the flock is outside at any one time. Furthermore, Keeling *et al.* (1988) reported an average of 15% of the flock outside at

25-28 weeks of age, which increased to 22% when the birds were 70-72 weeks old, showing that, although most (or all) birds will be exposed to the outside environment during the laying period, this does not necessarily lead to a large increase in the proportion of the flock outside. Therefore, it is proposed that birds continue to find the outside environment aversive because of its fear-evoking properties (such as the risk of predation), even though it could no longer be regarded as novel.

7.3.6. *The "discrepancy" theory*

If fear is the major factor *inhibiting* exploration, what motivates exploration when fear is low? One possible explanation is provided by the discrepancy theory outlined by Hinde (1970), Cowan (1983) and Russell (1983). As discussed earlier, exploratory behaviour may be influenced by novel stimuli (Berlyne, 1960), and, when confronted with novelty (or unfamiliarity), an animal may approach the source of novelty (exploration), or show withdrawal or avoidance (fear). Each animal possesses a "neuronal model" (or cognitive map) of its environment, and which response is given will be determined (in part) by the discrepancy between this model and the current sensory input. Low-to-moderately intense novelty will lead to small discrepancies, which will evoke approach and investigation of the source of change. A new model will be formed, and the discrepancy will be eliminated. Conversely, extreme or intense novelty will cause larger discrepancies, which will evoke withdrawal and an attempt to relocate familiar or non-discrepant stimuli (Cowan, 1983; Russell 1983). Therefore, another possible goal of exploration is a mild degree of discrepancy, and, subsequently, a new (and more complex) cognitive map. Hinde (1970) argued that some behaviours (such as feeding, sexual behaviour or nest-building) are involved in eliminating discrepancies by seeking consummatory stimuli, and these stimuli bring such behaviours to an end. Similarly, exploratory behaviour also seeks to eliminate a discrepancy (if the discrepancy is sufficiently small to evoke exploration), but differs from the above behaviours in that it does not seek to change the stimuli impinging on the animal, but to change the neuronal model so that it conforms to these stimuli.

It seems likely that for hens reared inside and transferred to a free-range house at 16-18 weeks old, there is a major discrepancy between the inside environment (enclosed, crowded, low light intensity) and the outside environment (open, few conspecifics, variable light intensity). According to this model, large discrepancies between an individual's neuronal model and the current sensory input will lead to withdrawal or avoidance, whereas smaller discrepancies will evoke exploration. The above study by Davison (1986) revealed that less than half the flock (48%) were outside for more than

25% of the time, 27% were outside for more than half the time, and only 3% were outside for more than 75% of the time. Thus, although most (or all) birds would have gained some experience of the outdoor area (thereby reducing its *novelty*), only a small proportion of the flock would have spent sufficient time outside to reduce the *discrepancy* between the indoor and outdoor environments, with the resultant change in the "neuronal model". One important difference between the small experimental groups used in the present study and the larger flocks in free-range systems was that, in the former, birds inside the covered box had an easy unrestricted visual access to the outdoor area. Therefore, these birds could gradually increase their familiarity with the outside environment without leaving the box. On the other hand, birds in large houses would not have an unrestricted view of the outdoor area unless they perch at a pop-hole (where they may experience jostling by other birds moving in and out), or leave the house altogether - a large and (potentially) frightening step.

Therefore, to attract birds out, one would have to do two things - reduce discrepancy (to a sufficiently low level), and reduce the fear-evoking properties of the outside environment. In the present study, most of the findings are consistent with this proposal, as birds displayed greater willingness to emerge into and disperse in the outside area when feeders were placed in the paddock (thus reducing discrepancy) (Chapter 2), when birds had regular exposure to the outside environment (Chapter 3), when other birds were already present in the paddock (Chapter 5), and when cover was present (Chapter 6).

Finally, why does the proportion of the flock leaving the house decrease as flock size increases? As previously stated, a given number of birds in an outdoor area will represent a decreasing proportion of the total flock as flock size increases. Therefore, the discrepancy between the inside and outside environment will decrease as flock size decreases. An alternative hypothesis is that, as flock size increases, the number of birds which an individual has to pass in order to move around the house (and to reach a pop-hole) increases. Although the findings of Chapter 4 indicate that hens do not limit their movements due to social factors (or "pecking pressure"), it is still possible that the presence of a large number of other birds will make movement *physically* more difficult, especially when stocking density is high. Thus, an individual hen's freedom of movement (and therefore its ability to reach a pop-hole) may decrease as flock size increases, which may subsequently reduce the proportion of the flock leaving the house.

7.4. Conclusions

It is clear that there is no single explanation for the apparent reluctance of free-range hens to leave (and to move away from) the house. In this thesis, various social and environmental factors have been shown to influence hens' use of space.

The attractiveness of the outdoor area was increased if a larger number of birds (or a larger proportion of the flock) was already outside. As flock size increases, a given number of birds outside will represent a diminishing proportion of the flock. This finding provides a possible explanation for the negative relationship between flock size and the proportion of the flock which is outside. Alternatively, it is possible that hens experience physical (rather than social) restriction of movement in large flocks, making movement round the house (and subsequent ability to reach a pop-hole) more difficult. Increasing the familiarity of the outside environment (either through the introduction of familiar stimuli, or through repeated exposure) and the introduction of cover, all had varying effects on influencing hens' use of space. It is concluded that hens might be more willing to use the available (outdoor) area if (1) the fear-evoking properties of the outside environment are reduced (through the presence of a larger number of birds, or the introduction of protective cover), or (2) through a reduction in the discrepancy between the inside and outside environments, either through increasing birds' experience of the outdoor area (possibly during the rearing period) to a sufficient degree to evoke a change in the neuronal model, or through the introduction of familiar objects into the outdoor area, especially if these objects (such as feeders) have some biological significance.

Finally, it must be stressed that the conclusions presented in this thesis are tentative, given that most of the findings were derived from experiments using small groups of birds. Further research, using an experimental group size intermediate between the small groups used in the present study and the large flocks normally housed in free-range systems, would be needed before firmer conclusions regarding hens' use of space can be reached.

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Appendix: Published Papers

The following papers (copies of which are included with the permission of the publishers) have been published by the author:

Grigor, P.N. (1991). Emergence behaviour in domestic fowl (Abstract). *Applied Animal Behaviour Science* **31**: 295-296.

Grigor, P.N. and Hughes, B.O. (1993). Social inhibition of movement in free-range domestic fowl (Abstract). *Applied Animal Behaviour Science* **35**: 297-298.

Grigor, P.N. and Hughes, B.O. (1993). Does cover affect dispersal and vigilance in free-range domestic fowl? In *Proceedings of the 4th European Symposium on Poultry Welfare, 1993, Edinburgh.* (Hughes, B.O. and Savory, C.J., eds.). (In press).

Emergence behaviour in domestic fowl

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ABSTRACT

In many free-range systems, only a small proportion of hens actually go out to range. One explanation for this may be that the open range is a totally alien environment to birds previously reared inside. The presence of a familiar stimulus outside might encourage birds to emerge. This experiment tested the willingness of birds to emerge from a familiar environment (a covered 0.9 m^3 box), into an unfamiliar environment (an open paddock). To alter the novelty of the external environment, 'tower' feeders, of a type familiar to the birds, were used. The feeders could be positioned inside the box, just outside in the paddock, or in both locations. The influence of social rank was also investigated. There were three treatments: T1, feeder inside box; T2, feeder 1 m outside box; T3, two feeders (one inside and one outside the box). The flock of 21 medium hybrids was ranked and separated into six groups for testing purposes, each consisting of three or four hens and containing one high ranking bird, one (or two) middle ranking birds, and one low ranking bird. Each treatment was replicated three times for each group. Results showed that birds emerged earlier when there was a feeder outside (T2) than when the feeder was inside (T1) and when there was a feeder in both positions (T3). Results also indicated that birds' latencies to emerge were not influenced by their social rank, and that emergence times decreased with habituation, as birds emerged earlier with successive trials.

Social inhibition of movement in free-range domestic fowl

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ABSTRACT

In many flocks of free-range domestic fowl, a large proportion of birds rarely, if ever, emerges from the house. In addition, as the flock size increases, the proportion of birds leaving the house decreases. One possible explanation for this is that hens in large flocks are unwilling to pass a large number of unfamiliar birds inside the house in order to reach a pop-hole. This experiment tested birds' willingness to move past a second bird in order to reach a preferred area. Birds were trained to move out of a small, empty cage (Cage 1) and into a larger cage containing food, water and shavings (Cage 2). Cages 1 and 2 were separated by a runway, into which protruded a third cage (Cage 3). There were four treatments: TC, Cage 3 empty (Control); TS, Cage 3 bird subordinate to Cage 1 bird; TD, Cage 3 bird dominant to Cage 1 bird; TU, Cage 3 bird unknown to Cage 1 bird. Each Cage 1 bird was given two replications of each treatment. Results showed that, compared with the Control (mean time taken to enter Cage 2 was 14.8 s), there was no significant difference when Cage 3 contained a subordinate bird (mean, 18.2 s), but having either a higher-ranking bird (mean, 45.7 s) or an unfamiliar bird (mean, 147.6 s) in the middle cage significantly increased the time taken to enter Cage 2. There was no significant difference between TS and TD. Birds reacted to unfamiliar Cage 3 birds in a variety of ways, including fear, aggression and curiosity. This resulted in a significantly longer time taken to enter Cage 2 than in any other treatment.

Paper submitted for presentation at the 4th European Symposium on Poultry Welfare, 1993, Edinburgh, and to be published in the proceedings.

Does cover affect dispersal and vigilance in free-range domestic fowl?

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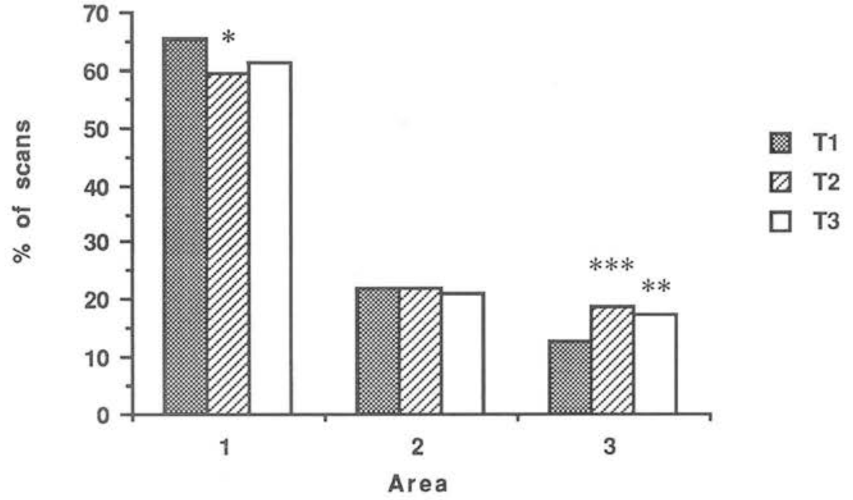
In many flocks of free-range domestic fowl, only a small proportion of the flock is outside at any one time. One possible explanation for this is that hens find the outside environment aversive. This may be largely due to its fear-evoking properties, such as the risk of predation. Previous studies have indicated that many species prefer habitats which provide vegetational cover, and display less anti-predator vigilance in such habitats. This experiment investigated the effects of providing various levels of cover on (a) birds' dispersal in an outdoor area, and (2) birds' postures in the outdoor area.

Thirty-six medium hybrid laying hens, housed in 3 indoor floor pens, were tested in groups of 4 pen-mates each. During testing, each group was transported to an outdoor paddock (11 m x 5.5 m), and placed in a familiar covered box (with an open front), from which they could emerge. The paddock was divided into 3 areas : 1 = inside the box; 2 = within 2 metres of the box; 3 = more than 2 metres from the box. The treatments provided 3 levels of cover in the outside area: T1 = empty paddock (Control); T2 = 4 objects providing 2-dimensional (ground-level) cover; T3 = 4 objects providing 3-dimensional (ground-level + aerial) cover. Each group was tested 9 times (with 3 replications of each treatment), each test consisting of a 60-minute period during which the birds could leave the box and disperse. The following were recorded: (1) the area in which each bird was seen, scanning every 30 seconds over the 60-min. period (2) the posture of each bird in the outside area. Postures were categorised as (a) Head Down (HD) - neck below horizontal (b) Head Up (HU) - neck between horizontal and vertical (c) Extreme Head Up (EHU) - neck vertical ("vigilant").

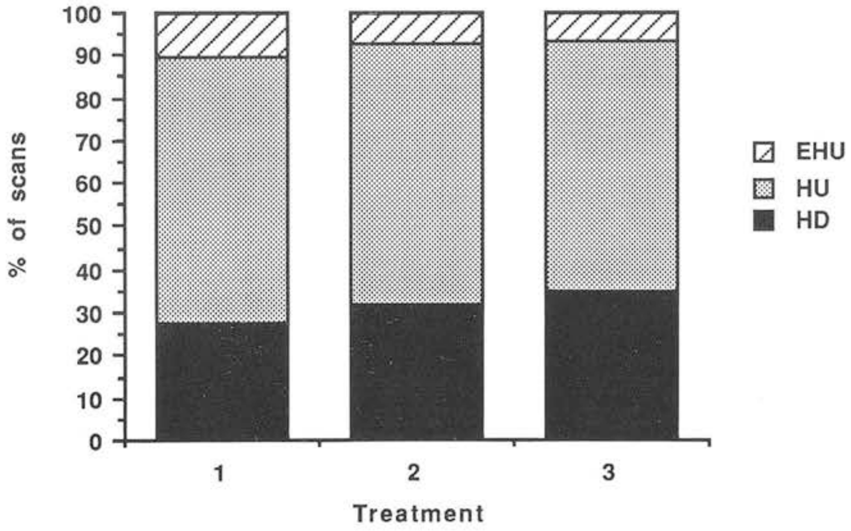
Compared to the Control, birds spent more time outside the box in both T2 (significant) and T3 (trend) (Figure 1). There was no significant treatment effect on the amount of time spent in area 2. However, birds spent significantly more time in area 3 in both treatments where cover was provided. To determine whether the proportions of each posture type varied with treatment, each posture was analysed separately. Results indicate that although birds displayed fewer "vigilant" postures (and more Head Down postures) when cover objects were present, in neither case was the difference significant (Figure 2). Thus, the presence of cover in an outside area had a limited effect on increasing the attractiveness of the outside area to domestic fowl, though this was not reflected in the birds' vigilance behaviour.

Figure 1. Treatment effect on % of scans in which birds were observed in each area



Difference from T1:		
	*	$p < 0.05$
	**	$p < 0.01$
	***	$p < 0.001$

Figure 2. Treatment effect on % of each posture type



Posture	Treatment effect
EHU	NS ($p > 0.05$)
HU	NS
HD	NS